



**CONTEMPORARY  
SCIENCE EDUCATION  
RESEARCH:  
SCIENTIFIC LITERACY AND  
SOCIAL ASPECTS OF SCIENCE**

**A collection of papers presented at  
ESERA 2009 Conference**

**EDITORS**

**G. ÇAKMAKCI & M. F. TAŞAR**



**CONTEMPORARY SCIENCE EDUCATION RESEARCH:  
SCIENTIFIC LITERACY AND SOCIAL ASPECTS OF SCIENCE**



**CONTEMPORARY  
SCIENCE EDUCATION RESEARCH:  
SCIENTIFIC LITERACY AND SOCIAL  
ASPECTS OF SCIENCE**

*Edited by*

**GÜLTEKİN ÇAKMAKCI**  
*Hacettepe Üniversitesi, Ankara, TURKEY*

**MEHMET FATİH TAŞAR**  
*Gazi Üniversitesi, Ankara, TURKEY*



**ISBN - 978-605-364-034-9**

© Copyright ESERA, 2010

### **Referencing articles in this book**

The appropriate APA style referencing of articles in this book is as follows:

Aguiar, O., Couto., F.P., & Buty, C. (2010). Connecting physical phenomena to models: Analysis of discourse in a practical physics class. In G. Cakmakci & M.F. Taşar (Eds.), *Contemporary science education research: scientific literacy and social aspects of science* (pp. 3–12). Ankara, Turkey: Pegem Akademi.

The copyrights of individual papers remain with the authors. A 3-page synopsis of each paper in this book was reviewed by two referees of an international panel and where appropriate and possible suggestions were made for improvement. Additionally, authors had the opportunity to gather ideas from colleagues during their presentations at the ESERA 2009 Conference before they submitted the full-text papers for this collection. Decisions and responsibility for adapting or using partly or in whole any of the methods, ideas, or the like presented in this book solely depends on the readers' own judgment. ESERA or the editors do not necessarily endorse or share the ideas and views presented or suggest or imply the use of the methods included in this book.

# TABLE OF CONTENTS

<b>Preface</b> .....	xiii
----------------------	------

## **PART 1: Discourse and Argumentation in Science Education**

Connecting physical phenomena to models: Analysis of discourse in a practical physics class.....	3
<i>Orlando Aguiar Jr., Francisco Pazzini Couto, Christian Buty</i>	
Teachers' discursive practices in a first organic chemistry course.....	13
<i>Andrea Soledad Farré, Alejandra María Rossi</i>	
Guiding student teachers towards more dialogic science teaching.....	23
<i>Sami Lehesvuori, Jouni Viiri, Helena Rasku-Puttonen</i>	
Classroom questioning and teaching approaches: a study with biology undergraduates.....	33
<i>M. Helena Pedrosa de Jesus, Betina da Silva Lopes</i>	
Argumentation about and understanding of science: Research exploring how to interrelate these two different perspectives.....	41
<i>Claudia von Aufschnaiter</i>	
Learning to TAP: An effort to scaffold students' argumentation in science.....	43
<i>Demetris Lazarou</i>	
Argumentation & scientific conceptions in peer discussions: A comparison between Catalan & English students...	51
<i>Marina Castells, Sibel Erduran, Aikaterini Konstantinidou</i>	
Argumentation and scientific reasoning: The "double hierarchy" argument.....	61
<i>Aikaterini Konstantinidou, Josep M<sup>a</sup> Cervero, Marina Castells</i>	
The quality of students' argumentation and their conceptual understanding – an exploration of their interrelationship.....	71
<i>Tanja Riemeier, Jan Fleischbauer, Christian Rogge, Claudia von Aufschnaiter</i>	

The teaching of socio-scientific issues for scientific literacy and citizenship ..... 79  
*Kacem Saida Merghli,*  
*Simonneaux Laurence,*  
*Azzouna Atf*

Pre-service teachers' ideas and knowledge about the notion of argument - a metacognitive approach..... 87  
*Nicola Mittelsten Scheid*

## **PART 2: Scientific Literacy**

A framework for practical work, argumentation and scientific literacy..... 99  
*Ros Roberts,*  
*Richard Gott*

The food-environment relationship: A socio-scientific issue in the perspective of sustainable development ..... 107  
*Laurence Simonneaux,*  
*Jean Simonneaux*

Scientific literacy and nature of science in early grades using cartoons..... 113  
*Eleni Kolokouri,*  
*Katerina Plakitsi*

Learning chemistry and mimicking political decision-making processes – a participatory action research study  
evaluating a lesson plan on bioethanol as a fuel..... 123  
*Timo Feierabend,*  
*Ingo Eilks*

Ways to promote essential elements of a developed scientific literacy in science education..... 131  
*Ingo Eilks, Jack Holbrook, Rachel Mamlok-Naaman, Ingo Eilks, Ralf Marks, Claus Bolte, Birgit Kirschenmann, Sabine Streller,*  
*Miia Rannikmäe, Anne Laius*

Enhancing the scientific literacy of students by exposing them to a historical approach to science ..... 133  
*Rachel Mamlok-Naaman*

Promoting scientific literacy by integrating authentic and controversial socio-scientific debates into science lessons  
..... 139  
*Ingo Eilks,*  
*Ralf Marks*

Enhancing pupils' abilities to properly judge and make informed decisions in the field of renewable energy sources –  
bioenergy..... 149  
*Claus Bolte,*  
*Birgit Kirschenmann,*  
*Sabine Streller*

Enhancing students' creativity and reasoning skills..... 155  
*Miia Rannikmäe,*  
*Anne Laius*

Aspects of critical thinking related with scientific literacy..... 161  
*Alice Rodrigues,*  
*Maurícia Oliveira*



Socioscientific issues, argumentation and conceptual understanding in high school genetics .....	165
<i>Grady Venville,</i>	
<i>Vaile Dawson</i>	

## **PART 3: Environmental Education**

School goes to the farm: Conceptualisation of rural-based sustainability education .....	175
<i>Helmi Risku-Norja,</i>	
<i>Ellli Korpela</i>	

University students' moral reasoning patterns toward environmental moral dilemmas.....	185
<i>Busra Tunca,</i>	
<i>Ozgul Yilmaz-Tuzun</i>	

How do pre-service teachers in Israel perceive the concept 'environment' .....	191
<i>Bella Yavetz,</i>	
<i>Daphne Goldman,</i>	
<i>Sara Pe'er</i>	

Evaluating the development of environmental literacy in preservice teachers .....	197
<i>Bella Yavetz,</i>	
<i>Daphne Goldman,</i>	
<i>Sara Pe'er</i>	

Social-psychological factors and personal determinants of students that influence effectivity of environmental education.....	207
<i>Daniel Kuracina,</i>	
<i>Lenka Ondrusova</i>	

Perceived seriousness of environmental problems: Dilemmas and resolutions .....	215
<i>Harika Özge Arslan,</i>	
<i>Ceyhan Çiğdemoğlu,</i>	
<i>Ömer Geban</i>	

An analysis of preservice science and technology teachers' attitudes towards environment.....	223
<i>Nevin Koşcu Çakır,</i>	
<i>Betül Timur, Fulya</i>	
<i>Öner Armağan,</i>	
<i>Gülcan Mıhladıç,</i>	
<i>Serkan Timur,</i>	
<i>Alev Doğan</i>	

Do schools make a difference in their students' environmental attitudes and awareness? evidence from PISA 2006 .....	231
<i>Jelle Boeve-de Pauw,</i>	
<i>Liesje Coertjens,</i>	
<i>Sven De Maeyer,</i>	
<i>Peter Van Petegem</i>	

## PART 4: Cultural, Social and Gender Issues

Sex education: Teachers' social representations, conceptions and practises.....	251
<i>Dominique Berger,</i> <i>Sandie Bernard,</i> <i>Graça Simoes De Carvalho</i>	
School health education: Impacts of a prevention AIDS programme in children 9 to 11 years old.....	261
<i>Dominique Berger,</i> <i>Didier Jourdan,</i> <i>Franck Pizon,</i> <i>Mabrouk Nekaa,</i> <i>Sylvie Pierre</i>	
Social and educational exclusion/ inclusion of Turkish immigrant youth in Canada.....	273
<i>Dilek Kayaalp</i>	
Exploring gendered stereotypes on science television with children and young people: towards a classroom application .....	277
<i>Elizabeth Whitelegg,</i> <i>Richard Holliman,</i> <i>Jennifer Carr</i>	
Introducing the nature of school science (NOSS).....	281
<i>Mattias Lundin</i>	
Qualitatively determining the physics teacher candidates' self-efficacies and attitudes towards problem solving.....	287
<i>Serap Çalışkan,</i> <i>Gamze Sezgin Selçuk,</i> <i>Hilal Aktamış</i>	
A comparative study on university students' attitudes toward a controversial issue: biotechnology .....	297
<i>Mehmet Erdogan,</i> <i>Murat Ozel,</i> <i>Saouma BouJaoude,</i> <i>Pavol Prokop,</i> <i>Muhammet Usak,</i> <i>Vincentas Lamanaukas,</i> <i>William Toli</i>	
Motivation of Colombian students working with a German computer-based learning environment.....	307
<i>Antonio Rueda,</i> <i>Manuela Welzel-Breuer</i>	
Application of computer aided learning environments in schools of six European countries .....	317
<i>Manuela Welzel-Breuer,</i> <i>Sönke Graf,</i> <i>Eric Sanchez,</i> <i>Valérie Fontanieu,</i> <i>Helga Stadler,</i> <i>ZbelyazkaRaykova,</i> <i>Roger Erb,</i> <i>Jari Lavonen,</i> <i>George Ioannidis</i>	

An example science education activity in multicultural environment.....	327
<i>Ismail Önder,</i>	
<i>Aysun Öztuna Kaplan,</i>	
<i>Şenol Beşoluk</i>	
Latent masculinity in school physics investigation activities: Microanalysis of small groups and whole class interactions .....	333
<i>Josimeire M. Julio,</i>	
<i>Arnaldo M. Vaz</i>	
Cultural influences on students' views about the origins of life .....	339
<i>Pam Hanley,</i>	
<i>Marcus Grace</i>	
Cultural aspects of decision-making about a controversial socio-scientific issue: Whaling .....	347
<i>Y.Chung Lee,</i>	
<i>Marcus Grace,</i>	
<i>Anita Wallin,</i>	
<i>Jenny Byrne</i>	



## Preface

At the ESERA 2010 Conference, over 1000 researchers met in Istanbul to exchange experiences and discuss contemporary issues in science education. This book is a part of series of the proceedings of the ESERA 2010 Conference. The book consists of four parts. The first part includes 11 papers on discourse and argumentation in science education, the second part includes 11 papers on scientific literacy, the third part includes 8 papers on environmental education and the last part includes 13 papers on cultural, social and gender issues.

We wish to thank all of the contributors in this book for their hard work

G. Çakmakçı  
Hacettepe Üniversitesi, Ankara

M. Fatih Taşar  
Gazi Üniversitesi, Ankara



**PART 1**  
**DISCOURSE AND ARGUMENTATION**  
**IN SCIENCE EDUCATION**





# CONNECTING PHYSICAL PHENOMENA TO MODELS: ANALYSIS OF DISCOURSE IN A PRACTICAL PHYSICS CLASS

Orlando Aguiar Jr.  
UFMG – Brazil

Francisco Pazzini Couto  
UFMG – Brazil

Christian Buty  
UMR ICAR, INRP – France

## Abstract

*The purpose of this study is to examine the potential relationship between the empirical elements of physical phenomena and the semiotic resources used by both the teacher and the students to construct explanations and make predictions about a practical problem proposed for discussion. In this paper we analyse a classroom episode in optics in which the teacher moves from the experimental device to structured representations (diagrams in optics) to construct, with the participation of the students, a solution to a problem posed as a challenge to the class. The analysis of the discursive interactions in such episode followed changes in the referentiality of discourse – empirical or theoretical – and in the communicative approach – dialogic or authoritative. We discuss the strengths and limitations of both experimentation and semiotic devices. We also examine the strategies used by the teacher to use them effectively to improve learning. The article brings evidence that the coordination of these two mediational resources – experimentation and semiotic devices – helps students to relate the world of physical phenomena to the conceptual world of Physics. We also sustain that such coordination is achieved through the discourse that the teacher weaves with the participation of students in the classroom.*

## Introduction

The role of experimental activities in science learning has been the focus of discussion for almost two centuries, with contributions from many fields of knowledge such as psychology, neuroscience, linguistics, philosophy, among others. Recently, articles related to the function and effectiveness of experimental activities in Science Education (Niedderer et al, 2003) have been redirected by studies that examine classroom discourse through which students and teachers create and share meanings and establish relationships between the world of empirical experiments and the theoretical world of science.

The origins of contemporary research on the relationship between language and cognition are found in Bakhtin's pioneer work of language philosophy and Vygotsky's studies of socio-historical psychology. In the book *Thought and Language* (Vygotsky, 1985), the author stresses the importance of accessing scientific knowledge for cognitive development, since it is inserted in a formal conceptual structure, in which the concepts mean within a network of relationships, through semiotic systems. Vygotsky alerts to the necessity of communication between everyday and scientific knowledge, by means of ascending (from concrete to abstract) and descending (from abstract to concrete) routes. In turn, Bakhtin's *Theory of Utterance* (Bakhtin, 1986; Voloshinov, 1973) highlights institutional and social relations in the study of discursive production. In such tradition of research attention is to be paid on the specific characteristics of the social environment of the science classroom.

Based on these authors, Mortimer and Scott (2003) and Mortimer et al. (2007) purpose research methodologies aiming at examining how meanings are developed in the social context of the science classroom. Therefore, the authors construct categories for the analysis of the teachers and students' discourse in science classes, a place where different cultural perspectives convene.

This article aims to examine the potential relationship between the empirical elements of physical phenomena and the semiotic resources used by both the teacher and the students to construct explanations and make predictions about a practical problem proposed for discussion. This examination will be done through discursive interactions in the context of an experimental activity in Physics classes in Brazilian secondary schools.

Our research problem can be formulated as follows: Does the combined use of semiotic and experimental resources coordinated by discursive interactions in a Physics classroom contribute to the development of the relationship, built by students, between the world of physical phenomena and physical models? A secondary question consists in examining the effectiveness and appropriateness of the teacher's strategy concerning this purpose.

## **Rationale**

In order to accomplish that, we might clarify what we mean by experimental activities, examine changes in the referentiality of discourse - whether they are empirical or theoretical - as suggested by Mortimer et al (2007), and the changes in the communicative approach – dialogic or authoritative – as proposed by Mortimer and Scott (2003).

The categories of dialogic/authoritative communicative approach are central to the theoretical framework developed by Mortimer and Scott (2003). The communicative approaches - dialogic and authoritative - are related to the two functions of language according to Lotman (1988): to generate new meanings and to convey culturally established meanings. These two functions are complementary, as the access to established forms of thought occurs by means of their relations with these understandings and experiences of the learning subject (Scott, Mortimer and Aguiar, 2006).

As regards experimental activities, it is necessary to be aware of the existence of a variety of names for the activities performed with material resources in the Physics classroom. Some categorizations emphasize the environment in which they occur, others the purpose of the activity: practical activities, demonstration activities, experimental classes, laboratory classes. Besides that, the meanings attributed to some of these expressions vary in the available literature.

Lunetta et al (2007) define experimental activities in teaching laboratories as "learning experiences in which students interact with materials or with secondary sources of data to observe and understand the natural world." Candela (1995) does not restrict the use of the term 'experimental activity' to situations in which students handle the equipment and phenomena. For the authoress, the experimental activity is "the set of material or exteriorized activities of one or more individuals who manipulate an object, or a model of a phenomenon, known for its properties" (Candela, 1995).

Demonstration, in the strict sense of the word, simply means the act or effect of showing a result already expected, or the empirical evidence of the validity of a law. As usually happens with words that are used in many fields of knowledge and for a long time, the term "demonstration" has had an inherent polysemy. The term "demonstration" is usually associated with any action capable of conferring authenticity or legitimacy to something, serving as unquestionable evidence of a proposition, idea or theory.

Ogborn et al. (1996) propose a different and more inclusive sense to the word, where the demonstration is the manipulation and presentation of an experimental setup, by the teacher, for teaching purposes. In this sense a demonstration may include different levels of questioning and of students' participation. Moreover, unlike the

traditional demonstration, it can precede an explanation or even monitor the construction of concepts of scientific models. "The main aspect of the demonstration is to make the material phenomenon to become something meaningful" (Ogborne et al., 1996), that is, "the materiality in the service of a theory." In this paper, we consider experimental activities not only the ones carried out in an environment suitable for this purpose, such as laboratories, but those carried out in any area used by the teacher to promote discussion about the content whose concepts are to be explored through the manipulation of setups, appliances and devices. Therefore, we believe that the term "shared activities" is more suited to their purposes.

Another theoretical framework used refers to the role of graphical representations such as diagrams of image formation, widely used by the teacher in lessons reported here. Peraya (1995) highlights specific characteristics of graphic / schematic language as presented in the scientific text. This author considers that this language: 1. Isolates invariant relations, which gives it capacity of abstraction; 2. Highlights certain relationships considered essential, and eliminates others, which are irrelevant; 3. Mediates between the abstract concept and the construction of a mental image of the concept - function of objectification - a mental image materialized; 4. Has a synoptic value - key elements can be presented simultaneously and not sequentially as in verbal language; 5. Presents cognitive economy: mnemonic load concentrated on the essential.

## Methods

We followed a Brazilian Physics teacher whose teaching style includes the systematic use of experiments and simulations in the classroom. This style of teaching is not very common in Brazil, where many teachers complete their physics courses without a single experimental activity. The criterion used to select the teacher was based on his/her innovative approach to experimental activities. During two months, the researchers videotaped the lessons of the teacher who developed the content of the Introduction to Geometric Optics up to Image Formation by Spherical Mirrors. The lessons were videotaped using two cameras: one, on one side of the room, focusing on the teacher and the other, in front of the room, trying to capture students' participation. The participating students are in their last year of high school and many of them will take university entrance examinations. The classes are held in a classroom in the form of an amphitheater. The room has a computer connected to a projector, a large central table (where the experiment was set up) and a camcorder. The teacher uses the camcorder to enlarge the images of some setups found on the table which needed to be shown in greater detail for the study.

Before any practical activity is carried out, the teacher provides an initial motivation to the question that will be presented to students, usually in the form of a challenge. The activities are developed in an interactive way, alternating between dialogic/authoritative discourses, with the prevalence of the latter. Besides that, the teacher consistently makes use of notes written on the board, videotapes, pictures, diagrams and PowerPoint simulations during class. Practical activities and semiotic resources are always used in a coordinated way, showing the student the world of phenomena and the world of ideas, and leading the class from specific references to abstract ones.

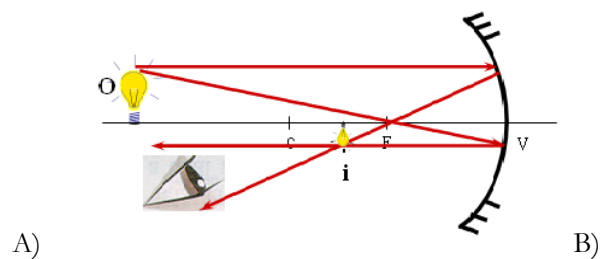
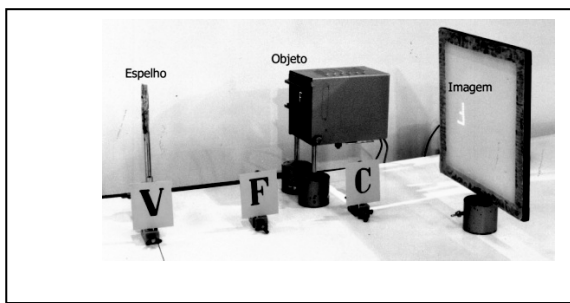
The part selected for analysis is the one in which the teacher, after having presented the most common cases of image formation by spherical mirrors. The choice of this specific episode was made because it characterizes very well the way the teacher worked during the time he was observed: he provided the students with an initial motivation; he frequently used experimental activities, he worked with drawings, diagrams and other semiotic resources; he tried to make the class participate in the elaboration of answers to the proposed problem; the teacher also moved around to hold students' attention, he presented a practical application of one aspect related to the topic presented.

The episode was transcribed and comments on the actions, gestures and diagrams were added. One of the authors of the article followed directly the Physics lessons recording the data not only on video but also in a field notebook, which registered some aspects that could not be recorded by the cameras. The other two authors made a further analysis of the records highlighting several issues not addressed before. The results were presented

afterwards to the teacher, when the authors shared their data and interpretations with the teacher. This verification and the participation of several researchers in the data analysis support the interpretations given to the events analyzed here.

In the previous lessons of the teaching sequence, the teacher discussed some ideas that were used by students in the episode which will be discussed here. These ideas, present in the teacher's discourse, were implicitly supposed to be shared with the class. Some of them were: type of light and vision, types of light rays and rectilinear propagation of light, laws of reflection, image formed by plane mirrors, distinguishing between real and virtual images, characterization of spherical mirrors, image formed by concave mirrors through auxiliary rays. In the lesson observed, the teacher develops the various cases of image formation by concave mirrors, changing the distance of the object in relation to the mirror and identifying the characteristics and position of the image formed in each case. This presentation was done alternately with the support of experimental resources and semiotic records, such as those shown in Figure 1.

In these presentations, the teacher emphasized the real focus as a place of convergence of a beam of parallel rays and the fact that this mirror shows real images when the object is beyond the focal length of the mirror. The experimental device was fitted to each diagram to show its correspondence. When dealing with such cases, the teacher discussed the practical applications associated with them: telescope, car headlights, solar oven and toys with "holographic" images.



**Figure 1: A) The setup for the experiment was displayed on a table in the room and projected for students to see on one large screen. B) An image from one of the slides used, which was representative of the theoretical elements of the study of image formation by spherical mirrors.**

After studying the last case of real image formation in concave mirrors, the teacher formulates the question that initiates the episode under discussion. The analysis is divided into two parts: the first relates to the theme *What should happen if ...?*, in which the teacher presents the problem to the class as a challenge and, the second part, *Re-examining the problem with the mediation of the model*, where the interactions between model-phenomenon are applied to solve the problem.

## Results

### Part 1: What should happen if ...?

In this first part of the episode, lasting 1min45s, the teacher challenges the students. At this point the students had already seen the cases of image formation and the experimental setup, which was displayed on the table, with a concave mirror, an object (letter "F") and a screen. A video camera shows the students the entire setup on a screen board.

<i>Transcript</i>	<i>Contextualized comments</i>
1. Teacher.: I have a difficult question for you. Only because now I can do this here in practice I'm going to do to it for you. What happens if you come here and cover half of this mirror?	The teacher moves towards the image projected on the screen and simulates to cover its upper half.
2. Many students: It's going to cover part of it. The half bottom part of it is going to appear	
3. Teacher: Have you understood? The mirror is like this here. If I come here and cover half of it, how will it be? Is it going to have an image?	The teacher (in the center of the room) removes the mirror from the set up and covers its half, showing it to the students.
4. Students: Yes	
5. Teacher : Yes	
6. Many students answer together: Half! No!	
7. Teacher: Which half is going to be? The top part, the bottom part, or that part here, which one is going to be?	While the teacher talks he cover the image of the letter "F" drawn on the board. He covers the top half, the top bottom, the half right or the half left .....
8. Students: (many answers at the same time): It depends on the part you are going to cover.	
9. Teacher: The question is ? Why the half bottom is going to show?	The teacher asks the question while he moves towards left, pointing at a student.
10. Students: (again, many answers at the same time): A3: Because you covered half of the mirror.	
11. Teacher: look here. Let's try to go a little further	The teacher uses the projector remote control to replace the image of the experimental setup projected on the board by the diagram of image formation by concave mirrors previously studied.
12. Student 2: I have an idea first.	
13. Teacher: Just a minute! Do you want to speak? So tell me..	The teacher points towards the left of the room, allowing the student to participate.
14. Student: I think it's not going to change. I think the image is going to be the same, just a little smaller.	
15. Teacher: Smaller! If we had to draw, construct here, look here, construct the image, how we would do? Teacher! A bunch of rays come out from here, don't they? There are rays coming out in this direction and this other! Which ones should I use to construct the image? The easily noticeable rays, of easy construction. Which one are they? Let's go: one incidence stops – axial . It returned. And the other ray?	The teacher projects on the central screen the simulation of image construction by concave mirror. He draws on the board, over the projected image, many rays going out from the top part of the object which is facing the mirror.

It is interesting to note that the problem is presented as a challenge, a "very difficult question" (turn 1) which, for students who are finishing high school and about to take university entrance examinations, is more motivating. Students' participation is intense, but disorganized. Many of them speak at the same time; the answers are short and without justification. When the teacher asks for justifications (turn 9), the answers are vague, such as "because you covered half of the mirror" (turn 10). This answer seems to link the image formed, as a whole, to the presence of the lens and ignores the light as an intermediary in the process of image formation. Thus, if half of the lens is covered, consequently, we will have half the image.

Despite the difficulty in identifying the individual students who take turns in speaking, it is possible to verify their involvement in answering the questions, even if this occurs on a somewhat disorganized way. The

communicative approach in this segment of the episode is interactive, because many students are engaged in finding a solution to the problem. This approach is also dialogic, as the teacher takes into consideration not only the students' point of view, but also the perspective of science education. The answers show different solutions – it will cut half of the image, the image will be smaller, there will be no image, the top part of the image will appear, the lower one - but at that point, the teacher neither selects nor excludes any of the options.

It seems that, in turn 11 the teacher believes that such events exhausted the students' possibilities to deal with the situation and he decides, then, to project on the screen the diagrams for image construction which the class had been working with. Throughout the episode, the students base themselves on empirical references - the lens is covered and a direct association of the lens to the image formed. The justifications given, when available, do not present yet reference to physical models, and they are supported only by the students' "intuition".

Between the first and second part of the episode, there are some speech turns (from 16 to 28) that will not be transcribed here. In those, the teacher uses the slide projections to remind students of the properties of auxiliary rays in image construction by concave mirrors. Initially, the image contains only the representation of a mirror and a candle, and the teacher mentions that it sends light in all directions. He then starts to project incident rays and, before he projects the reflected rays, he asks for the students' prediction. The participation of students is limited to short answers to choices questions and product questions (Mehan, 1979, Mortimer et al, 2007) made by the teacher: where does the ray goes after it is reflected in the mirror? The image formed is bigger, smaller or the same?

## 2nd Part: Re-examining the problem with the mediation of the model

In the second part of the episode, the teacher tries, with the help of semiotic resources to lead the students to the solution of the problem taking turns between the work with the diagrams and the experimental setup. Below is the transcript of the turns 29 to 65.

<i>Transcript</i>	<i>Contextualized comments</i>
29. Teacher: Now look here. This is a model that is going to help explain the shape of the image. So the question is: if I get here to this mirror, and if I take half of this mirror. I'm going to cover it; I'm going to put an opaque object here. Ok then. Your idea then is that the image was going to be smaller.	The teacher points to the diagram on the screen where the case of the image formation is drawn.  The teacher scratches the top part of the mirror ("put an opaque object") as if he wanted to erase it.
30. Student 1: The image won't show!	
31. Student 2: The focus will change.	
32. Teacher: What's going to happen to the image? Is it still going to be there? Only half of it?	
33. Students: (several responses at the same time):	
34. Teacher: Guys, I want you to justify it for me.	Insists on the need for justifications, expecting the students to use the model to do so.
35. Students: (again, several responses at the same time).	
36. Teacher: There's going to be a smudge! Why a smudge?	
37. Student from the back (along with some others): Because the ..... is going to disappear ... (several students at the same time).	The student starts making gestures showing the trajectory of the ray which is going to disappear, but is not able to express her idea.
38. Teacher: Did you hear what she said here? Isabela and .... Julia said. Sorry Julia, I forgot your name. I'm sorry. They said that there will be a ray, there will be a ray going through the center, ok. What then? Will there be a ray, then?	The teacher goes to the diagram and draws an extra ray going through the center of the mirror. He moves towards the students pointing to one who makes a comment.

39. Students: Yes.	Several students talking at the same time and a few groups talk among themselves in an attempt to solve the problem. None of them, though, share their opinion with the larger group.
40. Teacher: Yes? How about the changes?	The teacher moves his arms drawing circles in the air.
41. Henrique: None, no changes (along with several students at the same time).	
42. Teacher: What is it again, Galvão?	
43. Galvão: It gets other rays!	
44. Teacher: Ah! Ok then. That's interesting. Look. Julia and Isabela, what's going to be different in the image then?	Apparently, the students don't pay too much attention to the suggestion, made by Galvão, which is quite appropriate, because he was still paying attention to Isabela and Julia who were still talking to each other.
45. Henrique: (Along with other students): Nothing.	
46. Teacher: Nothing.	
47. Students: Nothing. It's going to be normal.	Students talk, among each other, about the solution given and apparently they agree with it.
48. Teacher: So, the conclusion we've reached is that it makes no difference whether the mirror is big or small. The image formed is the same.	The teacher presents a possible refutation to the solution proposed (structure of the argument being built collectively).
49. Students: (Several at the same time, babbling disconnected words).	
50. Teacher: Well guys! (2s) (he draws students' attention) ... that's a tough question, isn't it, (2s). Izabela and Julia gave a hint about ... (inaudible) there are other rays. There are other rays there.	The teacher goes to the board, erases the ray he had drawn leaving the object reflecting in the mirror and forming the image. After that, he taps the board to draw the group's attention.
51. If there are fewer rays reaching the mirror, what do you expect to happen with this image? What's this image? This image is ... so bright?	The teacher opens his arms doing a circular movement in the air.
52. Students: No.	
53. Henrique: No, it's less clear.	
54. Teacher: No, not clear! Not clearness! ... the question is ... not brightness, look here guys, 3, 2, 1, go. I'm going to put it. I'm going to cover here.	The teacher removes the images diagram, goes back to the experimental setup and covers half of the mirror.
55. Student: Cool!	
56. Teacher: I'm going to put it right in front here. I'm going to cover right in front of it. What's happening? Is there an image?	
57. Students: (altogether): Yes.	
58. Teacher: Look at this image and at this one. Student: ... the intensity ...	The teacher covers half of the mirror causing a reduction in the amount of rays forming the image.
59. Teacher: The intensity of the image.	
60. Students: Do it again! (another student) No way!	
61. Teacher: Look how clear .... (inaudible) ... the image is. Now look what is happening here. Look there ... Look at the difference, is there an image? There's an image	

The teacher starts turn 29 reminding that the diagram is a model, which characterizes, according to what has been emphasized during other classes, a representation of the real which helps forecast and explain phenomena. The first aspect to be highlighted is the fact that, after reviewing the model of formation of images, the teacher proposes the same problem again as he had already done in the first part of the episode. This procedure implicitly contains a suggestion that the model will help to answer the challenge in another way, in a more satisfactory one. Apparently, the students get the message since they start using the model as a tool to analyze the problem presented.

The communicative approach used in the beginning of this segment (turns 29 to 50) presents itself as interactive and dialogic, as many students help finding the answer to the questions presented and the teacher does not ignore any points of view. Nonetheless, such dialogic approach differs from the one observed in the first part of the episode (between turns 1 and 11) as it aims not only at evoking and exploring students' prior knowledge but also at giving students the opportunity to find a solution to the problem using a scientific model. Therefore, the dialogical approach is presented here in another level when the students resort to scientific knowledge among others, to solve a problem they do not have an obvious solution to (Scott, Mortimer and Aguiar, 2006). The solution presented does not belong to any of them as it is found collectively with the support of the teacher.

When the students Julia and Isabela said that the other rays would contribute to the formation of the images (turn 38) they conclude that the resulting image would not be affected by covering one half of the mirror. What Galvão said echoes the teacher's proposition when returning to the diagrams (extract not transcribed) in which he sustains, in the beginning, that the object emits light in all directions, but only a few rays will be considered, the ones regarded as principal. Several students, apparently, have the same line of thought. They affirm, along with Julia and Isabela, that there will be no changes in the image.

At that moment, the teacher interferes suggesting a contradiction in the conclusion (turn 48): if no changes are noticed in the characteristics of the image (turn 41), it means that nothing changes when we use either a small or a large mirror. What the teacher has just said evokes previous propositions, in the same class, in which he stressed the effort to build reflective telescopes with bigger and bigger mirrors to collect as much light as possible.

At this point, maybe due to the lack of time to continue the discussion or because the students were already able to understand the scientific solution to the problem, the teacher leaves the dialogic discourse and gives the solution to the problem. Turn 51 is, therefore, a transition between the dialogic discourse, which characterized the episode, and the authoritative discourse, which is adopted from then on. In fact, in turn 54, we see the teacher describing the necessity to keep to scientific terms when analyzing Henrique's suggestion.

The teacher keeps the atmosphere of suspense and only covers the mirror and corroborates the result after the solution is produced in its entirety. The result is received with enthusiasm by the class and some students demonstrate it verbally: "cool", "no way!", "do it again!".

## **Conclusions and Implications**

We can summarize the following work strategies of the teacher in the episode reported: 1. The teacher proposes a problem to the class in the form of a challenge to be faced (this is a very difficult problem), seeking predictions about the chosen situation and collecting students' ideas; 2. Once the students have given their answers, and considering their deficiency, the teacher leaves the empirical elements (mirror, images projected on screen) and starts working with the model (light rays, the mirror focus, diagrams of the formation of the image); 3. From these theoretical elements and with the students' participation, the teacher develops a new interpretation of the situation with forecasts different from those the students had so far; 4. Only then he indicates the result with the experimental setup and highlights to the students that it would be almost impossible to present the solution to this problem in a satisfactory manner without the aid of the experimental setup.



It is important to highlight teacher's discernment to stop using the experiment when the possibilities of advancement in the responses of students are exhausted, which were until then strictly related to the empirical elements (mirror and image) of the setup, not to mention the participation of luminous rays in the formation of the image. At that point (between the two segments of the episode) the teacher does a quick review of the model, for about 2 minutes, of formation of images. Again, he highlights the nature of the challenge and manages to maintain students' interest up to the final answer to the problem and the confirmation of the result.

We have identified changes in the quality of the solutions to the problem presented by students as the teacher provides the diagram of formation of images on the screen. Before that, students' responses were based solely on their intuitions, reinforced by empirical and external aspects to the problem (it will be cut in half ... because you will cover one half of the mirror). As the teacher shows the diagram of formation of images, students' findings are supported by the theoretical elements of the model (it will be the same ... there are other rays), which is again questioned by the teacher, this time using the elements of the empirical world (The same? Does it make no difference to use a small or a large mirror?).

In the episode analyzed, we found evidence that the diagrams of formation of images are used by many students not only as the algorithm of the solution of school problems, but as a tool for reasoning, a model of a physical situation to be broken down, simplified, adjusted to be conceptually operated. We believe that this fact results from the teacher's continuous work to associate representations with phenomena and experimental situations.

The main result of this research is, therefore, to highlight advantages in coordinating these two mediating resources – the experimental and semiotic one- and sustain that such coordination is achieved through the discourse that the teacher weaves with the participation of students in the classroom.

## References

- Bakhtin, M.M. (1986). *Speech Genres & Other Late Essays*. (Caryl Emerson & Michael Holquist, eds.; Vern W. McGee, transl.). Austin: University of Texas Press.
- Buty, C., & Mortimer, E. F. (2008). Dialogic/authoritative discourse and modelling in a high school teaching sequence on Optics. *International Journal of Science Education*, 30 (12), 1635 – 1660.
- Candela, A. (1995). Transformaciones del conocimiento científico en el aula. In: E. Rockwell. "La escuela cotidiana" (p. 173-197). México: Fondo de Cultura Económica.
- Kelly J. G. (2007) Discourse in science classrooms. In: Sandra K. Abell e Norman G.Lederman (Eds.). "Handbook of Research on Science Education." (p. 443-469). New Jersey: Lawrence Erlbaum.
- Lotman, Yu. M. (1988). Text within a text. *Soviet Psychology*, 26(3), 32 – 51.
- Lunetta, V.N. Hofstein, A. and Clough, M.P. (2007). Learning and teaching in the school science laboratory: An analysis of research, theory and practice. In: S. K. Abell and N. G. Lederman, N. (Eds.). "Handbook of Research in Science Teaching" (p. 393-442). New Jersey: Lawrence Erlbaum.
- Mortimer, E.F. and Scott, P.H. (2003) *Meaning making in secondary science classrooms*. Buckingham: Open University Press.
- Mortimer, E. F., Massicame, T., Tiberghien, A., Buty, C. (2007) Uma metodologia para caracterizar os gêneros de discurso como tipos de estratégias enunciativas nas aulas de ciências. In: R. Nardi. (Ed.). "A pesquisa em ensino de ciências no Brasil: alguns recortes" (p. 53-94). São Paulo: Escrituras.
- Niedderer, H., von Aufschneiter, S., Tiberghien, A., Buty, C., Haller, K., Hucke, L., et al. (2003). Talking physics in labwork contexts: A category based analysis of videotapes. In D. Psillos, H. Niedderer (Eds.). "Teaching and Learning In the Science Laboratory" (p. 31-40). Dordrecht, Boston, London: Kluwer Academic Publishers.
- Peraya, D. (1995). Vers une théorie des paratextes : Images mentales et imagesmatérielles. *Recherches en Communication*, 4, 1-38.

- Scott, P. H., Mortimer, E. F., & Aguiar, O. G. (2006). The tension between authoritative and dialogic discourse: A fundamental characteristic of meaning making interactions in high school science lessons. *Science Education*, 90(7), 605-631.
- Voloshinov, V.N. (1973) *Marxism and the Philosophy of Language*. Cambridge, M.A.: Harvard University Press.
- Vygotsky, L. S. (1985) *Thought and Language*. Cambridge, MA: The M.I.T. Press.
- Vygotsky, L.S. (1978). *Mind in Society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

# TEACHERS' DISCURSIVE PRACTICES IN A FIRST ORGANIC CHEMISTRY COURSE

María Gabriela Lorenzo

Centre for Research and Support of Scientific Education. Pharmacy and Biochemistry School, Buenos Aires University. National Council of Scientific and Technological Research

Andrea Soledad Farré

Centre for Research and Support of Scientific Education. Pharmacy and Biochemical College, University of Buenos Aires

Alejandra María Rossi

Centre for Research and Support of Scientific Education. Pharmacy and Biochemical College, University of Buenos Aires

## Abstract

*Discourse analysis of university chemistry teachers have not yet been described in the literature. Therefore, in order to know and to understand what happens when teachers and students try to build common knowledge in class, teachers' discursive practices in a first course, were analysed in this work. The focus is on dialogues' patterns used to introduce new information, and chemical language including representational systems. Our condensed theoretical model for studying communication in class is simultaneously presented. Guided and inductive modes were used to approach to discourse analysis. Ten organic chemistry teachers participated in this study. A pattern representing the structure of discourse in organic chemistry classes was developed. The results showed that this methodology is useful for both researchers and reflective practitioners. The outcomes showed that traditional teaching practices do persist. Lectures expository discourse is still the main way to explain organic chemistry in university. Hence, new ways for university teachers training are mandatory to improve old practices.*

## Introduction: The Problem of organic chemistry teaching and learning

Organic chemistry represents the cornerstone for many other disciplines (Liu and Asato, 1997) e.g. molecular biology, medicinal chemistry or pharmacology, among others. Unlike other areas, organic chemistry usually favours a qualitative approach for teaching, based on the presentation of diverse concepts (chemical structure, reactivity, equations) in a symbolic format. Students must learn specific technical vocabulary (nomenclatures, functional groups) and a certain grammar to represent reactions and mechanisms in order to be able to make sense of the organic chemistry explanations (Hassan *et al.*, 2004). This represents an obstacle for a great majority of students everywhere (Katz, 1996). Previous investigations have found that some difficulties related to chemistry learning are associated to its language (Blanco *et al.*, 2006, Pozo and Lorenzo, 2008, Salerno *et al.*, 2009).

Effective communication in class depends on a variety of circumstances, even at university level. Albeit its importance, there is not any research in the literature that analyses the discourse of organic chemistry university teachers. The poor information available arises from personal experience and from informal conversation with our colleagues. In order to improve teaching practices and the pedagogical training of university teachers, we cannot limit ourselves to the anecdotal and common sense evidences. Therefore, the aim of this research was to analyze organic chemistry teachers' discourse when new information is presented to students in order to identify the communicative strategies. In addition, to grasp what the effective interaction between teacher and students is like,

we will try to answer to questions such as: What happens in chemistry classes? What does the teacher say? Why does the teacher say it? And finally, how does the teacher explain chemistry in university classes? In a future study we will focus on how the students learn organic chemistry.

In particular, this work is part of a larger program which seeks to know and understand what happens when teachers and students try to build common knowledge (Edwards and Mercer, 1987). We present here the general theoretical framework with which we approached the study of science teachers' discourse. The outcomes have a double value: a) An intrinsic value. They give us a description of several particular features of organic chemistry university teachers' discourse that have not been investigated until now. b) A methodological value because through them new questions come to light. So, they pointed out new ways for additional investigation and deepen our knowledge of class' communication.

In the following sections we present our methodological approach and the main outcomes. Finally, we offer our conclusions and implication for further investigation and teaching.

## Rationale

### Chemical language: A key point in chemistry classes

Teachers and students interact with each other and with the subject matter using natural language, but also using chemical language. The gap between the young students' everyday language and the chemical language is wide, so students require specific skills to bridge both sides of language successfully. But, what is chemical language? It is a special creation of chemists to explain Nature with chemical eyes. From the beginning, the chemists have had to develop complex symbolic systems in order to understand the observed phenomena. So, nowadays, we can differentiate three levels of representation according to Johnstone's triangle (Johnstone, 1982, 1993, 2000): the macroscopic level, the submicroscopic level and the symbolic level (Gilbert, 2005, Lorenzo, 2008).

The macroscopic level is related to observational experience in the laboratory and everyday life. The submicroscopic level constitutes a world of chemical particles, a universe of analogical models. The symbolic level is the representation of the identities of chemical entities. This last level not only allows us the representation of existent chemical knowledge, but also the creation of new one. The symbolic level is the one that enables us to understand submicro chemical theories and observable facts in macrochemistry (Treagust *et al.*, 2003). Thus, it allows the connection with the other two levels. As a result, symbolic level plays a crucial role in chemical language. This language of Chemistry becomes an instrument, to think, to create and to communicate concepts, methods and goals, and it goes beyond everyday language (Schummer, 1998). Additionally, four levels can be recognized in chemical language (Jacob, 2001). Each level increases in abstraction with its own linguistic and epistemological characteristics. The first level (L1, *symbolic*) corresponds to the chemical symbols used to formulate substances and the formal (syntactic) and semantic rules that regulate their use. It includes chemical symbols, chemical formulas and chemical equations. The second level (L2, *relational*) contains the appropriate vocabulary to speak about substances in general. It is a sort of metalanguage that includes new terms like abstractors (a major abstraction level generalization), and it acts as a precondition for the formation of general theories. The third level (L3, *modelic*) includes terms to use and to discuss the abstractors, as part of laws, models and theories in a general context. Finally, the last level (L4, *epistemic*) represents the language for chemistry and, more broadly, scientific epistemological discussions as a whole.

Chemical language is always present in chemistry classes and it is an important part of the teacher explanations. The main purpose of an explanation is to be understood; so, central attention must be given to the identification of those classroom discourse features that assist or frustrate the learning experience of the listeners.

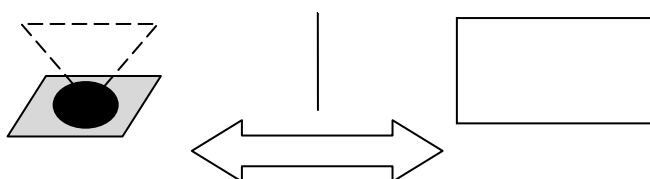
## Discourse Analysis

Oral discourse analysis in scholarly contexts has been thoroughly researched (Candela, 2001; Lemke, 1990, among others); and, it has been described as a language-in-action assembled by dynamic, intentional and coherently sequenced statements. Investigation is still poor at university level although its significance, and particularly in chemistry classes. In university classes, discourse is managed by the lecturer, with a latent dialogic component (Tarabay and Leon, 2004). Teacher's speech includes descriptions and conceptualizations which place the teacher in a higher status than that of the students, showing a radically asymmetric communicative act. The teacher is who decides who talks and who does not, and controls turn taking (Cazden, 2001). Additionally, he/she follows a set of rules that was summarized by Sánchez Miguel as a "compromise between the material already seen in class and that which is new". (Sánchez Miguel et al., 1994, p. 1). This author specifically focuses on the way the teacher manages with students' prior knowledge (already seen) and the way of presentation of new information. Therefore educational discourse can be conceived as an interactive process between previous explanations and new information introduced in class. Thus, what is already seen is assumed as shared knowledge with the interlocutor and therefore does not need to be made explicit again. Additionally what is new, becomes the informative and relevant part of the discourse, and should be presented in a coherent, organized and sequenced way, linked to information already seen in class (Sánchez et al., op. cit).

In the classic discourse analysis approach, three different levels of discourse organization can be recognized (van Dijk and Kintsch, 1983) (we must not confuse these levels with Johnstone's). Briefly, *microstructure* can be described as the level in which one idea is related to contiguous ideas, *macrostructure* refers to the global coherence of exposed information and *superstructure* shows the global pattern of discourse organization as a whole. Hence, a careful reading of the complete transcriptions of discourse in class allows detecting some of the teachers' ideas beneath their words, sentences and statements.

## Our theoretical model

The heart of this investigation is to analyse teachers' discourse having in mind all the aspects of the nature of chemistry. In Figure 1 we present our condensed theoretical model for this study. The model links the two separated realms described above: the realm of chemical language and the realm of the discourse analysis, in a new way that allows us the study of chemistry teaching. It visualizes the compromise as teachers' set of skills to organize and spread out his/her discourse to explain chemistry.



**Figure 1. Condensed theoretical model: m, submicroscopic level; M, macroscopic level, S and sy, symbolic level (Johnstone's and Jacob's respectively); re, relational; mo, modelic; ep, epistemic.**

## Methods

Teachers' discursive practices in an organic chemistry course were investigated focusing on dialogue patterns and sublanguages used to introduce what is new as well as verbal assessment interaction. Grounded theory methodology (Glaser and Holton, 2004), multiple-case study design and sociolinguistic tools were applied within a social constructivist framework to analyze the discourse, especially as related to univocal (transmitting meaning) and dialogic (dialogue to generate new meaning) functions. The teachers' explanations in class were regarded as texts susceptible of analysis. Class registries were studied according to the importance given to a subject matter in the discourse structure. Thus, full didactic sequences were considered in the specific context in which they occurred, and then some excerpts were selected for a deeper analysis.

The analyzed lectures were mandatory lessons for freshmen of a first course of organic chemistry at the Buenos Aires University, School of Pharmacy and Biochemistry ([www.ffyb.uba.ar](http://www.ffyb.uba.ar)). Around 900 students attend the course every year. They are often divided in twelve sections. It is a weekly four-hour module. There is one teacher in charge of around eighty students. All the students have the same work-book, follow the same syllabus and do the same final exam. It is important to point out that during the last ten years, this course did not include practical laboratory sessions. Actually, these classes were entitled “problem solving classes”, because their main purpose was to solve exercises of a workbook. So, more than in other chemistry courses it was only based in symbolic presentation of the contents. This implies that knowledge must be constructed from the subject matter extensive system of symbols and representations without direct experience at macroscopic level.

### Sample and participants

Sample consists of ten discourse registers’ transcripts corresponding to whole sessions of two topics included in the course: Alkenes and/or Aromatic Compounds. All the teachers that participate in the study were volunteers. Table 1 shows their profiles. T1 and T6 were selected for a deeper analysis (case study). Both of them have a PhD and work as researchers at university, but differ in their pedagogical training.

**Table 1. Characteristics of the teachers who participated in the study**

Teacher N°	Teacher experience (years)	PhD	Teacher training	Gender	Age
1	23	yes	yes	F	45
2	22	yes	yes	F	43
3	26	yes	yes	F	48
4	33	No	yes	F	52
5	26	No	yes	F	46
6	10	yes	no	M	32
7	10	yes	yes	F	29
8	12	No	in progress	F	35
9	8	No	no	F	28
10	1	No	no	M	27

### Procedures

We conducted non participant observations, and recorded lectures. Then, we transcribed the recorded classes into an electronic format and augmented them with the information obtained from our observations. We used two modes for approaching to discourse analysis: 1) *Guided mode*. We applied an observational questionnaire specially designed for the research (Fig. 2) in order to focus the attention in those relevant features that arise from our theoretical model. It was checked and reviewed in an iterative way until the final version was ready. 2) *Inductive mode*. We got relevant information in a direct way from transcriptions reading. We approached using grounded theory methodology focusing on the teacher’s participation in the class.

The transcriptions were analyzed by three researchers, two of them are specialized in organic chemistry (R1 and R2), and the third is specialized in science teacher training (R3). Initially, each researcher analyzed transcriptions individually. R1 and R2 used mode 1, while R3 used Mode 2. In a next step, we compared collected information from modes 1 and 2. Changes on the questionnaire were made in order to achieve a deeper analysis of the discourses. All of researchers collaborated in this step for the data description and interpretation of the results. Decisions were taken by consensus and there were no significant differences when the results obtained by each investigator were compared.

<p>In this discourse:</p> <ul style="list-style-type: none"> <li>– What is the predominant level according with Johnstone’s?</li> <li>– Does the teacher make any reference to the three levels? How?</li> </ul> <p>Specifically for the symbolic system:</p> <ul style="list-style-type: none"> <li>– Does the teacher employ different kind of graphic information? Which one?</li> <li>– Does the teacher explain carefully what each new representation means?</li> <li>– What level according with Jacob’s is reached in the class?</li> </ul> <p>Structure and chemical language</p> <ul style="list-style-type: none"> <li>– What is the structure of the discourse?</li> <li>– Does the teacher explain new technical vocabulary?</li> <li>– Does the teacher use varied resources to communicate with his/her students? Which one?</li> </ul> <p>Previous information indicators</p> <ul style="list-style-type: none"> <li>– Evocation of prior knowledge (... as we saw...).</li> <li>– Questions to explore concepts already known by students.</li> </ul> <p>New information indicators</p> <ul style="list-style-type: none"> <li>– Thematical pattern. Sequencing and hierarchical organization of contents and learning objects and the relations and connections among ideas.</li> <li>– Activities in class: interaction among teacher and students, tasks presentation.</li> <li>– Supports: teachers’ comments that enrich ideas without adding new information: Examples, analogies, repetitions or paraphrases, explanations of the procedures or strategies.</li> <li>– Rhetorical connections: words used to articulate discourse (subject-matter identification, return to the index, regular summaries).</li> </ul> <p>Teacher’s evaluation modes</p> <ul style="list-style-type: none"> <li>– Pseudoevaluation (rhetorical questions like: “Do you understand?”).</li> <li>– Assessment: Specific questions to detect students’ knowledge.</li> </ul>
--

**Figure 2. Questionnaire for guided mode of analysis**

Finally, in the last stage of the research, two classes of two different teachers with and without pedagogical training (T1 and T6) were selected for a deeper study. Most representative episodes from both classes were selected to show the main features of each discourse.

## Results

About the nature of organic chemistry, in general, all the teachers kept their explanations in the symbolic vertex of Johnstone’s triangle with some links to submicroscopic one. References to laboratory practices, to everyday life or to the profession were poorly commented by them. They explained the vocabulary and the representational systems, and used the multiple languages of chemistry. The analysed discourses displayed high “density” of the specific technical vocabulary, some of these terms have already been seen but others were introduced in the lesson as a new content. Generally, the new terms were defined with other technical words. Only younger teachers (< 35 years old) tried to use colloquial language to communicate with their students. All lectures included references to the symbolic level and the relational level of Jacob’s model. Only the teachers with large experience (> 20 years) reached sometimes the modelic or epistemic levels (T1 to T5), for example T1: “*you will never be able to isolate a transition state. It is a proposal depending on the actual results of a reaction, in the frame of reaction mechanism theory*”.

About the structure of organic chemistry classes’ discourse we observed:

**a) Superstructure.** The discourse in class was long expository monologues to carry out the lesson. Several narrative segments were also found, mainly when teachers wanted to illustrate very abstract ideas. For instance, the explanation about reaction mechanism (about how the reactants become into products) seemed to be a classic fairy-tale: beginning, middle, and ending. They managed the lesson timing and interaction to keep their students’ attention and motivate them (*Easy. Now we go. We are seeing what happens in each little step of the reaction.*). Some of the teachers gave

chemical compounds and their reactivity anthropomorphic features like intentionality or wishes (*If I have an aromatic ring which is very stable, it won't want to lose its aromaticity and its stability, right? It'll want to keep it...*).

**b) Macrostructure.** The organization, contents' hierarchical structuring and sequencing showed distinct features for each teacher. Although students' learning was not our aim in this research, we could observe more students' spontaneous participation when teachers' discourse was less structured, as the comparison between T1 and T6 in the next section exemplified. Our outcomes showed a great correlation between this aspect of the discourse and its legibility and therefore, a different pattern of the students' behaviour as we resume in table 2.

**Table 2. Relationship between discourse's macrostructure and students' behaviour**

<i>Macrostructure</i>	<i>Legibility</i>	<i>Students' behaviour</i>
Continuous (rolled)	High	They "follow" their teacher's explanation answering questions
Disrupted	Low	They have an active participation asking questions

**c) Microstructure.** Teachers usually structured the class using markers to change topics and recapitulated the information before introducing a new point, then looked for links between the new and the old information, comparing them, and finally they recapitulated the information presented. A group of teachers (T1, T2, T3, T4, T5 and T7) presented the new topics through their expositions by using linear causality and comparisons with "*those already seen*". In contrast, the new content presentation was confusing at times for the other group (T6, T8, T9 and T10), maybe due to the high level of students' active participation.

All the teachers in the study encouraged their students to participate, but in different ways. Some teachers seem to visualize their students like empty flask that need to be filled in. On the contrary, others give actual opportunities to participate to their students.

Generally, questions to assess students' knowledge showed a low cognitive level, pointing out particular concepts like: *What is this reaction type? Or, which is Carbon hybridization here?* But, in lower proportion, higher cognitive demands questions were requested (T1, T2, T7 and T9) using those as a strategic tool for their students' learning.

Most of the teachers checked their students' previous knowledge before going ahead with their explanations. The feedback to the students' wrong answers varied from teacher to teacher. Some of them corrected their students; others corrected and re-asked, while others asked metacognitive questions.

#### Case analyses: Teacher 1

This teacher exposed contents encouraging students' participation. She used genuine questions and "waited" for her students' answers before going on. Her strategy seems to be organized at the microstructure level in five steps that are repeated throughout her explanation (Fig. 3):

1. Question (genuine assessment), followed by waiting time to obtain an answer from her students.
2. She repeats the students' answers aloud. This "feedback" strategy may allow her to assure that the information has become part of *what has already been seen*. To this respect, it should not be forgotten that since the group of students is large (around 80), only some of them answered the question and not all of them may heard these answers.
3. She repeats the answer and completes or paraphrases it (supports)
4. She closes the explanation by including some evaluation guideline with positive motivational connotations. This strategy is interesting because it shows that even at university level, the teachers' encouragement favours active participation and grants continuity to explanations.
- 1'. A new question is formulated to the group and it restarts the cycle.

**Figure 3. Five steps used by T1**

Vocabulary is very rich throughout her discourse; so, it is a challenge for most of the students. T1 used several strategies to introduce the meanings of new chemical terms. When she taught them for the first time, she did



not only focus on their meaning but also in their representational form and gave references to the macroscopic level. In addition, she used thinking verbs, and tried to show the hypothetical nature of the explanations. T1 modelled problem solving by reading the statement, interpreting the exercise, analyzing the data and proposing hypotheses.

**Table 3. Teacher 1's organizational pattern (T: teacher; Ss: Students)**

	Example 1	Example 2
Step 1	T: ...while this carbon is $sp^3$ , this carbon (she points at the formula written on the blackboard) -what hybridization does it have? Pay attention... Ss: [inaudible answer] T: $sp$ ...? Ss: Two!	(She is explaining the reaction between ethene and gaseous hydrogen bromide) T: ...The reaction, what kind of reaction was it? Addition, elimination, substitution? Which was it? Ss: Addition.
Step 2	T: Two. Very good.	T: An addition.
Step 3	T: This carbon is $sp^2$ . Therefore, while this one is trigonal (she points at the formula written on the blackboard), this is flat.	T: A plus B gives me C, so the reaction is an addition.
Step 4	T: It means that this bond, this one and this bond, are all in the plane (she pointed at the formula written on the blackboard) and perpendicular to that plane. This orbital $p$ is empty. All right? Very well.	T: Right.
Step 1'	T: What else have I obtained here? Besides this carbocation?	T: And the reagent? What is it? A nucleophile or an electrophile?

Both episodes make clear that T1 displayed an ordered discourse, hierarchically sequenced, that is unfolded (as if unrolled) as her exposition advances, creating a macrostructure which we have called **continuous**. A high density of technical vocabulary was observed when the teacher explained specific contents. Her explanations were reinforced with multiple strategies. Students were taken into account throughout the class. She always answered her students' questions and did not make her students wait. Furthermore, she seemed to manage the timing and content in her explanations according to two criteria: a) sharing the question with the other students in order to give them the opportunity to take part in the discussion; b) managing the moment of the answer, immediately answering or delaying the reply.

#### Case analyses: Teacher 6

T6 started his explanation reviewing previous knowledge (*We are going to review first what an alkene is*). Next he presented the alkene orbital description while he wrote on the blackboard interacting with his students through pseudoevaluation "yes?/no?" type questions.

In this case it is interesting to point out a great students' involvement asking questions. He pays attention to his students' questions however the exchange of information was confusing and incomplete (Fig. 4). Although students' questions were inaudible, they allow us to notice several interruptions in teacher's discourse and the way that teacher managed his students' requirements.

<p>S: [inaudible question] T: No, wait a little. Wait, wait... let's see this one. We'll see [the other one] later. Now, which one then...? All right, we're getting there... this is the reaction mechanism, right? Now, this is called elimination two. Pardon? (paying attention to a student's question) S: [inaudible question] T: Two? No, because the elimination one, too. All eliminations take two... two coming out groups, they're coming out, there are two groups coming out. S: (the question was not audible) T: eh... No, no, because it is not a base. Pardon?</p>
--

**Figure 4. An example of confusing and incomplete exchange of information**

Although his explanation was acceptable from the subject matter point of view, it was difficult for students to understand because its microstructure and macrostructure were not well organized. Therefore, he was interrupted several times in order to seek to understand his explanation. We have called this type of macrostructure “**disrupted**”. T6 basically kept his discourse at the symbolic level of language (L1) while showing an appropriate and dense use of specific technical vocabulary. He did neither apply analogies, metaphors or examples of his own creation as a motivational strategy to help his students’ understanding.

## Conclusions and Implications

Teachers maintain traditional ways to explain subject matter using expository discourse. They control the situation and decide what to say and who says that. Although teacher and students pretend solving problems most of the time the teacher is the main (only) speaker in the class. When teachers speak, they usually present subject matter, without further information that complete or illustrate the concept (e.g. research, professional, or common life). We also found that teachers keep their discourse mainly in Jacob’s symbolic level of Chemistry (L1), although sometime it reaches relational one (L2). Statements referred to modelic (L3) or epistemic (L4) were rarely detected.

These facts lead us to reflect about which are the teachers’ conceptions of the nature of Chemistry that they communicate. Having in mind they are also chemistry researchers, we expected them to hold first-hand experience about chemistry. However, they present contents as perennial and unchangeable truths. In this way, we have begun to investigate the connection between teachers’ beliefs and their discursive practices (Farré and Lorenzo, 2009a).

As regards class’ macrostructure, it can be analysed considering the *continuity* dimension. Thus those discourses that flow easily throughout the class, where *what is new* is brought into the explanation almost naturally, should be located at one end of the spectrum. At the other end would be disrupted discourses. Disparity in the macrostructure of classes leads to different patterns of students’ intervention. When teachers considered previous knowledge (*what has already been seen*) students participate in the process of understanding *what is new*. However, when students find a contradiction between the teacher’s speech and the thematic pattern they try to build, they ask questions or challenge teacher disrupting his/her discourse. Students try to contribute with legibility to the class discourse. However, further studies should be carried out to determine which of the presented macrostructures leads to greater learning since the cognitive strategies that must be displayed by the students are different in each case.

In connection to the compromise between *what has already been seen* and *what is new*, important differences in the type of resources used by the teachers were detected. This study showed that the teacher with longer teaching experience and specific pedagogical training used a greater amount and variety of resources and introduced them in a more strategic way to facilitate comprehension. *What has already seen* appears as a resource that contextualizes the explanation in the experienced teacher’s speech.

The compromise from Sánchez Miguel (op. cit.) model can be reinterpreted using Shulman theoretical model (Shulman, 1986): pedagogical content knowledge (PCK). The four steps showed in T1’s discourse analysis could be consider a good example of teacher pedagogical content knowledge. Actually, we would not be wrong, if we affirm that any teacher with a greater PCK will have a larger set of resources and strategies to establish an effective compromise between what his/her students already know and that what remains to be learned. So, we have begun to apply the discourse analysis in order to investigate PCK of organic chemistry university teachers (Farré and Lorenzo, 2009b; Lorenzo and Farré, 2009).

Up to this point, perhaps it is time to ask ourselves why expository discourse has persisted so long. Is really the only way to teach? What was the usefulness of teacher training if the practices have not changed at all? Faculty uses a high percentage of class time to present new information to their students and to model attitudes and reasoning. Therefore, investigations dealing with the strategies that teachers apply in their teaching practice are of extreme importance. Discourse analysis is an entry door to look into this new object of study.

Someone would say that our outcomes, our description about organic chemistry teachers' discourse is not unique for this particular subject matter. Although it could be true, it is also true that some people think that chemist or chemistry teachers are different of others. Therefore is good to know that organic chemistry teachers share some features in common with other teachers. So, some general training activities would be planned in this way. But, however, it is necessary yet, to deepen in their specific features in order to understand their particularities and if they are linked with students' learning difficulties.

The results clearly show that it is necessary to seek new ways for university teachers training, because until now it does not seem to be effective in improvement old practices.

**Acknowledgements.** This work was carried out as part of the following projects: UBACyT B-055 (2008-2010), PICT 2005 N° 31947 and PICT-O N° 35552 of ANPCYT-FONCYT.

## References

- Blanco, M., Caterina, C., Salerno, A., Reverdito, A. and Lorenzo, M. (2006). La explicación en clase y su impacto en los aprendizajes de estudiantes universitarios [Explanations in Class and Their Impact on University Students' Learning], *Anuario Latinoamericano de Educación Química*, 21, 289-293.
- Candela, A. (2001). Corrientes teóricas sobre discurso en el aula [Theoretical strands on discourse in the classroom]. *Revista Mexicana de Investigación Educativa*, 6 (12), 317-333.  
<http://www.comie.org.mx/v1/revista/portal.php?idm=es&sec=SC03&sub=SBB&criterio=ART00313>
- Cazden, C. (2001). *Classroom discourse: the language of teaching and learning*, Second Edition, Portsmouth, NH: Heinemann.
- Edwards, D. and Mercer, N. (1987). *Common knowledge: The development of understanding in the classroom*. London, UK: Methuen.
- Farré, A. and Lorenzo, M. (2009a). Another piece of the puzzle: The relationship between beliefs and practice in higher education organic chemistry, *Chemical Education Research and Practice*, 10, 176-184.
- Farré, A. and Lorenzo, M. (2009b). El CDC de profesores universitarios de química orgánica: el caso del benceno. [University organic chemistry teachers' PCK: the benzene case] *Enseñanza de las Ciencias*, Número Extra VIII Congreso Internacional sobre Investigación en Didáctica de las Ciencias, Barcelona, pp. 706-711.  
<http://ensciencias.uab.es/congreso09/numeroextra/art-706-711.pdf>
- Gilbert, J. (2005). Visualization: A metacognitive skill in science and science education, in: Gilbert, J., Ed., *Visualization in Science Education*, Dordrecht: Springer, pág. 9-27.
- Glaser B. and Holton J. (2004). Remodeling grounded theory, *Forum Qualitative Social Research*, 5, art 4.  
<http://www.qualitative-research.net/index.php/fqs/article/view/607/1316>
- Hassan, A., Hill, R. and Reid, N. (2004). Ideas underpinning success in an introductory course in organic chemistry, *University Chemistry Education*, 8, 40-51. [http://www.rsc.org/images/p2\\_reid\\_tcm18-31146.pdf](http://www.rsc.org/images/p2_reid_tcm18-31146.pdf)
- Jacob, C. (2001). Analysis and Synthesis. Interdependent Operations in Chemical Language and Practice, *HYLE, International Journal for Philosophy of Chemistry*, 7(1), 31-50. <http://www.hyle.org/journal/issues/7/jacob.htm>
- Johnstone, A. (1982). Macro - and Micro - Chemistry. *School Science Review*, 64, 377 - 379.
- Johnstone, A. (1993). The development of Chemistry teaching. *Journal of Chemical Education*, 70 (9), 701-705.
- Johnstone, A. (2000). Teaching of Chemistry-Logical or Psychological? *Chemistry Education: Research and Practice in Europe*, 1 (1), 9-15. [http://www.uoi.gr/cepr/2000\\_January/pdf/056johnstonef.pdf](http://www.uoi.gr/cepr/2000_January/pdf/056johnstonef.pdf)
- Katz, M. (1996). Teaching organic chemistry via Student-Directed Learning. A Technique that Promotes Independence and Responsibility in the Students. *Journal of Chemistry Education*, 73 (5), 440-445.
- Lemke, J. (1990). *Talking science: language, learning and values*, Norwood, New Jersey: Ablex Publishing Corporation.
- Liu, R. and Asato, A. (1997). Making organic Concepts Visible. *Journal of Chemical Education*, 74 (7), 783-784.
- Lorenzo, M. (2008) Destilación fraccionada de ideas condensadas. Una invitación al debate sobre la naturaleza de la química [Fractionated distillation of condensed ideas. An invitation to debate about nature of Chemistry], *Educación en la Química*, 14 (1), 17-24.

- Lorenzo, M. and Farré, A. (2009). El análisis del discurso como metodología para reconstruir el conocimiento didáctico del contenido. [Discourse analysis as a methodology to reconstruct pedagogical content knowledge] *Enseñanza de las Ciencias*, Número Extra VIII Congreso Internacional sobre Investigación en Didáctica de las Ciencias, Barcelona, pp. 342-345.  
<http://ensciencias.uab.es/congreso09/numeroextra/art-342-345.pdf>
- Pozo, J. and Lorenzo, M. (2008). Representing organic molecules: the use of chemical languages by university students. In: *Representational systems and practices as learning tools in different fields of knowledge* Eds: C. Andersen, N. Scheuer, P. Pérez Echeverría, and E. Teubal. London: Sense Publishers. (pp. 243-266).
- Salerno, A., Lorenzo, M., and Blanco M. (2009). ¿Puede aprenderse química orgánica en la universidad presenciando una clase expositiva? [Can we learn organic chemistry attending a lecture?], *Educación Química*, 20 (1), 77-82.
- Sánchez Miguel, E., Rosales, J. Cañedo, I. and Conde, P. (1994). El discurso expositivo: Una comparación entre profesores expertos y principiantes. [Expository Discourse: A Comparison between Expert Teachers and Beginners] *Infancia y Aprendizaje*, 67-68, 51-74.
- Schummer, J. (1998). The Chemical Core of Chemistry I: A Conceptual Approach. *HYLE, International Journal for the Philosophy of Chemistry*, 4 (2), 129-162. <http://www.hyle.org/journal/issues/4/schumm.htm>
- Shulman, L. (1986). Those Who Understand: Knowledge Growth in Teaching, *Educational Researcher*, 15(2), 4-14.
- Tarabay, F. and León, A. (2004). La argumentación en la clase magistral [Argumentation in Theoretical Lectures], *Revista de Teoría y Didáctica de las Ciencias Sociales*, 9, 35-47.
- Treagust, D.F., Chittleborough, G. and Mamiala, T.L. (2003). The Role of Submicroscopic and Symbolic Representations in Chemical Explanations. *International Journal of Science Education*, 25 (11), 1353-1368.
- Van Dijk, T. and Kintsch, W (1983). *Strategies of Discourse Comprehension*. New York: Academic Press.

# GUIDING STUDENT TEACHERS TOWARDS MORE DIALOGIC SCIENCE TEACHING

Sami Lehesvuori  
University of Jyväskylä, Finland

Jouni Viiri  
University of Jyväskylä, Finland

Helena Rasku-Puttonen  
University of Jyväskylä, Finland

## Abstract

*The purpose of this paper is to present how a specific teaching programme about teacher talk influenced student teachers' practice of and beliefs about teaching physics. Student teachers were familiarised with the concept of a communicative approach to teaching that categorises teacher talk into four different classes. Whilst it has been suggested that science teaching is commonly based on monotonic and transmission modes of teaching alone, the communicative approach adds a sociocultural aspect to teaching and learning therefore extending student teachers knowledge to include new or innovative approaches to teaching science. The results of this paper indicate that, although student teachers struggle with the challenge of implementing new approaches into teaching, they are still able to include them in their physics lessons even during initial teacher training.*

## Introduction

### Background

A central idea of research in the field of science learning and instruction, with particular reference to Vygotsky and the sociocultural perspective, is that communication is the central element in linking students' views to science's way of modelling the world. From a sociocultural perspective communication is understood as a tool, not only to transfer information, but rather to engage students in 'talking their way' into the world of science. Furthermore, instead of evaluating the individual ability of students and teachers, educational success may be explained first by the quality of classroom dialogue (Mercer, 2004). In line with the sociocultural approach, researchers have developed the concept of 'dialogic teaching' (e.g. Alexander, 2004; Nystrand, Gamoran, Kachur, & Prendergast, 1997), understood not only as interaction between participants in the classroom, but, especially in science, with teachers orchestrating the dialogue between everyday views and the view of science (Mortimer & Scott, 2003).

The elements of dialogic teaching such as questioning in a way that promotes higher order thinking (Chin, 2007) and the appropriate use of different communicative approaches could include also the motivational factor, which would further lead to meaningful learning activities (Scott & Ametler, 2007). The most important role in initiating and sustaining these kinds of activities belongs to the teacher who is intended to not only be the source of information, but also the orchestrator of classroom communication. Students are not expected to learn without the guidance of their teacher (Roth, 2005), but, however, they are able to adopt meaningful discursive strategies within their emerging learning processes if they are purposefully enabled to do so (Mercer, Dawes, Wegerif, & Sams, 2004).

As indicated above, it appears to be important that teachers are aware of different discursive strategies and their functions in promoting learning. In order to reform the classical and safe lecture and transmission modes of teaching we need ways of teaching teachers to be professionals in the field of classroom interaction. Arguably this is a lifelong process, but in order to initiate this development, the theory and practice within this field should be introduced during initial teacher training. Mortimer and Scott (2003) have posed the hypothesis that student teachers are able to adopt new approaches within their communicative repertoire if the topic is discussed and practised during the pre-service period. Furthermore, it has been shown that student teachers can vary their communication if they are given the tools for planning and reflecting on their lessons (Viiri & Saari, 2006; Lehesvuori & Viiri, 2009).

The teaching programme reported here was first conducted for student teachers of physics during the academic year 2007-2008 and further developed for the following academic year 2008-2009. Themes and activities of the teaching programmes were closely connected to video reflection and the lessons were analyzed by the participating physics student teachers themselves. This paper concentrates on the improved teaching programme, although reports from the earlier programme will be drawn on when appropriate (Lehesvuori, Viiri, & Scott, 2009)

### Research purposes

The aim of the study is to discuss how a student teacher implemented an alternative, dialogic approach, to teaching having participated in the teaching programme (chapter 2.1.). After presenting an excerpt of an episode from the student teacher's physics lesson, we will reflect on the results of a thematic analysis of the group interview from the 2008-2009 year group. We will focus in particular on the theme that concerns the challenges student teachers face when trying to implement a dialogic approach to science teaching. Furthermore, based on the results mentioned above, it is valuable to discuss the role of the teaching programme as an influence on student teachers' beliefs about science teaching in general.


## Research design

### Teaching programme

Over the course of an academic year (2008-2009) seven physics student teachers (Pseudonyms: George, Rosanna, Lea, Mark, Melanie and Joanna) were introduced to the teaching programme. At the beginning six student teachers volunteered to participate, but one of them with the limitation that she would not be video recorded. In contrast to the previous semester all of the participants joined the programme at the beginning due to research purposes and, thus, there was no need for a partial control group to be formed. Forming a separate comparison group would also have been challenging, because, this small group of student teachers formed a uniform group limiting in this way the isolation of the content of the teaching programme.

The general aim of the designed teaching programme was to encompass a wide range of research perspectives, but at the same time to maintain the presence of the key concept, the communicative approach, during each phase (e.g. theoretical instructions, practical activities and reflective feedback sessions). In this sense the study could be considered as design-based research (The Design-Based Research Collective, 2003). A more detailed description of the phases and activities of the teaching programme are presented elsewhere (Lehesvuori, Viiri, & Scott, 2009). In the second year, the basis of the teaching programme was overall similar to the pilot programme although a couple of significant modifications were made. One of the two major changes was that instead of the researcher video recording the lessons given by the student teachers, the videoing was done by peers (Hartford & MacRuairc, 2008). There were a number of reasons for this change: firstly, peer videoing reduced the evaluative atmosphere during the implementation phase, and secondly, student teachers gained empirical experiences as researchers of their own profession. Hartford and MacRuairc (2008) note that peer videoing can be "a catalyst for reflection and critical dialogue among student teachers" (p. 1890). During the first year the videoing and the equipment reached the

standards of international video study (Seidel, Prenzel & Kobarg 2005), while during the second year the equipment was reduced to one camera, which according to the student teachers was expedient for reflection and analysis. Another significant change, and surely an improvement, was the use of the video database of physics student teachers' collected with the 2007-2008 cohort. The selected authentic video clips were used during the familiarisation instruction phase. The student teachers commented on the clips first without any analytical tool and then again after having been familiarised with the concept of the communicative approach. As the discussions with the student teachers at the end of the first semester revealed, methodological issues should be practised properly before systematic use for reflection and analysis (Lehesvuori, Viiri, & Scott, 2009). The topic will be addressed further later in this paper. The overview of the teaching programme is presented in figure 1.

	<b>Phases and Activities of the Teaching Programme 2007-2008</b>	<b>Related activities and improvements for the semester 2008-2009</b>
Oct  May	Theory of the teaching programme <ul style="list-style-type: none"> <li>• Instruction including theoretical background and the concept of the communicative approach (2 hours)</li> </ul>	Improvement: <ul style="list-style-type: none"> <li>-Video clips from semester 2007-2008</li> </ul>
	Observations <ul style="list-style-type: none"> <li>• Two teaching sessions. One physics lesson taught by a peer and one lesson by teacher tutor in teacher training school</li> <li>• Written report by student teacher about observations</li> <li>• Group discussion between researcher and the student teachers about the observations (2 hours)</li> </ul>	Improvement: <ul style="list-style-type: none"> <li>-Improved observation forms</li> </ul>
	Planning and Implementing <ul style="list-style-type: none"> <li>• 2 physics teaching sessions including written lesson plans completed individually following the instructions of researcher</li> </ul>	Improvement: & Related activity: <ul style="list-style-type: none"> <li>-Peer videoing</li> </ul>
	Reflective feedback sessions <ul style="list-style-type: none"> <li>• Guided reflective feedback sessions with the researcher based on the stimulated recall interview technique (O'Brien, 1993) after every teaching session</li> </ul>	Related activity: <ul style="list-style-type: none"> <li>-Small scale research</li> </ul>
	Group interview (2 hours) <ul style="list-style-type: none"> <li>• Discussions between researcher and the student teachers about the teaching programme and the concept of the communicative approach</li> </ul>	<ul style="list-style-type: none"> <li>• About teacher talk using the communicative approach and the video data of student teachers' lessons (own &amp; others')</li> <li>• Supervised by the pedagogy of physics</li> <li>• Both semesters</li> </ul>

**Figure 1. Phases and activities of the teaching programme**

### The Communicative approach

During the early stages of the programme the student teachers were introduced to a tool for characterising classroom talk, the concept of the communicative approach (Mortimer & Scott 2003) (Figure 2). This framework for analysing classroom discourse consists of four categories generated from the combination of two dimensions: interactive – non-interactive and authoritative – dialogic. The authoritative approach focuses on the scientific point

of view. In contrast, the dialogic approach explores and exploits students' ideas (everyday views), and has no evaluative aspect. Interactive talk allows students to participate, whereas non-interactive talk is of a lecture type.

	<b>Interactive</b>	<b>Non-interactive</b>
<p style="text-align: center;"><b>Authoritative</b></p> <p style="text-align: center;">focus on science's view</p>	Presentation  Question & Answer routine  IRF	Presentation  Lecture
<p style="text-align: center;"><b>Dialogic</b></p> <p style="text-align: center;">different points of view are considered</p>	Probing  Elaborating  Supporting  I-R-F-R-F	Review

I = initiation

R = response

F = feedback

(Lemke, 1990)

**Figure 2. Communicative approaches with teacher interventions and the common patterns of talk**

Classroom teaching is known to be commonly based on authoritative types of communication which should not be the case all of the time in the science classroom meaning making processes (e.g. Alexander, 2004). This focus on authoritative talk is most likely explained as dialogic approaches being more challenging to identify and implement in teaching if not even commonly acknowledged by teachers. This remark will be further considered in the findings section of this paper. Dialogic discourse, in Mortimer and Scott's categorisation, is realised when the teacher is not trying to achieve a specific point of view (i.e. the science point of view). Rather the teacher tries to elicit the students' point of view (students' everyday views) and to then work with these contrasting points of views. If the teacher asks for further explanations in order to negotiate the correct answer, or the science view, the discourse is not classed as the dialogic communicative approach although it could be considered as an I-R-F-R-F-chain. The problematic methodological issue of identifying between interactive authoritative and interactive dialogic approaches is discussed in more detail in another paper (Lehesvuori, Viiri, & Scott, 2009).

## Methods

Data was collected in various forms throughout the teaching programme for different research purposes. The data includes video recorded lessons and reflective feedback sessions, literal reports and observational forms. Some of the data plays a key role in answering the research question set before the main study and some of the data is for monitoring, evaluating, and, further improving the teaching programme.



## Small scale study

The general idea of the small scale study was that the student teachers would take a role as researchers of their own profession. The participants of this study were guided to analyse their lessons using the communicative approach as an analytical tool. Otherwise the assessment was flexible and the study was intended to be relatively brief, 5-10 pages, with the student teachers analysing and reflecting on episodes that they thought were informative when it comes to the investigation of alternative communicative approaches included in their physics lessons. This paper concentrates on and discusses a particular episode Joanna had chosen as representative of an interactive/dialogic approach.

## Thematic analysis

Group interviews were videotaped, and, transcribed comments concerning student teachers professional development and indicating initiated reformation of teaching beliefs were raised and discussed. During the familiarisation phase with the video and transcription data of the group interview, the researcher identified (according to his own judgement) common themes, which led to the analysis, display and interpretation of the data applying the thematic approach (Braun & Clarke, 2006). After becoming familiarised with the data, the following phase involved the definition of themes. A more detailed description of the analysis is presented in another paper (draft), whereas this paper focuses more closely on one theme that was common to the group interview of the improved teaching programme. This theme considers the challenges the student teachers experience when implementing dialogic approaches.

Video analysis of student teachers' lessons is discussed more in other papers (Lehesvuori & Viiri, 2009; Lehesvuori, Viiri, & Scott, 2009)

## Results

### Joanna's small case study

First we are going to present an illustrative episode from one student teacher, Joanna. Joanna had also chosen this episode to be an example of an interactive/dialogic approach in her small scale study. The episode begins with Joanna introducing the 8<sup>th</sup> graders (14-15 year olds) to the topic of the day, pressure.

Teacher: Good morning... Today the topic is pressure and tomorrow we will briefly discuss buoyancy?

What do you know about pressure beforehand? This must be a familiar concept.

Mike: When the pressure can move to that certain point, when it is for example in a certain container, it explodes, the container, when the pressure is too high.

Teacher: Yes (not evaluating), and could you tell, what it depends on, the pressure being so high that the container explodes. Layla, you know about pressure...

Layla: Isn't it like that when you place in water that kind of a plastic bottle, that is filled with air, or like that, or like under the surface of the water, that it flattens, because there is that pressure?

Teacher: Yes (not evaluating). And do you know what it depends on, can you explain further?

Layla: Well it's because... I can't remember.

Teacher: That's all right. I think it will become clearer during the lesson. And then John?

John: Isn't there pressure in the sea, because the water is weighing more, or there's more water on the top, so the thing flattens.

Teacher: Yes, the water causes the increase of the pressure, the deeper you go. Where else is there pressure? Or have you noticed pressure somewhere? Do you have pressure succeeding in physics? No-one? Pressure is definitely used in contexts other than physics (Pupils are silent). Well, in car tires there's surely pressure. Is there higher or lower pressure than in the surrounding atmosphere?

Michael: Much higher?

Teacher: How do you know?

Mike: If you place a rubbery thing like that into this room... that no air goes away and you pop it. Then no specific explosion occurs. But if you pop car tire there will be a quite an enormous explosion.

Teacher: Yeah, that was quite a good explanation. You can definitely notice it there. Okay, there is pressure in car tires. Where else do we need pressure? Do you need pressure? Tony?

Tony: Well in that kind of... distinguishers, or deodorants, and that kind of stuff. Isn't there pressure?

Teacher: Yes there is. You can fill more space when you apply pressure to it. There is more styling spray than it seems in the can. That is why it's forbidden to throw the can into an open fire, because it might explode, and the pressure is released. You demonstrated quite good prior understanding of pressure and what it's needed for. Now we shall continue with an introductory task from the workbook.

The excerpt above could be, also in Joanna's opinion, considered to fulfil the criteria as an interactive/dialogic approach since the purpose of Joanna, as she also wrote, was to map the prior knowledge of the pupils. One characterising feature for instance was Joanna asking for extensions and explanations of pupil responses. Although the quality of the dialogue could be always posed under a question, observations and previous studies have shown that even short dialogic episodes are very uncommon and often unintentional when it comes to student teachers (and probably to majority of the typical science teachers of Finland! Addressed in a forth-coming study). In this respect the excerpt might be considered to offer proof about the influence of the teaching programme and increased awareness of teacher talk on Joanna's communicational behaviour.

Although we presented a student teacher successfully adopting a dialogic approach in her teaching more commonly student teachers feel they have difficulties in engaging with this approach. This is how Joanna discusses the issue in her study:

"It is hard to plan the approaches beforehand, if you are going to use a dialogic approach. Using a dialogic approach fluently requires good subject knowledge from the teacher, and a clear sense of what kind of prior knowledge the pupils probably have. Especially inexperienced teacher will face difficulties in guiding the discussion logically, if pupil responses are very unexpected during the lesson. According to this, tutor teachers could have told student teachers more about the emerging pupils' views, because year after year the pupils most certainly have the same preconceptions about the topics. Alternatively student teachers could be handed with literal material which they could use to address the pupils' preconceptions by themselves."

Joanna's remark indeed contains a very important message, not only for teacher educators, but also for researchers and furthermore text book contributors. Knowledge about misconceptions and how they should be addressed can be considered to be a part of a sophisticated pedagogical content knowledge (Shulman, 1986). Thus, information should be brought up explicitly in materials teachers often rely on throughout their in-service career.

## Group interview

At the end of the academic year 2008-2009, a group interview was conducted with the participants George, Rosanna, Lea, Mark, Melanie and Joanna. After analysing the group interview of the ‘pilot’, as researcher-facilitators we became interested in some specific topics that we wanted to prompt ideas on from the student teachers during the semi-guided discussion. Still, as obvious as the difficulties of linking theory to actual practice might be, we wanted to find out what student teachers found *challenging in adopting dialogical approaches to teaching*. This was one of the new subthemes defined when compared to the analysis of the first group interview. This subtheme was located between the change in beliefs and behaviour (see figure3; draft). Instead of bringing separate examples about old (2007-2008) or new (2008-2009) subthemes, we are going to give an example of an entire chain of dialogue initiated by the facilitator. Firstly, because this was an authentic and participant-driven episode, and secondly, because it includes very informative, well-reasoned comments with reference to our interest mentioned above.

... = pause

[...]= talks over or right after

Facilitator: Why do you think that dialogic teaching does not occur there (in service schools) from your own experiences... or just from another point of view?

Lea: Well you can't prepare yourself for the questions beforehand when anything could come up. At this moment I have physics lessons continuing, and as we were discussing the students work someone asked "what is an ionization motor?"... Or "What are you going to do if there is a meltdown?". Questions come that are not so relevant to the topic, and because they expect you to answer, and you should guide them towards... It's not easy to manage in that kind of situation in a way that you would maintain the topic in discussions...

Joanna: I just discussed this in that small scale study, because not during any phase of the teacher training have you have been told what kind of prior knowledge the pupils have. And you are also in trouble yourself when you try to discuss when necessary... And there might be questions you can't answer... And for sure some of those questions come up frequently every year... So if you have taught one or two times you might know how to answer. I was wondering if I would have felt the dialogic discourse easier, if I'd had some material or background reading where there would have been dialogues that possibly emerge.

George: I really think that the teacher turns to survival mode and other things... But firstly about the talk or dialogues we do not even discuss that much here during the teacher training and if you have taught many years you will forget those small details and you will take the easiest way to survive in the lessons. And peer discussions can be sometimes frustrating, when you feel that the discourse doesn't proceed and you start to respond to your own initiations and again one lesson is behind.

Facilitator: Hmm... Yeah, it could really easily go off the track as we have talked about [George: Hmm] and there is the issue of time [Joanna: I don't know...]

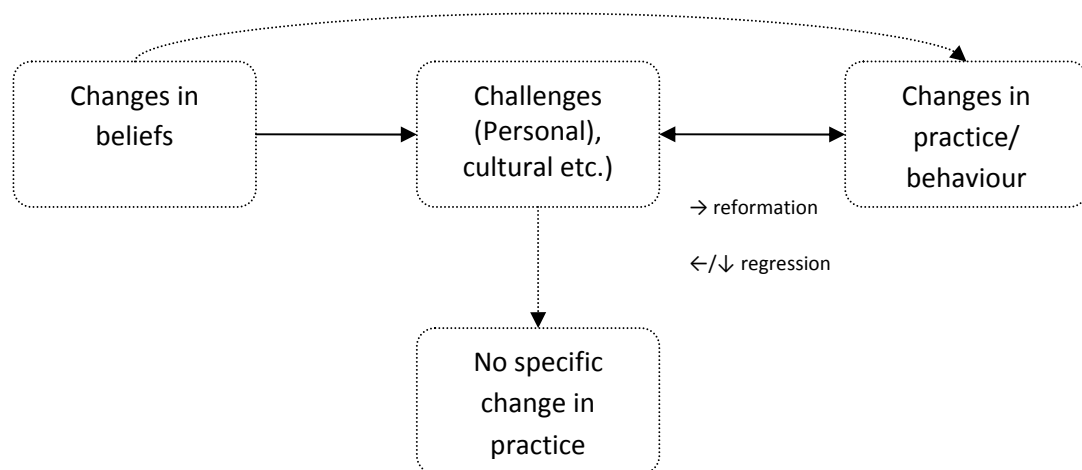
Joanna: I don't know if it is really so, that if a teacher teaches dialogically that it would be slower in every case than when a teacher is teaching by lecturing... That... is it always inevitable? [Lea: I'm sure it isn't...]

Lea: I'm sure it isn't, when you think for example about Mr. James, who in my opinion can teach dialogically and those lessons in my opinion are very good... It requires like that very broad subject knowledge... [George: It requires...]

George: It requires that you do the same thing with the class so that everyone will get used to it, that they would understand... If you try just once or twice and don't succeed then you might easily think "well just forget about it"... You should probably work this thing with every class separately, that "in these lessons you will learn by talking", because it is not obvious to every pupil, since, if no other teacher does it, then it could go to bantering the whole thing

Joanna: One teacher, who has done work with pupils in this way, told me that, "It has taken so long time that through the rest of the lesson we have to hurry by lecturing."

In the previous excerpt the same challenges as Scott, Mortimer and Aguiar (2006) have discussed (p.623-624) can be identified. As many of the turns reveal, student teachers are concerned with the *question of time*. They feel that dialogic teaching takes more time and if it is practiced then they will face problems in achieving the goals set out in the *curriculum*. The power of authoritative approaches is seen to be having more control of time, without neglecting the control of other things too. Comments also indicate that student teachers are concerned with their *subject knowledge*, since they feel they are not able for example to answer pupils' initiations, which as the student teachers relate, especially emerge during dialogic discussions. As illustrated in the dialogue, student teachers feel there are several challenges when implementing dialogic approaches to teaching. Content knowledge is a personal challenge student teachers struggle with the most. We would, however, argue that one of the side effects of this kind of teaching programme is that student teachers relax from the role of the owner of the knowledge and shift their attention more to taking account of what pupils think, rather than feeling obligated to 'know it all'. In-service it would probably be cultural challenges, like questions of time and control, which could lead to no specific change taking place in behaviour or retention of established reformation. It has been shown that children are able to adopt discursive strategies that promote learning (Mercer & Littleton, 2007). These discursive strategies should however be explicitly displayed and practised, since it is not obvious that children would understand what is going on in the 'dialogic classroom' if they are not used to it. This is exactly how George described the issue in the previous excerpt.



**Figure 3. From the change in beliefs to change in practice (draft)**

## Conclusions and Implications

The results of this study (and other related studies) indeed indicate that even though student teachers are concerned with issues of control and time they are capable of challenging traditional forms of teaching even during teacher training in both theory and practice (Lehesvuori & Viiri, 2009; draft). This finding further enhances understanding of the development of student teachers' pedagogical content knowledge, an area neglected in Kagan's (1992) extensive review (Nettle, 1998). According to this study, student teachers demonstrated the ability to consider and to implement alternative approaches to teaching; even if the extent to which these approaches could be implemented varied during teacher training lessons. This finding furthermore suggests that increasing the communicative repertoire of teachers is a sophisticated aspect of pedagogical content knowledge. Although there most certainly are challenges on the path toward the reformation of an individual's educational practice it may be hypothesised that if a

teaching programme has a positive influence on student teacher's beliefs, it fosters change in practice with or without personal/cultural challenges occurring in-service (see Figure 3).

The group interview at the end of the teaching programme was a valuable forum for student teachers to share their experiences and furthermore for the researcher to investigate progressively emerging comments. It is not assumed that student teachers would achieve the 'reflection-in-action' type already during the teacher training. Yet to achieve this level of reflection in the future, teaching programmes such as presented in this study, play a key role. The group interview of the improved teaching programme, in particular, along with the discussions can be seen to support higher levels of reflection which also included cultural factors (Hatton & Smith, 1995). Kagan (1992) argues that before student teachers can adopt new insights into their teaching, they must master the control of the classroom. In this case we disagree with Kagan and agree with Grossman (1992) who stresses that if student teachers are supposed to go beyond technical aspects of teaching and question their practice they should be guided towards doing so:

If our goal is not helping prospective teachers attain an immediate mastery of classroom routines but preparing prospective teachers to ask worthwhile questions of their teaching, to continue to learn from their practice, to adopt innovative models of instruction, and to face the dimensions of classroom teaching, then we must place our emphasis elsewhere. (p.176)

Conforming to these words we are confident that the student teachers that took part in this study had an opportunity to go beyond subject knowledge and came to realise the importance of pedagogical content knowledge. The teaching programme in particular increased the awareness of communicative approaches and the role they play in guiding pupils' construction of knowledge.

### Acknowledgements

The corresponding author gratefully acknowledges the support of the Finnish Cultural Foundation.

### References

- Alexander, R. (2004). *Towards Dialogic Teaching: rethinking classroom talk*. York: Dialogos.
- Braun, V., and Clarke, V. (2006). Using Thematic Analysis in Psychology. *Qualitative Research in Psychology*, 3, 77–81.
- Chin, C. (2007). Teacher Questioning in Science Classrooms: Approaches that Stimulate Productive Thinking. *Journal of Research in Science Teaching*, 44(6), 815–843.
- Crespo, S. (2002). Praising and Correcting: Prospective Teachers Investigate Their Teacherly Talk. *Teaching & Teacher Education*, 18, 739–758.
- Grossman, P.L. (1992). Why Models Matter: An Alternate View on Professional Growth in Teaching. *Review of Educational Research*, 62(2), 171–179
- Hatton, N., & Smith, D. (1995). Reflection in Teacher Education: Towards Definition and Implementation. *Teaching & Teacher Education*, 11(1), 33–49.
- Hartford, J., & MacRuairc, G. (2008). Engaging Student Teachers in Meaningful Reflective Practice. *Teaching & Teacher Education*, 24(7), 1884–1892.
- Kagan, D., (1992b). Professional Growth Among Preservice and Beginning Teachers. *Review of Educational Research* 62(2); 129–169.
- Lehesvuori, S., & Viiri, J. (2009). The Effect of Knowledge of Discourse Types to Student Teachers' Talk Patterns. In A. Kallioniemi (Eds.), *Uudistuva ja kehittyvä ainedidaktiikka: Ainedidaktinen symposium 8.2.2008 Helsingissä Osa 2*.
- Lehesvuori, S., Viiri, J. & Scott, P. (2009). A Programme on Teachers' Talk in Subject Teacher Training: An Approach to Develop and to Reform Student Teachers' Classroom Talk. In Selkirk, A., & Tichenor, M. (Eds.), *Teacher Education - Policy, Practice and Research*. New York: Nova Science Publishers. 367–368.
- Lemke, J. L. (1990). *Talking Science: language, learning and values*. Norwood: Ablex Publishing Company.
- Mercer, N. (2004). Sociocultural Discourse Analysis: Analysing Classroom Talk as a Social Mode of Thinking. *Journal of Applied Linguistics*, 1, 2, 137–168.

- Mercer, N., Dawes, L., Wegerif, R., & Sams, C. (2004). Reasoning as a Scientist: Ways of Helping Children to Use Language to Learn Science. *British Educational Research Journal*, 30(3), 367–385.
- Mercer, N. & Littleton, K. (2007). *Dialogue and the Development of Children's Thinking. A sociocultural approach*. London : Routledge.
- Mortimer, E.F., & Scott, P. (2003). *Meaning Making in Secondary Science Classrooms*. Milton Keynes: Open University Press.
- Nettle, E. B. (1998). Stability and Change in the Beliefs of Student Teachers During Practice Teaching. *Teaching & Teacher Education*, 14(2), 193–204.
- Nystrand, M., Gamoran, A., Kachur, R., & Prendergast, C. (1997). *Opening Dialogue: Understanding the Dynamics of Language and Learning in the English Classroom*. New York: Columbia University.
- O'Brien, J. (1993). Action Research Through Stimulated Recall. *Research in Science Education*, 23, 214–221.
- Roth, W-M. (2005). *Talking Science: language and learning in science classrooms*. Lanham, United States of America: Rowman and Littlefield.
- Scott, P. H.; Mortimer, E. F. i Aguiar, D. G. (2006). The Tension Between Authoritative and Dialogic Discourse: A Fundamental Characteristic of Meaning Making Interactions in High School Science Lessons. *Science Education*, 90(3): 605–631.
- Scott, P., & Ametller, J. (2007). “Teaching science in a meaningful way: striking a balance between ‘opening up’ and ‘closing down’ classroom talk.”. *School Science Review*, 88(324), 77–83.
- Seidel, T., Prenzel, M., & Kobarg, M. (Eds.). (2005). *How to Run a Video Study. Technical report of the IPN Video Study*. Münster: Waxmann.
- Shulman, L. S. (1986). Those Who Understand: Knowledge Growth in Teaching. *Educational Researcher*, 15(2), 4–14.
- Viiri, J., & Saari, H. (2006). Teacher Talk Patterns in Science Lessons. *Journal of the Science Teacher Education*, 17, 347–365.

# CLASSROOM QUESTIONING AND TEACHING APPROACHES: A STUDY WITH BIOLOGY UNDERGRADUATES

M. Helena Pedrosa de Jesus & Betina da Silva Lopes

Portugal, University of Aveiro

Research Centre for Didactics and Technology in Teacher Education (CIDTFF)

## Abstract

*The present paper reports some results of a larger naturalistic study that is being conducted at the University of Aveiro, Portugal, with four Professors teaching biology to undergraduates. The main goal is to understand how teacher's preferential teaching approach, including questioning practices, relates with their students questioning behaviour. Data were collected by observing and tape-recording forty lecture-sessions, during the academic year 2007/2008 (ten per teacher). The teacher's preferential teaching approach was identified by the analysis of semi-structured interviews and the administration of a validated Portuguese translation of the Approaches to Teaching Inventory (Trigwell, Prosser & Ginns, 2005). In this paper we will focus our discussion on the results obtained from the analysis of oral teacher-student interactions (through questions) taken from twelve randomly selected and fully transcribed lecture-sessions (three per teacher). Preliminary results indicate that teachers use their classroom discourse to interact differently with students, according to their preferential teaching approach. It was also possible to establish a relationship between teachers' questioning practices and students questioning behaviour. It is believed that by deepening this research it will be possible to stimulate and encourage teachers' reflection, promoting the scholarship of teaching and learning in higher education.*

## Introduction

In the past decade a vast and consistent body of research literature dealing with the concepts of teaching styles, modes or approaches has been emerged (Kane, Sandretto & Heath, 2002). Many of these investigations include the analysis of relationships between teacher's beliefs or motivations and the adopted teaching strategies, including questioning. For example, Trigwell and co-workers, who have been investigating general teaching approaches in the context of higher education, consider two context dependent 'ways' that academics adopt to teach: CCSF – conceptual change student focused and ITTF – information transmission teacher focused. These authors use the 'Approaches to Teaching Inventory' (Trigwell, Prosser & Ginns, 2005) to identify the corresponding characteristics. Although several studies (Chin, 2006; Chin, 2007; Trigwell, Prosser & Taylor, 1994) mention the expected relationships between teaching approaches and questioning practices, there is still a need for finding sound empirical evidence for those relations. We have been especially interested in finding evidence for those relationships in the use of questioning in higher education. Indeed, 'talking' is central to the meaning making process and thus central to learning' (Mortimer & Scott, 2003). The main purpose of the present study is therefore to describe teachers' and students' questioning practices observed during first year lecture sessions and relate them to the preferential teaching approaches of the teachers.

## Rationale

Many investigations indicate that the promotion of a true spirit of inquiry can improve the quality of the teaching-learning processes. For example, questioning helps to scaffold ideas, to organize tasks and encourage reflection (Pedrosa de Jesus, Almeida, Teixeira-Dias & Watts, 2007). Also, students' questions can trigger their thinking process and generate opportunities for the identification of incorrect conceptions and main obstacles for concepts' understanding. This facilitates the adoption of strategies according to students' needs (Chin, 2007). However, Graesser & Person (1994) showed that 96 per cent of classroom questions are formulated by the teacher, implying that the type and the way teachers ask questions can play a relevant role on students' questioning practices and the quality of their learning.

Concerning this rationale our main research questions are:

- What are the main teacher questioning practices used during undergraduate biology lectures?
- Which is the relationship between teacher questioning practices and the preferential teaching approach?
- How do teachers' questioning practices relate to their students questioning behaviour?


## Methods

A qualitative approach, using classroom observation and semi-structured interviews as the main sources of data, was adopted. At the beginning of academic year 2007/2008 the preferential teaching approach of four Professors teaching undergraduates was identified through semi-structured interviews and the administration of a validated Portuguese translation of the 'Approaches to Teaching Inventory' (Pedrosa & da Silva Lopes, 2008). Three Professors taught *Microbiology* during the 1<sup>st</sup> semester (each of them being responsible for lecturing a specific topic). The fourth professor taught *Evolution* during the 2<sup>nd</sup> semester to the same group of undergraduates.

In order to identify and describe the que questioning practice of each Professor:

- (i) ten lecture-sessions per teacher were observed and audio-taped ( 90 minutes sessions attended by 40 students);
- (ii) three lecture-sessions per teacher were fully transcribed in order to be able to proceed with the classroom discourse analysis.

Our discussion will focus on teacher-students interaction episodes involving questioning 'moves' (Stubbs, 1980):

'move 1'  **Teacher:** What is the molecular base of the DNA code? Where are they? I mean they aren't in the air, are they?! This is not a virtual thing...

'move 2' **Student:** RNA

**Teacher:** No. Nucleotides.

In our analysis we have adopted the categorization system by Pedrosa de Jesus (1987), considering questions' cognitive level based on Bloom's taxonomy (1956). However, routine and rhetorical questions were excluded – Figure 1. Only teacher-student interaction episodes, involving questions of the six following thinking levels were considered: knowledge, comprehension, application, analysis, synthesis and evaluation..



<b>Lower Cognitive Level</b> (single/ limited number of acceptable/“right” answers)	Cognitive – Memory (C-M)	What is a gene?
	Convergent thinking (CT)	Bacteroids are the most abundant microorganism in our thick intestine. Why do bacteroids survive in this condition?
<b>Higher cognitive Level</b> (thought-provoking with a wide range of acceptable responses)	Divergent Thinking (DT)	Some antibiotics connect to the local A or B of the ribosome. If they connect to the local A, what do you think that happens?
	Evaluative Thinking (ET)	To what extend did the discovery of the DNA structure influenced medical advance?

**Figure 1. Questions’ cognitive level categorization system (Pedrosa de Jesus, 1987)**

The analysis of the cognitive level of each ‘thinking question’ formulated during lectures (three per teacher, 12 in total) revealed no significant difference between the teachers, being the majority of questions at C-M and CT level (Pedrosa de Jesus & da Silva Lopes, 2008).

However, data gathered through classroom observation revealed significant differences between the nature/type of teacher reactions to student interventions (questions and answers) (Pedrosa de Jesus, da Silva Lopes & Watts, 2008). Deeper analysis of the ‘questioning moves’ identified during transcription lead us to the development of a teacher questioning behaviour categorization system based on the conceptual dichotomy of ‘being’ dialogic (concept adapted from Alexander, 2004; Mortimer and Scott, 2003) or non-dialogic. According to this system (presented in Figure 2) a teacher is ‘being dialogic’ (during a specific ‘move’), when he engages with the student’s idea, expressed by a questions and/or answer, and, consequently, stimulates further reasoning.

This categorization system also takes into account a more procedural context, namely the type of teacher reaction facing the absence of a solicited student answer (this is the teacher’s behaviour after an unsuccessful initiation effort). It was decided to include this dimension since this situation tends to change the continuum of the natural speech. Indeed, a sequence of teacher-student(s) interaction would be different *if* the teacher had got an answer at the first time.

## Results

In this section we will present data obtained through the analysis of twelve fully transcribed lecture sessions of four teachers (three lectures per teacher) considering their preferential teaching approach: teachers one (T1) and two (T2) are predominantly IT\*TF and teachers three (T3) and four (T4) have a preferential CCSF teaching approach.

Indeed, looking at Table 1 it is possible to recognize that Professors T3 and T4 used more commonly long interaction episodes. On the contrary classroom discourse of teachers T1 and T2 is mainly composed by ‘short’ interaction episodes, reinforcing the “traditional” lecture format: long periods of teacher ‘monologue’ interrupted by ‘brief’ teacher-student interaction.

Classroom discourse interaction is mainly initiated by the teacher, with all Professors asking significantly more questions than their students. For instance Teacher 1 asked 89 questions whereas the students only asked 13 questions. Teacher 3 asked 260 questions and the students only asked 26 questions.

Looking at what happened after a teacher question (see Table 2) Professors T3 and T4 seem to use questions in a more ‘effective’ way than the other two colleagues, getting a higher percentage of student’s answers (69% and 70% ). Low frequencies of self-answers after the absence of a solicited student-answer reinforce the higher interactivity during classroom discourse with T3 and T4.

<b>‘Successful initiation – interaction</b>	<b>Reaction to student answer (82%)*</b>	<i>Dialogic</i>	The teacher ‘accepts’ students answer. Maintaing (or not) neutral concerning scientific correctness. Based on the students answer the teacher formulates a ‘follow-up’ question stimulating the students’ intellect.
		<i>Non-dialogic</i>	If the students answer is correct/parcially correct the teacher accepts the students answer (implicitly or explicitly – by repeting or completing it), proceeding then with his discourse. He may eventually formulate a new question but it is NOT based on the reasonigs expressed by the students answer, not promoting intellectual stimulation of the student.
	<b>Reaction to student question (100%)*</b>	<i>Dialogic</i>	The teacher answers to the question, formulating a follow-up question based on the students questions. The teacher may even ‘respond’ directly with a new question, trouging the responsibility of thinking to the students’. It is very common that the teacher valorize the students’ questions (even if the question is scientifically incorrect). Situation where the teacher explores the students questions in terms of the reasonings expressed, but without formulating a ‘follow-up’ question are also integrated in this category.
		<i>Non-dialogic</i>	The teacher answers directly to the students question. He doesn’t explore the reasonings behind the questions and doesn’t formulate a ‘follow-up’ question.
		<i>Re-initia-tion</i>	The teacher after formulating a question, and by not obtaining a student answer, repeats the questions or reformulates it.
	<b>Unsuccesful initiation (95%)*</b>	<i>Self-Res-ponse</i>	
<b>Other relevant behaviour (90%)*</b>			Other teacher behaviours recognizible during in the teacher-student interaction episodes not included in previous categories but also relevant to the nature of teacher-student interaction: Eg. Teacher relates students statement to formal assessment items of the discipline

\* Agreement between researcher and the four Professors on seven teacher-student interaction episodes (involving 40 questioning ‘moves’).

**Figure 2. Teacher’s behaviours during ‘questioning moves’**

**Table 1. Classroom discourse: number and ‘length’ of teacher-student interaction episodes**

Teacher	Nº of Interaction episodes	Questioning moves				
		<2	2	3-4	5-6	≥ 7
1	58	16 (28%)	20 (34%)	17 (29%)	4 (7%)	1 (2%)
2	163	73 (45%)	49 (30%)	30 (18%)	8 (5%)	3 (2%)
3	82	7 (9%)	13 (16%)	13 (16%)	17 (20%)	32 (39%)
4	52	7 (13%)	13 (25%)	12 (24%)	5 (10%)	15 (29%)

It seems that the higher teacher-student interactivity during lectures of Professors T3 and T4 is related to a more frequent ‘dialogic’ reaction to students’ interventions (see Table 3). At the same time, higher frequency of dialogic attitudes in teachers with a preferential CCSF approach may be related to different teacher intentions during interaction (Table 4).

In order to exemplify the differences between questioning practices of teachers with ‘opposite’ preferential teaching approaches, figures 3 and 4 show two interaction episodes, one from T2 (ITTF) and the other from T4 (CCSF).

**Table 2. Frequency of teacher questions’ and second ‘move’ type**

Teacher	1st interaction move		2nd interaction move (absence of a student answer)	
	Teacher Question	Student answer	Teacher ‘self ‘answer	Repetition/reformulation of the initial question (move 1)
1	89	45 (51%)	19 (21%)	25 (28%)
2	244	103 (42%)	87 (36%)	54 (22%)
3	260	180 (69%)	13 (5%)	67 (26%)
4	138	96 (70%)	10 (7%)	32 (23%)

**Table 3. Teacher’s reaction after student intervention**

Teacher	Student question*			Student answer (Feedback)*		
	Dialogic	Non-dialogic	Other	Dialogic	Non-dialogic	Other
1	0 (0%)	10 (77%)	3 (23%)	4 (9%)	41 (91%)	0 (0%)
2	2 (12%)	14 (82%)	1 (6%)	14 (14%)	89 (86%)	0 (0%)
3	9 (35%)	11 (42%)	6 (23%)	103 (57%)	77 (43%)	0 (0%)
4	5 (33%)	9 (60%)	1 (7%)	62 (65%)	34 (35%)	0 (0%)

\* % calculation based on the total number of students’ questions/answers.

## Conclusions and Implications

The results of the present study indicate that university with a preferential CCSF teaching approach tend to have different questioning practices comparing to colleagues with a more ITTF teaching approach. It was also possible to perceive that the way each Professor was able to manage questioning has clear effects on students’ behaviour, in particular the number of obtained answer.

The very low number of student questions, observed with this group of teachers, reinforces the results of previous studies pointing to the ‘passive’ undergraduates’ behaviour (Maskill & Pedrosa de Jesus, 1997; Pedrosa de Jesus, da Silva Lopes & Watts, 2008). Classroom observation revealed that many undergraduate biology students see lectures as “information reception moments” and do not make an effort to understand the concepts that are being explored. Students intervene only when solicited by a teacher question and rarely by self-incentive.

We are conscious that this study did not take into account other relevant factors, such as the time that teachers waited for a students answer (‘wait-time’), and that the context differences concerning “time” (first semester vs. second semester) and “discipline” (*Microbiology* vs. *Evolution*) may have influenced the results.

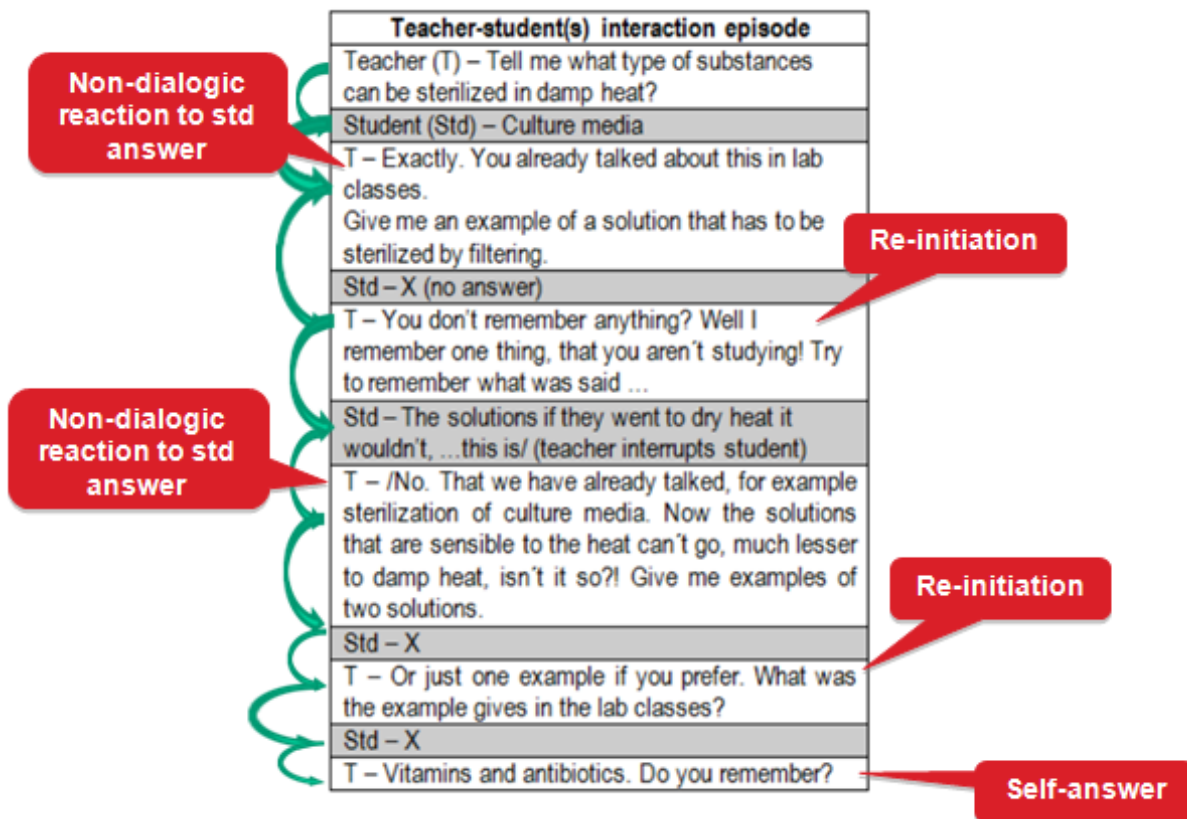
Even so, it is believed that the data collected is relevant for providing information for teacher reflection on more ‘efficient’ modes of interaction. In particular, it gives evidence that teachers should minimize self-responses to their questions, taking into account more often students’ ideas/concepts expressed by their questions/answers (‘dialogic’ attitude) in order to promote quality in the learning-teaching processes.

**Table 4. Main teacher intention during each teacher-student interaction episode**

Teacher Intentions*	Teacher			
	1 (ITTF)	2 (ITTF)	3 (CCSF)	4 (CCSF)
Regulate students behaviour	3	5	0	0
Verify factual knowledge	25	72	30	21
Transmit content knowledge	25	76	30	33
Support students in the (re)construction of an integrated framework	4	7	27	9
Other	7	7	6	5
$\Sigma^{**}$	68	167	93	68
Total number of interaction episodes	58	163	82	52

\* 89% agreement between the researcher and the four undergraduate biology teacher on seven teacher-student interaction episodes (involving 40 questioning ‘moves’); \*\*Above the total number of counted teacher-student interaction episodes, because in some examples, there were identified two main intentions.

We acknowledge the financial support of Fundação para a Ciência e Tecnologia (FCT), Portugal, (POCI/CED/59336/2004). We also thank Professors A. Almeida, A. Correia, F. Gonçalves & S.Mendo, from the Department of Biology of the University of Aveiro, Portugal.



**Figure 3. Example of a teacher-student interaction episode (ITTF) (note: std = student).**

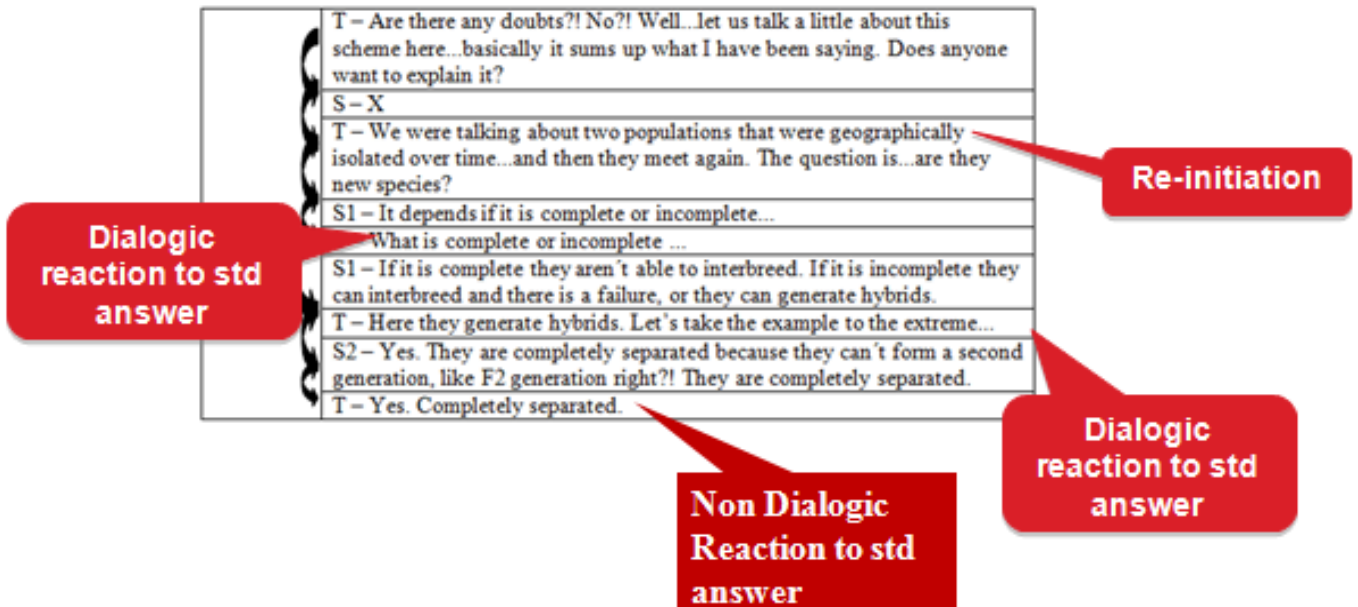


Figure 4. Example of a teacher-student interaction episode (Teacher 4) (note: std = student).

## References

- Alexander, R. (2004). *Towards dialogic teaching: Rethinking classroom talk*. Dialogos, Cambridge.
- Chin, C. (2006). Classroom Interaction in Science: Teacher Questioning and Feedback to student responses. *International Journal of Science Education*, 28 (11), 1315-1346.
- Chin, C. (2007). Teacher Questioning in Science Classrooms: approaches that stimulate productive thinking. *Journal of Research in Science Education*, 44 (6), 815-843.
- Graesser, A.C. & Person, N.K. (1994). Questioning asking during tutoring, *American Educational Research Journal*. 31,104-137.
- Kane, R., Sandretto, S. & Heath, C. (2002). Telling half the story: a critical review of research on teaching beliefs and practice of university academics. *Review of Educational Research*, 72, 177-228.
- Maskill, R. & Pedrosa de Jesus, H. (1997). Asking Model questions. *Education in Chemistry*, 34 (5), 132-134.
- Pedrosa de Jesus, H. (1987). *A Descriptive Study of Some Science Teachers Questioning Practices*, Unpublished Master Thesis, University of East Anglia., U.K.
- Pedrosa de Jesus, M.H. & da Silva Lopes, B. & Watts, M. (2008). *Teaching approaches in Higher Education: the role of classroom questioning*. Paper presented at International Conference of Scholarship of Teaching (SoTL), London – UK (May 2008).
- Pedrosa de Jesus, M.H. & da Silva Lopes, B. (2008). *Questioning and strategies and teaching approaches': a study in university biology*. Paper presented 13<sup>th</sup> annual conference of the European Learning Styles Information Network (ELSIN), Gent – Belgium (pp. 385-408).
- Stubbs, M. (1983). *Discourse Analysis: the sociolinguistic Analysis of Natural Language*. Chicago.
- Trigwell, K., Prosser, M. & Taylor, P. (1994). Qualitative differences in approaches to teaching first year university science. *International Journal of Higher Education and Educational Planning*, 27, 75-84.
- Trigwell, K., Prosser, M. & Ginns, P. (2005). Phenomenographic pedagogy and a revised Approach to Teaching Inventory. *Higher Education Research and Development*, 24 (4), 349-360.
- Mortimer, E. F., & Scott, P. H. (2003). *Meaning making in secondary science classroom*. Philadelphia: Open University Press.



# ARGUMENTATION ABOUT AND UNDERSTANDING OF SCIENCE: RESEARCH EXPLORING HOW TO INTERRELATE THESE TWO DIFFERENT PERSPECTIVES

Claudia von Aufschnaiter  
Justus Liebig University Giessen

## Abstract

*Since the mid 90<sup>th</sup> research has increasingly focused on students' argumentation. Science educators not only argue that argumentation is an important aspect of science education in general; it is also assumed that argumentation promotes the learning of the science content. Conversely, research indicates that students' ability to argue is limited by their content specific knowledge. Even though these two claims are made, research rarely explicitly addresses the interrelationship between argumentation (learning about science) and conceptual understanding (learning of science). Research reported in this symposium explicitly addresses students' argumentation and how students incorporate conceptual understanding while they argue. The three projects focus explicitly or implicitly on distinguishing different qualities in students' argumentation and their conceptual understanding of the content which they deploy into their argumentation.*

## Introduction to the Symposium

Since the mid 90<sup>th</sup> research has increasingly focused on students' argumentation (e.g., Erduran & Jiménez-Aleixandre, 2008). Science educators not only argue that argumentation is an important aspect of science education in general; it is also assumed that argumentation promotes the learning of the science content (e.g., Zohar & Nemet, 2002). Conversely, research indicates that students' ability to argue is limited by their content specific knowledge (e.g., Means & Voss, 1996; Sadler, 2004). Even though these two claims are made, research rarely explicitly addresses the interrelationship between argumentation (learning *about* science) and conceptual understanding (learning *of* science).

Partly, this problem might be caused by different approaches towards learning in these two areas. Whereas research on argumentation often addresses the *processes* of students' activities (that is, their discourse about a topic or a task), research on students' conceptual learning typically focuses on the *outcomes* of such processes (that is, students' conceptions at a specific point in time). Only rarely does research on students' conceptions focus on how students utilize their conceptual understanding while acting in "normal" learning settings. As a consequence, research aiming to interrelate argumentation and conceptual understanding typically addresses students' conception prior and/or post to instruction which focuses on argumentation but not *during* this instruction (e.g., Zohar & Nemet, 2002). Another methodological limitation in current projects is the idea of "quality" as a means to distinguish "good" from "poor" argumentation. Studies in science education typically offer at least two different approaches with either a content-oriented or a more structure-oriented focus (or a mixture of both). On the one hand, students' argumentation being of high quality is assumed, when students' argumentation shows high relevance between data and claim (e.g. Means & Voss, 1996). On the other hand, the quality of an argumentation is assumed to increase when it consists of more justifications, which also rebut alternative arguments (e.g., Jiménez et al., 2005; Osborne et al., 2004; Zohar & Nemet, 2002). However, the quality of an argumentation might also differ in terms of the quality of conceptual understanding incorporated (e.g., v. Aufschnaiter et al., 2008). This is not solely a problem

of “correct” or “incorrect” knowledge but also an issue of “advanced” or less “advanced” understanding, leading to improved argumentation.

Research reported in this symposium explicitly addresses students’ argumentation and how students incorporate conceptual understanding *while* they argue. All four projects focus explicitly or implicitly on distinguishing different qualities in students’ argumentation and their conceptual understanding of the content which they deploy into their argumentation. Furthermore, the projects comprise science issues (biology, chemistry, and physics) as well as socioscientific issues. These different approaches, all with a common focus, aim to shed (more) light into the debate on how argumentation and conceptual understanding interrelate. Such an understanding would improve both, the teaching *about* science and the teaching *of* science.

## References

- Erduran, S., & Jiménez-Aleixandre, M. P. (2008). *Argumentation in science education*. Dordrecht: Springer.
- Jiménez Aleixandre, M. P., López Rodríguez, R., & Erduran, S. (2005, April). *Argumentative quality and intellectual ecology: A case study in primary school*. Paper presented at the annual conference of the National Association for Research in Science Teaching, Dallas, USA.
- Means, M. L., & Voss, J. F. (1996). Who reasons well? Two studies of informal reasoning among children of different grade, ability, and knowledge levels. *Cognition and Instruction, 14*(2), 139-178.
- Osborne, J., Erduran, S., & Simon, S. (2004). Enhancing the quality of argumentation in school science. *Journal of Research in Science Teaching, 41*(10), 994-1020.
- Sadler, T. D. (2004). Informal reasoning regarding socioscientific issues: a critical review of research. *Journal of Research in Science Teaching, 41*(5), 513-536.
- von Aufschnaiter, C., Erduran, S., Osborne, J. & Simon, S. (2008a). Arguing to learn and learning to argue: Case studies of how students' argumentation relates to their scientific knowledge. *Journal of Research in Science Teaching, 45*(1), 101-131.
- Zohar, A., & Nemet, F. (2002). Fostering students' knowledge and argumentation skills through dilemmas in human genetics. *Journal of Research in Science Teaching, 39*(1), 35-62.



# LEARNING TO TAP: AN EFFORT TO SCAFFOLD STUDENTS' ARGUMENTATION IN SCIENCE

Demetris Lazarou  
University of Bristol

## Abstract

*The paper describes a research study in which students learned to structure their arguments by using Toulmin's Argumentation Pattern (Toulmin, 2003). Data sources included students' written answers and audio-recorded oral answers given in classroom discussions in seven science education lessons during a five month period. Data were quantitatively analysed, based on the analytical tool suggested by Erduran, Simon & Osborne (2004), to evaluate possible improvements of students' argumentation skills. The analysis revealed that positive improvements of students' skills could be observed over time. Important implications for promoting argumentation in primary science are also suggested.*

## Introduction

Argumentation is highlighted by various researchers as one of the most important activities of science education (e.g. Newton, Driver, & Osborne, 1999). The reasons for this do not refer just to the educational value of argumentation as a skill but also to its value as a social skill (e.g., Erduran, Simon, & Osborne 2004). Despite its noted importance and the assertion that it is a skill that needs to be explicitly taught (e.g, Kuhn & Udell, 2003), argumentation is not adequately practiced in primary science education (Tytler & Peterson, 2003).

The aim of this research effort was to help primary school students enhance their argumentation skills through promoting structured argumentation in primary science education. The specific interest of the study thus, centred upon the structure of the argument and an effort to scaffold students' understanding concerning the argument's structure, as this was considered as the initial, but still the fundamental skill students have to acquire before dealing with the inner validity of an argument. The reasons for these are presented in the following section of the paper.

To address the aims of the research study, Toulmin's Argumentation Pattern (TAP) (Toulmin, 2003) was utilised as a teaching medium and a scaffold for supporting and enhancing students' argumentation in primary science education; it was utilised as a medium for assisting students realise the essence of the argument and a means of helping them realise how they can structure an argument and how they can evaluate the adequacy of their arguments in terms of its inner structure. It needs to be noted that this study is a part of a larger study examining in more detail the ways structured argumentation can be integrated in primary science education.

## Rationale

As Newton et al. (1999) suggested, science education should not focus only on knowledge acquisition by the students but it should also emphasise aspects around the nature of science, about its epistemology, the methods and the practices that scientists utilise, in a way of helping students realise that science is not equivalent to a fixed, ready-made set of facts that they have to learn. Students need to understand that science is a way of constructing theories

which explain how the world may be (Erduran et al., 2004), a way of becoming socialised into the discourse being used and the practices of the scientific community (Newton et al., 1999), a way of being introduced to scientific ways of knowing and not just acquiring facts about the way the world is (Driver, Asoko, Leach, Mortimer, & Scott, 1994), a way of being able to evaluate claims in the light of new evidence (Newton et al., 1999) and a way of comprehending that scientific theories are constructed explanations that help us make sense of the world (Sandoval & Millwood, 2005). As these researchers suggest, this is possible only through incorporating argumentation in our teaching and learning practices.

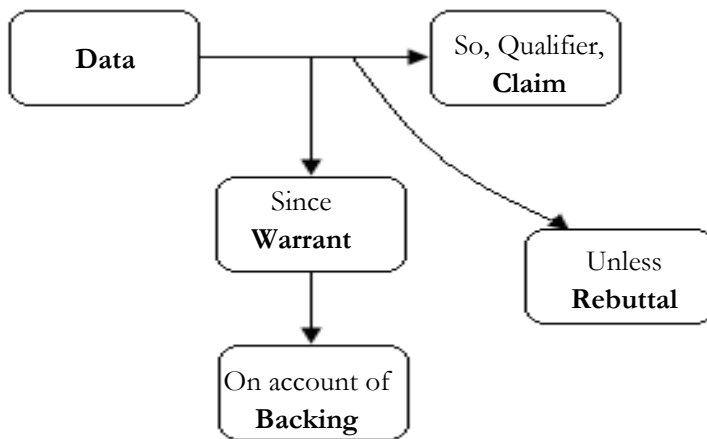
Some people may argue that argumentation is a skill that should be addressed at a later stage in students' lives. Even though there are various research projects indicating the importance of engaging students with argumentation in secondary school (e.g., Erduran et al., 2004; Jiménez-Aleixandre, Bodríguez, & Duschl, 2000; Sandoval & Millwood, 2005) it seems that argumentation is a skill that needs to be addressed while students are still in primary school. Kuhn and Udell (2003) report that there are research projects which suggest that even small children are capable of showing competence in producing arguments to support a claim and in understanding the structure of an argument (Chambliss & Murphy, 2002). Kuhn (1991) showed that a significant improvement of argumentation skills can take place across preadolescence to early adolescence (11-13 years) whereas no significant change of the argumentation skills can be noticed between adolescent and young adult participants, indicating thus the crucial importance of addressing argumentation in primary school. The importance of addressing argumentation in primary school is evident by the reported inadequacy of students to undertake an effort not only to challenge their opponent's argument but also to advance their own (Kuhn & Udell, 2003). Additionally, Kuhn (1991) argues that children of early adolescence seem to have weak metacognitive skills as they think with the theories they implicitly hold about the world they live in and not explicitly about the theories; this suggests that there is a need to support students to acquire the metacognitive skills needed in order to engage productively with argumentation and learn strategies for productively interacting with the theories they hold.

However, is the structure of the argument important for promoting students' argumentation skills? One of the main reasons for fallacious argumentation identified by Zeidler (1997) is students' naïve conception of argument structure; "*when students begin to formulate propositional arguments and counterarguments, their lack of a conceptual awareness about the structure of arguments gives rise to misconceptions about the validity of their claims*" (Zeidler, 1997, p. 488). Having awareness about the structure of arguments is thus presented as a crucial factor in assisting students express a valid claim which could be a significant instructional implication for teaching argumentation. Walker and Zeidler (2007) further supported this by recommending that students should be explicitly taught about the structure of an argument either prior or during argumentation activities. A very interesting finding of Cross, Taasobshirazi, Hendricks and Hickey (2007) which further supports the importance of teaching students about argumentative structures is that these seem to play a significant role in positively influencing students' learning and achievement in science education. Furthermore, another recent project by Sibel Erduran, Jonathan Osborne and Shirley Simon (e.g., Erduran et al., 2004; Osborne, Erduran, & Simon, 2004) has shown that pedagogical practices implemented by teachers which had a focus on the structure of the argument, resulted in qualitatively and quantitatively enhancing students' arguments.

In spite of the noted importance of argumentation through research studies, the assertion that it is a skill that can be developed (Erduran et al., 2004; Kuhn, 1991; Kuhn & Udell, 2003) and the assertion that it is a skill that needs to be explicitly addressed and taught (Erduran et al., 2004; Kuhn & Udell, 2003; Walker & Zeidler, 2007), scientific argumentation is not adequately practiced in primary science education (e.g., Kuhn, 1991; Tytler & Peterson, 2003). This research study attempted to address these issues to a certain extent.

Toulmin's (2003) Argumentation Pattern (TAP) was utilised as an argumentation framework for fulfilling the aims of the research; a model through which an argument's structure is defined by its interlinked components: i) a claim (C), which is an assertion put forward and which awaits to be established, ii) data (D), which are facts in order to support the claim, iii) a warrant (W), which is a clause which justifies the connection between claim and data, iv) a backing (B), which justifies the authority of the warrant, and v) a rebuttal (R), which is a clause which may reduce

the strength of the warrant (Figure 1). TAP seemed to be a suitable tool for primary school students to use due to its well-defined and puzzle-like structure with clearly defined interlinked components placed in a well-organised diagram.



**Figure 1. Toulmin's Argumentation Pattern (Toulmin, 2003, p.97).**

## Methods

Three sixth-grade classrooms participated in this research study. The findings described in this paper refer to the work that took place in one of these classrooms, so that a more comprehensive part of the overall effort is presented. The classroom consisted of fifteen 12 year-old students and the teacher of the classroom was the author of this paper.

TAP was explicitly taught by the teacher in a single instance and was further revised and practiced by the students in a series of six other instances during a five month period. Students had not been previously involved in any effort aiming at explicitly teaching them structured argumentation. More explicit details concerning these instances are reported along with the findings in the following section.

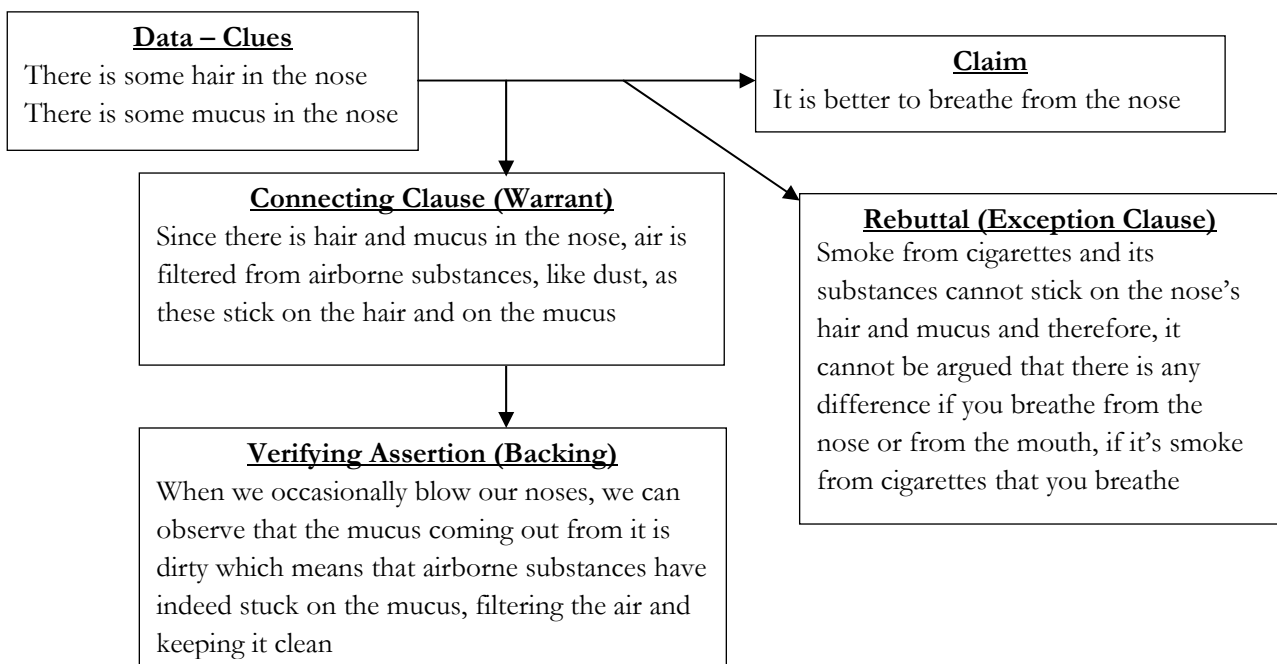
Students' written answers and audio-recorded oral answers given in classroom discussions were then quantitatively evaluated based on the analytical tool suggested by Erduran et al. (2004). The tool focuses on the argument's structure and suggests that arguments can be quantitatively evaluated by generating clusters characterising the argument (e.g., CD, CDW, CDWB) based on the components of that argument, as suggested by Toulmin (2003) (e.g., CD stands for Claim-Data, etc); clusters with increasing number of components suggest a more complex argument. This tool can practically provide the necessary evidence so that to evaluate any improvement of students' skill to provide structured arguments over time. Nevertheless, it should be noted that the aim of this study is not to report on a deep and detailed statistical analysis of the arguments constructed by the students but to provide the reader with an overall impression on how students' arguments may evolve over a relatively long period of time, when their argumentation efforts are scaffolded by utilising TAP.

## Results

Results from the 7 teaching instances during which TAP was explicitly taught and revised are presented here. Information about the teaching and learning processes are described through which the evolution of students' arguments can be depicted.

Instance 1

Initially, the model was explicitly taught during a single science lesson by using a specific question that related to the lesson of the day. At the beginning of the last lesson about the respiratory system, students were given the question “Is it better to breathe from the nose or from the mouth?” and were asked to work individually and construct a written argument in order to address it. They were then asked to evaluate the adequacy of their peer’s arguments in a whole class discussion; the aim of this was to help students realise the need to engage in an effort to enhance their argumentation skills. Afterwards, the teacher guided the discussion in such a way so that the constituent components of the argument, based on TAP, could emerge and the whole argument could be portrayed on a structured diagram on the white-board (Figure 2). Moreover, the teacher named the various components of an argument and placed their names on the diagram so that students could begin familiarising with the terms. Nevertheless, the teacher had to explicitly assist students to express a rebuttal as this was one of the components that did not emerge from the discussion. A post analysis of students’ initial arguments after the completion of the lesson revealed that 4 out of 15 had provided an argument consisting of a claim (Cluster 1 argument e.g., “*From the nose*”, Student 2), 8 out of 15 expressed some data along side the main claim (Cluster 2 argument e.g., “*It’s better to breathe from the nose because the air is filtered*”, Student 5) and only 3 out of 15 suggested an argument consisting of a claim, data and a warrant (Cluster 3 argument e.g., “*We breathe from the nose because we have hair and the air we take is cleaned*”, Student 12).



**Figure 2. The structured argument that emerged from the classroom discussion during Instance 1.**

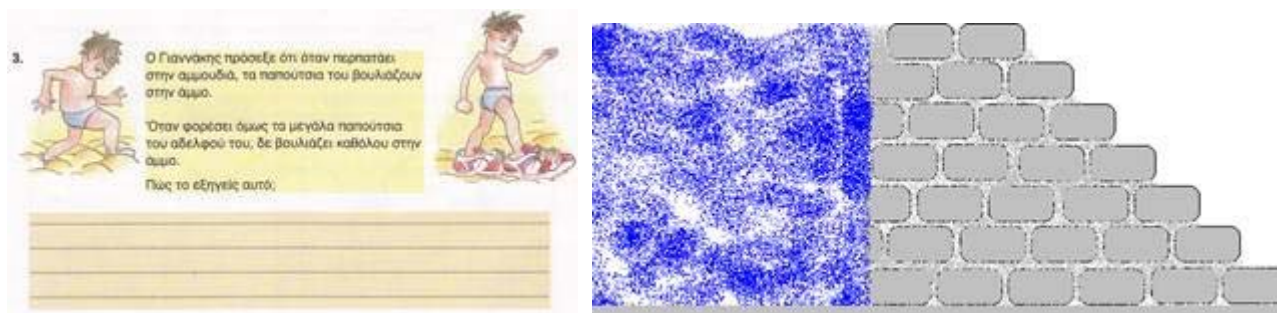
Instance 2

TAP was revised again after two weeks based on the same question as in Instance 1. Students made an effort to revise the components of the argument and their names and a complete structured argument was built on the white-board. Students’ effort was scaffolded by the teacher and their peers.

Instance 3

Students’ next attempt to practice structured argumentation followed after three weeks and was related to two questions given in an evaluation test on pressure and hydrostatic pressure. For the first question, students had to provide an argument on which of two pairs of shoes was better to be worn while walking through sand, which

related to the topic of pressure (Figure 3). In the second question, students had to explain the reasons for which the supporting wall of a dam was built having a slope and a gradually increasing thickness from top to bottom, which related to hydrostatic pressure (Figure 3).

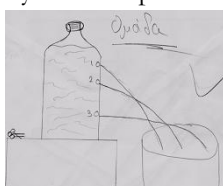


**Figure 3. Question related to pressure (left) and hydrostatic pressure (right).**

The teacher's motivation for practicing argumentation was the quality of students' arguments as in the question related to pressure, 12 out of 15 students built arguments classified as CD arguments (Cluster 2 arguments) and the rest of the students expressed arguments classified as CDW arguments (Cluster 3 arguments). At the beginning of the lesson, a whole-class discussion was facilitated by the teacher through which students evaluated the adequacy of their arguments in the question related to pressure and an argument based on TAP was constructed on the white board; through this effort, students were given the opportunity to revise the structure of the argument, name its various components and build a complete argument. Afterwards, students were asked to work in their groups (three groups of 4 and one group of 3) in order to first evaluate the initial argument they had constructed in the second question of the test, related to hydrostatic pressure, and afterwards build a revised argument based on TAP. Their effort was scaffolded by the teacher, their peers and the constructed argument of the previous question concerning pressure that was portrayed on the white-board. An analysis of the revised arguments revealed that students, when scaffolded, could build Cluster 4 or Cluster 5 arguments. An example of how students' argument evolved through their effort to build a new argument and revise their previous one is illustrated in Table 1. In the revised argument, students presented the general rule, which was suggested in a previous lesson, as data to backup their claim, they then justified the connection between the data and their claim by proposing a warrant that explained the significance of the general rule in terms of the problem and finally, they suggested an experiment they had performed during a previous lesson as a backing to justify the authority of their warrant.

**Table 1. An example of a group's initial and revised argument about the question on hydrostatic pressure.**

Group 2 Initial Argument	Group 2 Revised Argument
Because as the water is next to the wall, the hydrostatic pressure is very big. So, if they built a vertical wall it would collapse. That is why they built it in this way so that it can hold the hydrostatic pressure and not collapse.	It would be better if the wall was built diagonal because the deeper the water the more the hydrostatic pressure increases so as the wall was built diagonal then it can bear the hydrostatic pressure more than a thin wall. The deeper the water the more the hydrostatic pressure increases because it depends on the depth of the water. An experiment that we've done and supports this is when we had a bottle and we opened 3 small holes on its side. Then we filled it with water and we saw that from the last hole more water was flowing than the first and the second because the deeper the depth of the water the more hydrostatic pressure is applied.



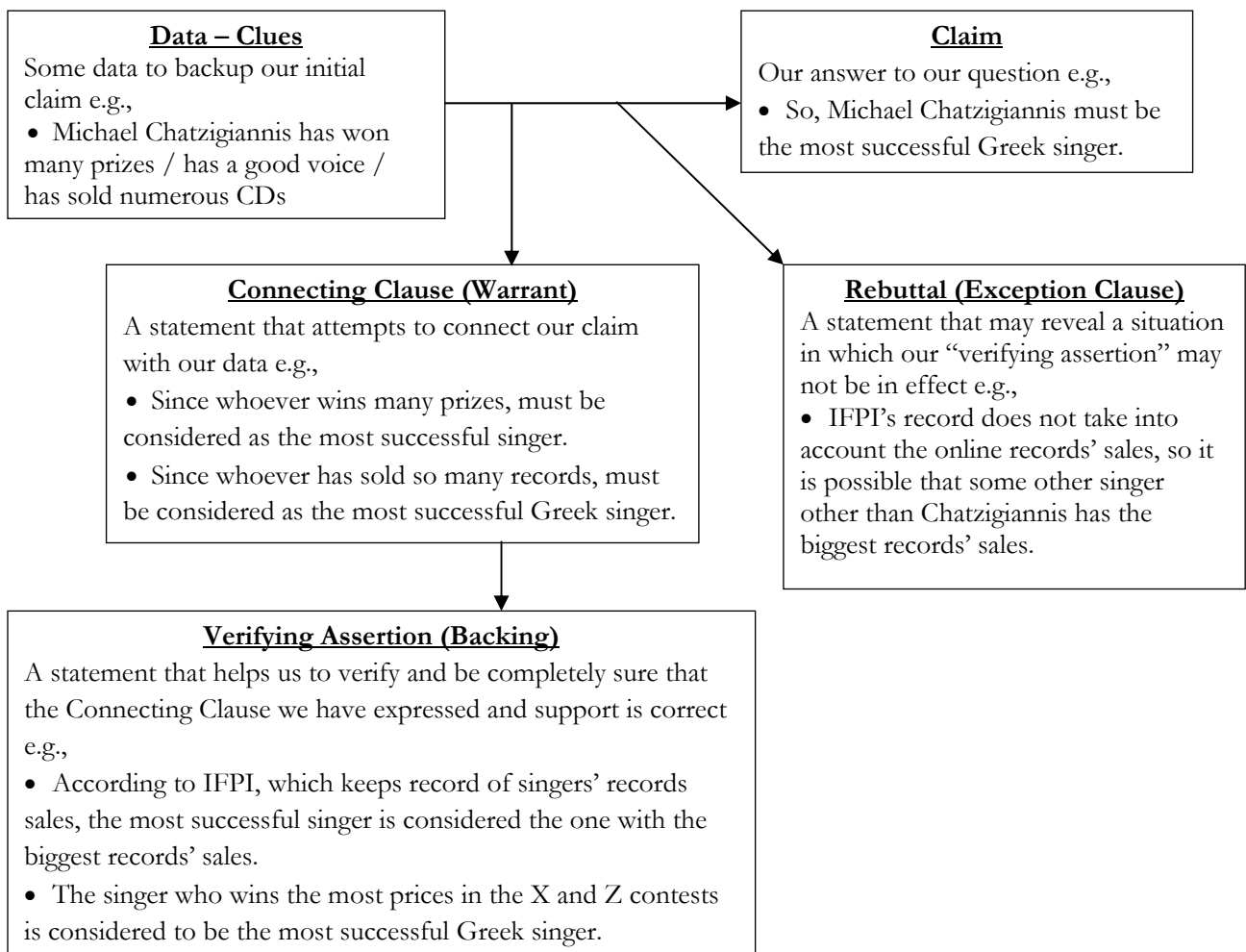
\* The picture was a part of students' written answer.

Instance 4

The groups which had constructed the best argument in terms of structure in the question related to hydrostatic pressure during Instance 3 were given the opportunity to read aloud their argument in the following lesson. During a whole class discussion that followed, students were given the opportunity to comment on the quality of the arguments through which they were able to revise the structure of the argument, based on TAP, and the names of its constituent components. Their effort was scaffolded by the teacher and their peers.

Instance 5

Students were given an additional opportunity to revise TAP in a lesson that followed after three weeks. The question related to a non-scientific subject so that students could realise that structured argumentation, based on TAP, could be utilised in various social instances as well. The question required students to argue who they considered the most successful Greek singer was. Through a whole-class discussion that followed, students had the opportunity to revise and name the components of the argument, based on TAP, construct a complete argument and realise in a better way the nature of the warrant and the backing of the argument, related to a non-scientific subject. A diagram of TAP with the complete argument built about the question concerning the most successful singer was placed in students' textbooks and was also portrayed in the classroom through a poster that was placed on the notice board for future reference (Figure 4).



**Figure 4. The argument built concerning the question about the most successful Greek singer.**

### Instance 6

The next argumentation instance related to a bonus question administrated to students in an evaluation test on electricity and electrical circuits; the question required students to work in their groups and produce an argument on whether the Christmas lights were connected in parallel or in a series circuit. Students' effort was scaffolded by the poster depicting TAP, which was on the notice board, and the TAP diagram that was placed in their textbooks during Instance 5. A group's argument is following presented as a representative example of the arguments built by the groups; letters in brackets suggest the constituent components of the argument as these emerged from the post-analysis that was performed based on TAP:

If one bulb is burned out then all the others will continue to work [D] because electricity can go through the other wires [W]. This is observed when we have a circuit where lights are connected in parallel [W]. We have proved this with the experiment that we did with the light bulbs that were connected in parallel and when we took out a bulb the electricity could still go through and the other bulbs worked [B]. But they might have placed the lamps in series and when one is burned out then all the others will stop working, but maybe there is a problem with the electricity in the entire house and that's why all the lights went out [R]. (Written answer, Group 1)

A post-analysis of students' arguments revealed that all group arguments that were produced could be classified as Cluster 4 or Cluster 5 arguments (CDBW or CDBWR).

### Instance 7

Group arguments constructed during Instance 6 were read aloud during the next lesson. Afterwards, each group had the opportunity to name the components of their argument and explain why they believed their argument could be considered as a complete argument, based on TAP. Students' effort was scaffolded by the teacher and their peers. This was considered as the final instance in which students had the opportunity to revise the use of TAP.

## Conclusions and Implications

The findings of the research suggest that positive improvement of primary school students' argumentation skills can be observed through explicit teaching of argumentation by utilizing Toulmin's Argumentation Pattern (Toulmin, 2003) and by scaffolding students' argumentation efforts. This seems to be in agreement with what other researchers have suggested (e.g., Kuhn & Udell, 2003), that through explicit teaching, students' argumentation skills can be enhanced.

This research study notes the importance of the structure of the argument for supporting students' argumentation skills, as other researchers have suggested (e.g., Erduran et al., 2004; Walker & Zeidler, 2007), and proposes that it should be considered as an integral part of argumentation efforts employed in science education, prior to engaging students with the process of examining and assessing the inner validity of arguments.

Nevertheless, it needs to be noted that, for results to last, the effort needs to be continuous, aiming at assisting students reach a point when they internalise TAP, resulting in them being able to structure an argument without any external scaffold as well as being able to assess the adequacy of the structure of their arguments. Additionally, the study stresses out the role of the teacher as a supportive mediator of students' efforts and as a facilitator of argumentation opportunities through which students can be enabled to structure and assess their arguments.

Lastly, the research suggests that Toulmin's Argumentation Pattern (Toulmin, 2003) can be considered as a significant mental scaffold for students, as its well-structured form can be a significant mediator of students' argumentation efforts. It is also proposed that through the use of TAP students can be enabled to assess their

arguments and keep track of the development of their argumentation skills; something that could be considered as an intrinsic motivation for them.

## References

- Chambliss, M., & Murphy, P.K. (2002). Fourth and fifth graders representing the argument structure in written texts. *Discourse Processes, 34*, 91–115.
- Cross, D., Taasobshirazi, G., Hendricks, S., & Hickey, D. T. (2007). Argumentation: A strategy for improving achievement and revealing scientific identities. *International Journal of Science Education, 30*(6), 837-861.
- Driver, R., Asoko, H., Leach, J., Mortimer, E., & Scott, P. (1994). Constructing scientific knowledge in the classroom. *Educational Researcher, 23*(7), 5-12.
- Erduran, S., Simon, S., & Osborne, J. (2004). TAPping into argumentation: Developments in the use of Toulmin's Argument Pattern in studying science discourse. *Science Education, 88*(6), 915-933.
- Jiménez-Aleixandre, M.P., Bodríguez, A.B., & Duschl, R.A. (2000). “Doing the Lesson” or “Doing Science”: Argument in High School Genetics. *Science Education, 84*, 757-792.
- Kuhn, D. (1991). *The skills of argument*. New York: Cambridge University Press.
- Kuhn, D., & Udell, W. (2003). The Development of Argument Skills. *Child Development, 74*(5), 1245–1260.
- Newton, P., Driver, R., & Osborne, J. (1999). The place of argumentation in the pedagogy of school science. *International Journal of Science Education, 21*(5), 553-576.
- Osborne, J., Erduran, S., & Simon, S. (2004). Enhancing the Quality of Argumentation in School Science. *Journal of Research in Science Teaching, 41*(10), 994-1020.
- Sandoval, W.A., & Millwood, K.A. (2005). The Quality of Students’ Use of Evidence in Written Scientific Explanations. *Cognition and Instruction, 23*(1), 23-55.
- Toulmin, S. (2003). *The Uses of Argument*. New York: Cambridge University Press.
- Tytler, R., & Peterson, S. (2003). Tracing Young Children’s Scientific Reasoning. *Research in Science Education, 33*, 433–465.
- Walker, K.A., & Zeidler, D.L. (2007). Promoting Discourse about Socioscientific Issues through Scaffolded Inquiry. *International Journal of Science Education, 29*(11), 1387-1410.
- Zeidler, D. (1997). The Central Role of Fallacious Thinking in Science Education. *Science Education, 81*, 483–496.



# ARGUMENTATION & SCIENTIFIC CONCEPTIONS IN PEER DISCUSSIONS: A COMPARISON BETWEEN CATALAN & ENGLISH STUDENTS

Marina Castells  
University of Barcelona

Sibel Erduran  
University of Bristol

Aikaterini Konstantinidou  
University of Barcelona

## Abstract

*The purpose of this study is to compare the arguments used by English and Catalan Pre-service Primary Teachers students in peer discussions about two scientific tasks. The comparison is based on argumentative schemes of their arguments as well as on ideas, conceptions and beliefs that are in their base. The analysis is carried out at three levels. At the first level, we compare the number of arguments by tasks and by country; at the second level, we analyse arguments and make a comparison between types of argumentative schemes by tasks and by countries. More in depth, qualitative descriptions were carried out in order to illustrate the similarities and differences between the Catalan and English students' arguments and scientific conceptions. Results illustrate that the arguments generated by students are quite similar in both samples in terms of number of arguments and frequencies of types of arguments, but with some differences in the order of these frequencies related to specific tasks. More relevant is the qualitative difference in the way that appellations are made to give evidence and theories, given the identification of premises and argumentative schemes; this favours good understanding of scientific knowledge.*

## Introduction

With respect to the aim of our research, there have been attempts to identify general patterns of reasoning that were not related to a specific content of the questionnaire or the interview, commonly used in research about science conceptions of students and that in some way could explain the ideas of students (Andersson, 1986; Guidoni, 1985, 1990; Maurines, 1991; Rozier and Viennot, 1991; Viennot, 1996). Researchers from different fields have given other interpretations of these conceptions, in some cases, through cognitive entities as “schemes”, “p-prims”, “mental models”, and so on (Rumelhart, 1980; DiSessa, 1980; Genter and Stevens, 1983; Gutiérrez & Ogborn, 1992). These works contribute to our thinking that beneath the specific forms of reasoning of the students some common or general ways of reasoning, or patterns of argumentation schemes, can be found. As our hypothesis is that these ways of reasoning or types of arguments are learnt by students in society and mainly outside the school, there may be differences among different communities. Our research proposes to find these differences between Catalan and English students, so that this research will contribute to comparative studies (related to argumentation) that are scarce in the literature.

As our interest is mainly on types of patterns of arguments to compare the reasoning of Catalan and English students related to scientific activities, we suppose that theories of argumentation that consider argumentative schemes could provide an interesting framework for our research, which will give a new way to better understand the scientific conceptions of the students and will ease that comparison.

## Theoretical framework

As we are interested on the spontaneous argumentation of the students that are plausible and related to solve a difference of opinion, both frameworks that consider the argumentation as a social practice to convince and critical dialogues will be useful. As we try to compare arguments, theories that focus mainly on types of arguments are suitable. Thus, we use the Theory of Argumentation from Perelman & Olbrecht-Tyteca (1958) and the Schemes for Presumptive Reasoning of Walton (1996, 2006), which will be complemented with some of Aristotle's "topoi" because they provide us with common sense argumentative schemes and premises, which we expect to find in the discussions of the students. These theoretical bases have been used in science education research only in few studies (Duschl and Guitomer, 1997; Pontecorvo & Giradei, 1993; Jimenez-Aleixandre et al., 2000; Sandoval and Millwood, 2005; Duschl, 2007; Fagúndez & Castells, 2007; Konstantinidou, 2008); our research will extend those works trying to combine several theories of argumentation in our analytical framework and thus, we will contribute to the theoretical level in relation to argumentation as well. We presented these theories of argumentation in previous papers (Castells et al., 2007; Konstantinidou & Castells, 2008), we will not comment about them here because of space.

According to our perspectives, we consider an argument consisting of a thesis, one or several premises and the scheme that allows the transference of the accepted premises to the thesis or conclusion. We have to see these elements, not in a lineal direction, but interrelated among them. We share the Perelman's (1986) notion of premise, that means, the data or agreements on which the arguments are built. The premises can be of several types. From the real: facts<sup>1</sup>, truths or theories and presumptions. From the preferable: values, hierarchies of values and "loci"<sup>2</sup>. The argumentative schemes of single arguments are the discursive structures that allow to transfer the agreements from the premises to the theses. These argumentative schemes are categorized differently according the theory of argumentation considered, but many of those categories, coming from different theories, may share characteristics that makes sense we combine those categories in some new ones.

## Methods and Samples

The *aim* of the research is to compare arguments of Catalan and English Pre-service Primary Trainee Teachers in small discussion groups about scientific tasks and to infer and explain about the scientific misconceptions of the students. This is part of a wider research about qualitative comparison of the spontaneous argumentation<sup>3</sup> of the students.

Our interest focuses on types of patterns of arguments, or argumentative schemes, to explain the scientific conceptions of the students and, given that we use categories from several Theories of Argumentation, we will also contribute to the theoretical level in relation to argumentation.

---

<sup>1</sup> Facts are universal agreements, and therefore unquestionable. An argument gains convincing force if it is based on facts (Perelman & Olbrechts-Tyteca, 1958)

<sup>2</sup> General *Loci*: They are premises of general carácter that are useful for all sciences and all kind of discursive genres. They are affirmations about what is presumed to be of higher value in any circumstances whatsoever, (Perelman & Olbrechts-Tyteca, 1958; Perelman, 1962)

<sup>3</sup> The wider research comparing English and Catalan students argumentation about scientific and socioscientific tasks have received the support of the Anglo-Catalan Society and the DURSI (Generalitat de Catalunya) by the Project with Reference N. 2006 PBR 10019 based at University of Barcelona in collaboration with University of Bristol.

## Research questions

What types of argumentative schemes can we find in the argumentations of the students? Are they related to countries? Are they related to specific tasks?

What type of premises (facts, theories or values) are the arguments of the students based on? Are these premises related to the tasks? And to the countries?

Which scientific conceptions of the students can be drawn from their premises and thesis? Are they related to the countries?

## Data collection and analysis

The **data** comes from the transcriptions of the discussions of students among their peers about two tasks: (1) free falling and (2) floating and sinking and climate change.

Task 1: *Free fall and the spit*. A physics problem was presented in the form of a cartoon taken from a magazine which has no connection with physics teaching or scientific popularization materials. The situation is about a man that first throws a spit from a window in a building of several flats and then, he throws himself down from the same window.

Task 2: *Floating and sinking and climate change*. A physics and social problem is presented in the form of a picture with ice floating on the water, where the students have to do a prediction and, afterwards another picture of what will happen in reality is shown to students. Then, they have to argue about this result compared to their predictions and after, students have to relate the specific case of these pictures to the climate change in the world.

Three groups of students in Bristol and three groups of students in Barcelona participate in the research. The groups were between three and five volunteer students. All the groups performed the tasks outside the timetable of classes in the university. Students didn't receive specific instructions about the scientific topics of the tasks, neither about argumentation. A researcher was in the room during the discussions, but her role was only to give general instructions and enforce the conversation with neutral questions if she realised that it was appropriate.

The **analysis** is carried out at several levels. At the first level, we identified arguments by means of thesis, in each argument we identify thesis, premises and argumentative schemes or patterns of the argument and we compare the number of arguments by tasks and by country; at the second level, we make a comparison between types of argumentative schemes by tasks and by countries. Frequency counts were recorded giving a quantitative indication of arguments generated and of types of argumentative schemes. More in depth, qualitative descriptions are also carried out in order to illustrate the similarities and differences between the arguments of the teachers of Catalan and English students and their scientific conceptions. Based on the results, we try to explain certain ideas or scientific conceptions more frequently found in one or other country, or task. We will present here the analysis done in a specific argument to illustrate how we proceed.

However, the analysis is not easy because in the interventions of the students there are many incomplete arguments or many implicit parts of the arguments we have to suppose; very often we would need information about the ideas of the students or the patterns of reasoning to “understand” what they “want” to say. Also the real argumentation in which we isolate arguments make them to lose their meanings. There are different possible levels of argumentation to consider. For example, the previous case could be analyzed taking in consideration partial arguments that integrate the global argument, the arguments form a series of arguments that goes in the same direction to the thesis that affirm there is climate change. Our level for the analysis of arguments is intermediate.

## Analysis and Results

### Counting Arguments and Types of Argumentative Schemes

a) There is no difference between countries related the total number of arguments identified in the two tasks together, neither related to the number of arguments per minute. This number is bigger in Barcelona but the difference is not considerable. We measure the number of arguments per minute defined by the relation between the total number of arguments in the whole activity and the mean of the duration time of each activity.

b) The Ice task facilitates giving more arguments than the spit task although the number of arguments per minute is bigger in the spit task. We think that this result is influenced by the way we presented the tasks; in the ice task, students had to do a prediction first, then we gave them the result in a picture and they had to argue about it, and finally, they had to think about the climate

c) The general tendency in the total number of arguments by task and in the number of arguments per minute is very similar between countries. In both countries, the ice task tends to give more arguments but the rate of the argumentation is bigger in the spit task. We can interpret these results because the spit task treats a situation that is more familiar to students than the one of the ice task in both countries. Students have possible arguments on hand more easily. Evermore, in the ice task there are two different contexts, and so this task is more complex for the students.

**Table 1: Analysis of an Argument from the Ice task**

---

<i>Student intervention:</i> "...And more, the climate change makes that the heat arrive before and makes that the trees produce flowers before and that in February the allergies begin because of the pollen although they would have to begin at the end of March..."
<i>Thesis:</i> There is climate change (implicit)
<i>Premises:</i> 1) The climate change makes the heat arrive before (truth or presumption) 2) The flowers of the trees bloom before (fact) 3) The flowers produce pollen (fact or truth) 4) The allergies begin in February before the normal time at the end of March) (fact) 5) The allergies are caused by the pollen (truth)
<i>Description of the Argument:</i> We know that the climate change is produced because there are events that are consequence of the climate change.
<i>Argumentative scheme:</i> Facts and consequences
<i>About the scheme:</i> In using this scheme the speaker asserts that because certain events exist, then certain other events can be expected to exist either simultaneously or subsequent in time as a result of the first events. (Walton, 1996, 2006) It is a scheme based on a causal nexus, a type of linkage of coexistence that is supported by a structure of reality, (Perelman & Olbrecht-Tyteca, 1958)

---

**Table 4. Summary counting arguments by tasks and separated countries (Bristol / Bcn)**

Task Bristol	Total Number of Arg.	Number of Argument per minute
Spit	<b>40</b>	<b>2.17</b>
Ice melting	<b>59</b>	<b>1.60</b>
Total	99	1.79

Task Bcn	Total Number of Arg.	Number Argument per minute
Spit	<b>43</b>	<b>2.09</b>
Ice melting	<b>56</b>	<b>1.64</b>
Total	99	1.81

### *Specifying the analytical framework*

Our analytical framework combines the list of schemes of Perelman (1962) and the list of schemes of Walton (1996, 2006), which are completed by some topics of Aristotle (IV bC). We have proceeded from the theoretical framework to the analysis and *vice versa* several times. That means, from the lists of schemes (Perelman, Walton) we identified some schemes in the arguments of students in the recorded discussions. We compare schemes that are similar to Perelman's and to Walton's list of scheme. From the identified schemes in the dialogues, we elaborate a list of type of argumentative schemes, which joint the categories of these authors and in some cases combine with arguments (topics) of Aristotle in new big categories. We presented a first version of this analytical framework at the GIREP 2008 Conference (Castells, Erduran & Konstantinidou, 2008), which we change in some points here from our last analysis. At following we give the list of these main categories of the synthesis we have used in this paper, the list is still provisional, more analysis is need and it could produce new changes in this list of Types of Schemes:

**Quasilogical arg. based on Logical Relations** (transitivity, implications from a rule; implications from a classification, implications from a definition, contradiction and incompatibility, from the proper -several topics from Aristotle-, etc.)

**Quasilogical arg. based on Mathematical Relations** (by identity/rule of justice, of reciprocity or symmetry, by the inverse, of compensation, of complementarity, of contradiction, of comparison (by the sacrifice), of all and parts, of division/addition, by probabilities, etc.)

**Facts and Consequences** (pragmatic argument, argument by mean and end; from correlation to hypothesis, from correlation to cause, from cause to effect, from effect to cause, from consequences, from sign, etc.) (Linkages of Succession)

**Gradualism** (the procedure by stages, of direction, the soaped slope or of the finger in the gear, from gradualism, of the slippery slope, of propagation, of overcoming, of unlimited development, etc.).

**The Waste** (of waste, of sacrifice, based on opportunity, of shortcoming, of redundancy, of the decisive, etc.)

**Group and Component** (Liaison of Coexistence: person & acts; group & individual, essence & correlation, body and physical behaviour, by Commitment, arg. against person, etc.)

**From Social Acceptation** (by authority or expert opinion-person, text, institution, scholar rule, from popularity, ethotic argument, topics of quantity and topics of quality, etc.)

**Double Hierarchy** (DH, of degree and order, by more -> more, arg. *A Fortiori*)

**By the Particular case** (by the example, by the illustration, by the precedence, by the model)

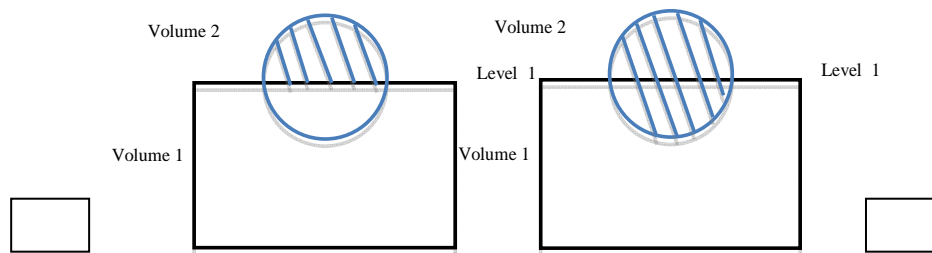
**Analogy** (analogy, metaphor)

***Some examples of arguments to illustrate argumentative schemes***

We will illustrate some of these categories with other cases from Bristol or from Barcelona, in the next cases we also will comment about the identified premises

**Table 5. Analysis of arguments in a student S1 intervention about the Ice task**

<i>Student S1 intervention:</i> “I think the water will rise when the ice melts. As the ice melts it adds to the volume of the water, therefore increasing the water level”
<i>Thesis:</i> The water will rise when the ice melts.
<i>Premises:</i> 1) As the ice melts, it adds to the volume of the water, (fact) 2) If the volume of the water in a beaker increases, the level of the water will rise. (implicit fact)
<i>Description of the Argument:</i> Quasilogical of Mathematics Relationship (a type of argument by Division, related to the mathematics relationship of Addition)
<i>About the scheme:</i> It is a type of Quasilogical argument into the type of arguments by Division which, from the identified parts, assumes the sum of parts equals the whole and thus infers about the whole from the parts or <i>viceversa</i> .



**Figure 1. Representation of the geometrical views of the initial situation of the Ice task of S1 and S2**

In what student S1 says we interpret in “it adds to the volume of the water”, this “it” as a volume, the volume 2, marked in the first drawing of the figure 1. The student’s argument, as a whole, seems related to a specific “geometrical view” of the situation, he “sees” the line of the water’s level separating the content of the beaker (volume 1) from the part of the ice above of the level 1 line (volume 2). So, for this student, when the ice melts, its water volume is added to the volume 1 of the beaker and so, the level will rise. We present in the following table the analysis done. From his intervention, we can think student S1 perhaps would share a misconception: “The volume of the water doesn’t change when it changes to ice and vice-versa”.

We will comment the intervention of another student S2 related to the same task.

In this case, we can interpret that student S2 has a “geometrical view” of the situation as the volume 2 of ice differentiated from the volume 1 of the water of the beaker; in this view, the ice is considered an external system from the water of the beaker.

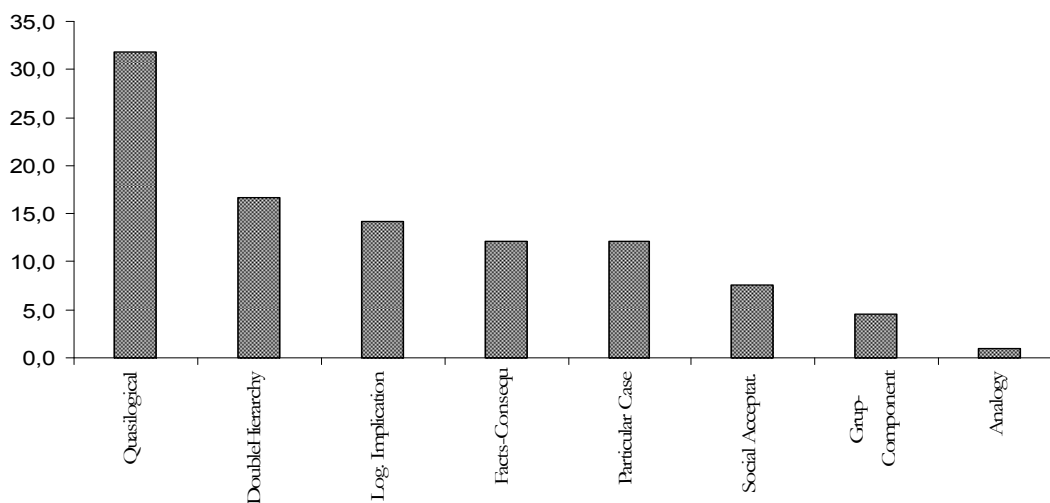
With the previous examples, we try to show that the study of argumentation in real contexts is more than identifying thesis, premises and schemes. In this last example, student S2 seems to use a sequential reasoning, a type of general reasoning identified by other researchers (Viennot, 1996; Castells, 2001). For this case, we may conclude that the student S2 gives an incorrect answer because he has argued by Device of Stages in a not appropriated way to this situation, which impedes him to have a global appreciation of the situation.

**Table 6. Analysis of arguments in a student S2 intervention about the Ice task.**

<i>Student S2 intervention:</i> “I think that the water level will stay the same, because when the ice is <u>first</u> added to the water, displacement takes place forcing the water level to rise. <u>As the ice melts</u> this would counteract the displacement, but obviously the melted water <u>would add</u> to the volume, therefore creating a <u>neutral effect</u> where the water level would stay the same”.
<i>Thesis:</i> The level of the water will stay the same
<i>Description of the argument:</i> It is a complex argument that includes several arguments. As a whole, we can identify a Method or Device of Stages (Perelman, 1982) but in every stage we can identified other alone arguments. The sequence in the argumentation of student S2 is the following: 1 <sup>st</sup> ) There is a specific level of water when no ice is in the beaker (level 1), 2 <sup>nd</sup> ) the solid ice system is put into the water and so, the level of the water will rise (level 2), 3 <sup>rd</sup> ) when the ice melts (the solid disappears) the level of the water would have to decrease, but 4 <sup>th</sup> ) as the water from the melted ice is added to the water of the beaker, it will compensate the decreasing, and the level of the water will be the same.
<i>Scheme:</i> In the 2 <sup>nd</sup> stage and the 3 <sup>rd</sup> stage we can identify Quasilogical schemes of Logical Implication; and in the 4 <sup>th</sup> stage, the scheme is a Quasilogical of Compensation (based on mathematical relations). Together is a Method or Device of Stages.
<i>About the Scheme:</i> The Method or Device of Stages is a method used when the gap between the theses the audience accepts and those the speaker defends is too great to be overcome all at once, it is advisable to divide the difficulty and arrive at the same result gradually. Quasilogical Scheme of Logical Implication are schemes which claim to be rational because they resemble the patterns of formal reasoning as Implications from a Law or Theory, Implications from a Classification or from a Definition, etc. Quasilogical of Compensation is a type of scheme based on a mathematics relation of

***Percentages of types of argumentative schemes in the total sample***

There are types of argumentative schemes that are found with bigger frequency than others in our sample. The order of the percentages of the types of argumentative schemes identified counted in the total sample (Bristol and Barcelona) (198 arguments) can be read in the figure 2, the type of schemes that have the biggest percentages are into de group of Quasilogical Based on Mathematics Relations schemes. It is not a strange result considering we proposed scientific tasks.



**Figure 2. Percentages of types of schemes on the total number of schemes (Bristol & Bcn)**

**Comparing the percentages of types of argumentative schemes by tasks**

We find that the types of arguments with the biggest percentages are the same in both tasks, but the order of percentages presents some differences between tasks. In the ice task the biggest percentage corresponds to the Quasilogical Based on Mathematics Relations scheme, instead in the spit task in which the biggest percentage is the Double Hierarchy scheme.

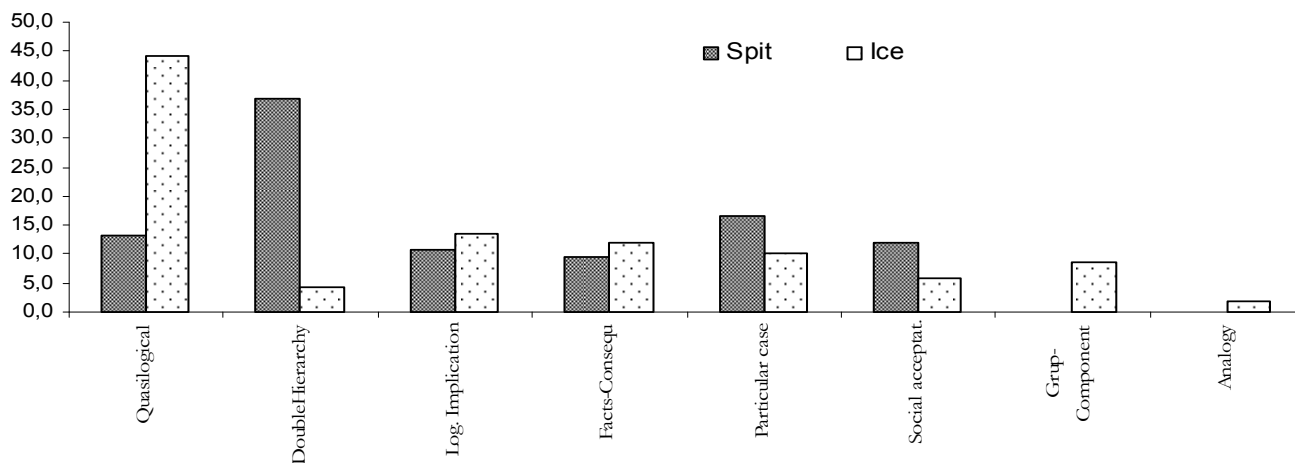


Figure 3. Comparison of percentages of types of argumentative schemes by tasks (Bristol & Bcelona)

**Comparing percentages of the types of argumentative schemes by countries (Spit + Ice)**

In the two separated samples (Bristol and Barcelona) we found that the order of percentages of schemes is not exactly the same, but the category with the biggest frequency coincides in both samples, this is the Quasilogical argument based on Mathematical Relations, which seems linked to an appreciation of the activities as scientific activities. There are clear differences relating the percentages of other types of argumentative schemes that we find in both countries but those are not easy to interpret (we don't include the table here), there is difficult to know if these differences are by the effect of the countries or of the tasks.

**Comparing the percentages of argumentative schemes by tasks and separated countries**

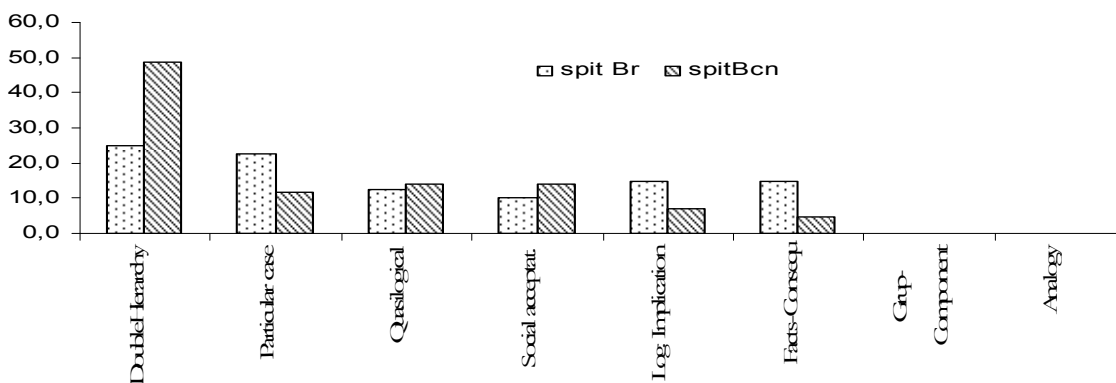


Figure 5. Percentages of types of argumentative schemes by Spit task by countries (Bristol / Bcn)

Analysing the tables of the figures 5, we found that related to the spit task although the Double Hierarchy scheme is the most frequent in Bristol and in Barcelona, the difference between the percentages is more big than the difference between the percentages of the other types of schemes, result that can be interpret as students from Barcelona answer the spit task near to the arguments the scientists use in their argumentations, using an argument that implies students reason identifying variables and supporting the arguments on their ideas about relationships between factors o magnitudes they consider in the structure of reality.



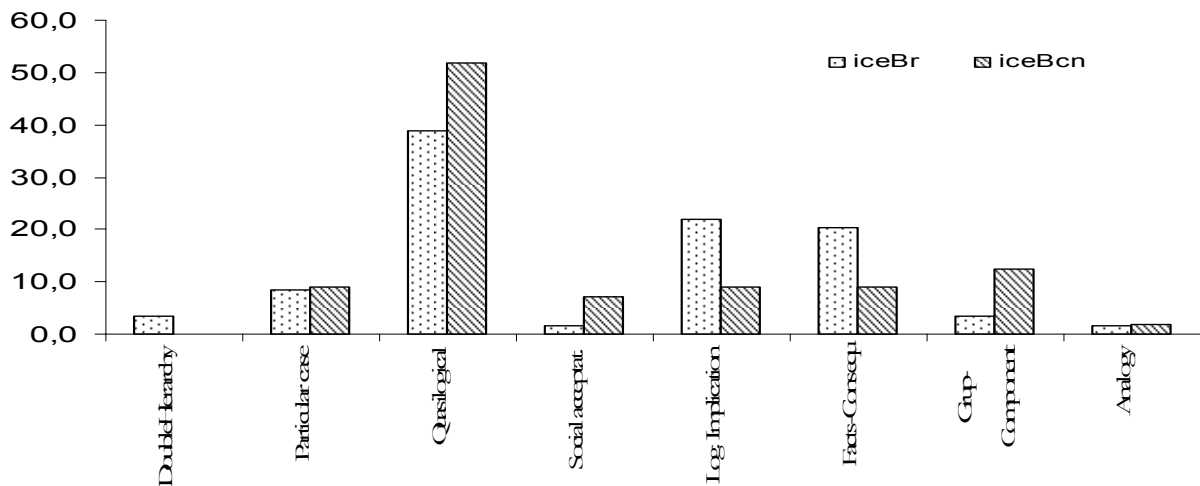


Figure 6. Percentages of types of argumentative schemes by Ice task by countries (Bristol / Bcn)

If we compare both tables 5 and 6 with the table 4, the global result is that there are differences in the percentages of types of schemes by tasks in both countries. For example, in the Spit task the scheme most used is the Double Hierarchy one, whereas in the Ice task the most frequent scheme, in both countries, is the Quasilogical argument Based on Mathematical Relations.

### Discussion of Results

The total number of arguments and the number of arguments per minute are similar in both countries, however, there are small differences in relation to the types of tasks. The ice task facilitates to give more arguments than the spit task although the number of arguments per minute is bigger in the spit task. This result can be interpreted by the influence of the way the tasks are presented and of their content. Related the types of schemes identified counting for the total sample, the type of schemes with the biggest percentages are into de group of Quasilogical Based on Mathematics Relations schemes. It is not a surprising result considering we proposed scientific tasks. These schemes are followed in order of percentage by the Double Hierarchy, Logical Implications, These results indicate students can identify variables in the situations presented in the tasks and that they use schemes that are near to the arguments the scientist use. But the percentages also say us that they use other types of arguments that are easy to find in not scientific contexts too, like the argument by the Particular Case and the argument by Facts and Consequence.

The differences in the percentages of types of schemes by tasks are bigger than the differences in the percentages of types of schemes by countries. For example, in the spit task the scheme most used is of Double Hierarchy one. This is an interesting result because means that students see variables and relationship between them in the spit task, as the scientist would do in other scientific context. In the ice task the most used scheme is the Quasilogical argument Based on Mathematical Relations, but among these mathematical relations the ones with the biggest percentatges are the schemes of Addition and the scheme of Compensation. This result indicates that in this activity the reasoning of students seems be mainly by systems and elements of the systems, that means students reason by having their topological considerations as an important factor that direct the way students argue. In summary, the way students “see” globally the situations presented in the tasks is the most important factor that affect the types of schemes students use.

The argumentative analysis has been very useful to constatate and to act in relation to the scientific conceptions students share in relation to those activities. In concret, in the spit task, the majority of students share the misconception that the speed of the free fall depends of the bodies’ mass. In the case of the Ice task, students accept that it is producing a climate change but the argumentative schemes are mainly from expert opinion or authority (of media) or by examples, that can be also from media. But students, in general, share misconceptions or show a very bad scientific knowledge related to the question about floating and sinking.

There are not very big differences between students of Bristol and of Barcelona related their abilities to argue. But we find some differences related the premises used in the arguments, students of Bristol seems based more on examples or illustrations coming from the media and students in Barcelona based more on social or political ideas or values shared.

## Conclusions and Implications

Results confirm the necessity to improve the knowledge of the teachers about the arguments students give communly and especially their disposition to question their (or of the other) premises in order to foster critical thinking and conceptual change. The identification of premises and argumentative schemes favours a good understandings of the way students think and about which misconception they have. These understanding provides argumentative resources for the teacher to be used to help students to improve their scientific knowledge and their critical thinking.

## References

- Andersson, B. (1986) The experiential Gestalt of causation: a common core to pupils' conceptions in Science. *European Journal of Science Education*, 8(2) , pp151-171.
- Castells, M. & Pintó, R. (2001) Students' reasoning strategies in solving qualitative problems of galilean relativity. In: *Physics Teaching Education Beyond 2000*. R. Pintó & S. Suriñach (eds). Barcelona: Elsevier Edition
- Castells, M., Enciso, J., Cerveró, J.M., Lopez, P., Cabellos, M. (2007) What can we Learn from a Study of Argumentation in the Students Answers and Group Discussion to Open Physics' problems? In: Pintó & Couso (Eds) *Contribution for Science Education Research*. Dordrecht: Springer, pp 427-431
- Castells, M.; Erduran, S.; Konstantinidou, A. (2008) Comparison between Catalan and English Students' Argumentation Discussing about Scientific and Socioscientific Issues. GIREP 2008 Conference. Nicosia (Cyprus)
- Driver, R. Newton, P. & Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science Education*, 84, 287-312.
- Duschl R. & Osborne, J. (2002) Supporting and Promoting argumentation discourse. *Studies in Science Education*, 38, 39-72
- Duschl, R. (2008) Quality Argumentation and Epistemic Criteria. At: Erduran & Jiménez-Aleixandre (Eds) *Argumentation in Science Education*, Netherlands: Springer, 159-175
- Erduran, S.; Simon S. & Osborne, J. (2004) TAPping into Argumentations: Developments in the Application of Toulmin's Argument Pattern for Studying Sciences Discourse. *Science Education*, 915-933
- Erduran S & Jiménez-Aleixandre, M.P. (eds) (2007) *Argumentation in Science Education*. Netherlands: Springer
- Fagundez, Th. & Castells, M. (2007) Una aproximación seimótico-comunicativa a las explicaciones de física universitaria. *Revista Brasileira de Pesquisa em Educação em ciências* V. 7 N°3
- Guidoni, P. (1985) On Natural Thinking. A: *European Journal of Science Education*, 7, pp133-140
- Jiménez-Aleixandre, M.P, Burgalló, & Duschl R.A. (2000) "Doing the lesson": or "doing science": Argument in high school genetics. *Science Education* 84 (6) 1-36
- Konstantinidou, A (2008) Argumentation and Science Education-Review. *International Syros Conference. Technoscience: Historical, Sociological and Philosophical Perspectives*. (Proceedings, in press)
- Konstantinidou, A. & Castells, M. (2008) Argumentation as a Means for Understanding Science: Past and Present. Proceedings of 3er International Conference of the European Society for the History of Science. Vienna (CD) (In process)
- Perelman CH & Olbrechts-tyteca, L. (1958) *Traité de l'Argumentación. La nouvelle rhétorique*, Bruxelles: Editions of Université of Bruxelles (1<sup>st</sup> edition, 1958)
- Simon, S., Erduran, S. & Osborne, J. (2006). Learning to teach argumentation: Research and development in the science classroom. *International Journal of Science Education*, 27(14), pp.137-162.
- Viennot, L. (1996) *Raisonnement in Physics: La part du sens commun*, Pratiques Pedagogiques, Paris: De Boeck and Larcier
- Walton, D. (1996). *Argumentation schemes for presumptive reasoning*. Mahwah, N.J.: Lawrence Erlbaum.
- Walton, D. (2006). *Fundamentals of Critical Argumentation*. New York: Cambridge University Press.

# ARGUMENTATION AND SCIENTIFIC REASONING: THE “DOUBLE HIERARCHY” ARGUMENT

Aikaterini Konstantinidou  
University of Barcelona

Josep M<sup>a</sup> Cervero  
University of Barcelona

Marina Castells  
University of Barcelona

## Abstract

*In the present study we have investigated junior high school students' arguments related to scientific and socioscientific issues. In a previous study (ESERA 2007) we have analysed students' arguments using theories of argumentation as Aristotle (Topics, Rhetoric), Perelman & Walton. In this way we wanted to recognise the schemes that student's arguments are based on and categorise them according the above-mentioned theories. Our hypothesis was that teachers could provide more convincing arguments to the students if they are aware not only with students' misconception but also the kind of argumentation scheme that they use when they argue their ideas. In other words, it is like a deeper way to investigate their conceptions about scientific matters. One of our results in this study was the repentance of a particular pattern that students' arguments could be included. Perelman called it as the “double hierarchy” argument. So, in this study we wanted to give a deeper analysis of this particular pattern-argument and recognise the great significance that it has among students' argumentation. Therefore, we have re-analysed several transcribed dialogues of students during several open activities in a secondary school, recognise this particular argument and find the relevance between this argument and students' scientific preconceptions. The results have showed that previous ideas of the students often follow this argument and we concern that further investigation of this relation could make us understand even better the structure of the arguments and the process of thinking. The analysis is useful both a deep understanding of students misconceptions in physics and to provide a “tool” to improve the science knowledge of the students.*

## Introduction

The last decades numerous studies have focused on the analysis of argumentation discourse in educational contexts, among others, Driver, Newton, & Osborne, 2000; Duschl, 1999; Jimenez-Aleixandre, Burgalló & Duschl, 2000; Kelly & Takao, 2002; Erduran and Jimenez-Aleixandre, 2008. Great influence of this significant attention has been contemporary's theories of argumentation. Especially Toulmin's, who apart from the theoretical part of his work, has provided with his schematics representation of arguments, which has been a useful and practical tool to analyse the arguments made by the students. The new approach of this work is to use the argumentation schemes as an instrument to understand the ideas and conceptions of students through the analysis of the structural part of the arguments and identifying in which schema the argument is based on. With our proposal, the misconceptions of the students, that of course, has taken part of numerous studies the last decades in the field of science education and physiology, could be re-analysed with an argumentation focus approach. In this way, we could be capable to characterise and identify the kind of arguments that are used mainly by the students and to understand better the difficulties of the conceptual change widely discussed in science education.

From previous research about student's scientific ideas and conceptions, we know that regarding many previous ideas in physics it is difficult, even with demonstration, to make students understand and accept the scientific theory.

In the present study we investigate junior high school students' arguments related to scientific issues. We base our study on different argumentation theories because each of these theories was elaborated with the purpose to serve a particular context. We use argumentative schemes of Perelman (1958), Hastings (1963?), Walton (1996, 2006) and also from the two works of Aristotle (IV b)), *Topics* and *Rhetoric*. According those authors when people argue elaborate arguments, a single argument is made of several premises, a thesis or conclusion and the argumentative scheme that allows and justifies the transference from the premises to the conclusion or thesis. None of these argumentation theories are made to serve the discourse analysis in an educational context. So, one of our purpose is to see the particular need of this context and build an analytical framework, based on these theories, capable to help us understand students' reasoning in scientific issues. The synthesis of these schemes might be a useful tool for future researches in argumentation in an educational context, in order to understand better students' ideas and misconceptions. Our hypothesis was that teachers could provide more convincing arguments to the students if they are aware, not only of the previous ideas of the students, but also the kind of argumentative scheme that they use when they argue their ideas. One of our results in that study (Castells, Erduran & Konstantinidou, 2008) was the repetition of a particular pattern, which could include several students' arguments that are present in different situations. Perelman (1958) named it as the "double hierarchy" argument.

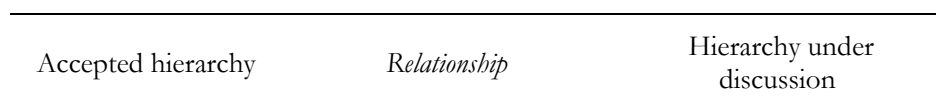
In this study we want to do a deep analysis of this particular pattern-argument of Double Hierarchy (DH) and recognise the great significance that it has among students' argumentation.

## Rationale

As we mention before, analyzing the different arguments, we have found an argument that was repeated quite often. The purpose of this paper is the focus on the structure of this argument, not only for its repetition but also for its relation with some student's misconceptions.

In the DH argument (Perelman, 1969), arguers use the DH strategy when they take an established series or hierarchy, one accepted by, or at least familiar to an audience, and form a second series on the model of the first, in the process trying to transfer implications of order or value from the first to the second. The goal of the DH argument is to make a second ordering possible and plausible. For example mediaeval alchemists ordered the seven known metals by the hierarchy of the seven heavenly bodies, equating gold with the sun, silver with the moon, and so on (Jeanne Fahnestock, 1999). According Perelman (1958), DH arguments are based on liaisons either of succession<sup>4</sup> or of coexistence<sup>5</sup> and can be classified among the arguments based on the structure of reality, which are arguments that are based to the nature of things themselves. With this kind of argument, a hierarchy is argued from other hierarchy by a correlation between the terms of one and of the other. The DH usually expresses a relationship of direct or inverse proportionality or at least a link between the parts of each hierarchy. Arguments of double hierarchy could be interpreted many times by the combination of a scheme of cause and effect, or other type of relation, and a scheme of more -> more, and this gives to this type of argument a very interesting inclusive character.

The DH scheme has at least three parts. The hierarchy under discussion, (many times is the hierarchy that we are arguing), the accepted hierarchy (the hierarchy that we based our argument and that correspond to our ideas about the real world) and the third part is the relation that we establish between the two hierarchies.



---

<sup>4</sup> Sucesión linkages

<sup>5</sup> Coexistence linkages

Summarising, the scheme of DH is based on the argumentation of a hierarchy that is under discussion, using a hierarchy that is accepted. The hierarchies could be quantitative or qualitative. We have found hierarchies of both types in our analysis. Important part of the DH argument is the relation that students establish between the two hierarchies. Many times, it expresses a proportional or non-proportional relation between the elements of the two series.

It is very essential to define very clear the above three parts. Knowing the procedure of analysis of an argument can help us understand better the misconception that is related to this argument and see where it is mistaken. In this way, the teacher is better prepared to counter argue the arguments of the students. According the argumentation theory, the DH arguments can be refuted by three ways:

- Denying the correctness of one of the hierarchies
- Denying the relation between the two hierarchies
- Opposing a different DH from the first presented and by this way the necessity to change it.

The first refutation type implies a miscomprehension of the quantitative or qualitative values of the hierarchies. The second case of refutation indicates a change of point of view on the structure of reality that has been proposed as the base of the DH. The last type of refutation, introduces a point of view that the students didn't take into account. It also modifies the structure of reality, engaging more aspects of the complexity of the situation, showing that the first aspect was too simple. This new perception is not only pure new knowledge for them, it is their own modified knowledge, in other words a more complex vision of their own perhaps limited point of view. Another interesting point of the refutation procedure is the role of the experiments in this process, especially in the quantitative DHs. One may think that the experiment is by itself a sufficient and definitive argument. We think that the experiment needs to be part of the argumentative procedure of refutation and the convincement of the other. So, it is necessary that students explicit their arguments in detail and by this way the experiment could be integrated to the refutation of the arguments of the students.

## **Methods**

This is a qualitative study where the major objectives of the research were to identify the students' arguments and then relate these arguments with their prior conceptions in domains relevant to science and specifically in physics.

### **Subjects**

All 15 students who participated in this study were primary pre-service teachers in the University of Barcelona. The scientific background of these students was quite limited in science topics. These students were distributed in four groups.

### **The activities**

The two open activities (Appendix A) were given to all the groups. Students were asked first to do the task individually, writing down their answer, expressing their point of view. After completing this part, they had to discuss their own answers with the rest of the group and try to find a solution to the problem.

Written individual answers and the discussions of 4 groups to the two activities on physics were collected and transcribed, then they are analysed and in them double hierarchy argumentative schemes are identified. We observe the structure of these specific arguments and its relation with previous ideas in science.

## Results

Before entering with more details to the results of this study and the presentation of examples of the DH argumentation scheme, it would be wise to considerate that many arguments are not very clear explained and that their interpretation could be with more than one argumentation schemes. This situation makes more difficult the argumentative analysis because many times we could interpret different possible argumentation schemes in the students' interventions

Students' responses and transcript discussions were analysed. First by trying to identify the different arguments of the students and then isolate the particular pattern of DH argument that we focus in this study. We have found DH argument to most of the discussions, which means that in activities with topics as free falling and floatability, this type of argument is applied and it is a rather common argument. Once one double hierarchy argument is identified, its structure is analysed.

### Examples of the DH argument

#### *Activity 1*

Here we present the most typical students' arguments with a proposal of refutation. For example one student wrote:

Marta: "I thought that **this could happen** because I thought that if a man is heavier than his spit or vomit he could ... he would fall quicker"

In this argument we can identify two hierarchies. The hierarchy that is under discussion, in this case is the velocity of the spit, in other words the spit have less speed from the man that has more. The accepted hierarchy is the weight of the spit and the man. It cannot be questioned that the spit weights less than the man. The relation between the two hierarchies in this particular case is the proportionality that students consider between the speed and the weight.

**Table 1. Example of DH argument (activity 1)**

Accepted hierarchy	Relationship	Hierarchy under discussion
Weight -spit → +man	The velocity is proportional to the weight	Speed -speed → +man

In this example the hierarchy of weigh is undeniable and the speed hierarchy could be denied experimentally but first we would like to search for argumentative resources. So, we can use the third refutation type and oppose a different hierarchy between the weigh (mass) and the velocity. The bigger the mass of an object is, and thus the weight, the lesser the gain of speed when we apply a force to it. This hierarchy is familiar to the students; from their own experience they know that an object of a greater mass is more difficult to be displaced. By combining the two DHs, we can have an argument of compensation in such a way that the two effects are compensated and perhaps we might contribute to change their ideas about free falling.

More weight	→	more speed
More mass	→	less speed

Another type of refutation could be the following. In the case that the students have expressed in their arguments a direct proportionality between weight and speed, a second type of refutation is possible. In order to deny the relation between the two hierarchies a possible refutation might be, ask the students what would have happened with two balls that the one has the double mass than the other. After their prediction, the realisation of the experiment wouldn't confirm the prediction, so we would have a counter-argument that denies the suggested relation between the two hierarchies of weight and speed. It is quite obvious that it's not inconvenient to use different types of refutation. The combination of different arguments of refutation could make stronger the convincing value of the arguments and change the point of view of reality of the students.

Form the above refutation procedure, we might use the metaphor that performing the whole procedure is like performing an intervening operation to a patient, which is our wrong argument, after making the diagnosis with medical scanner, which is the DH argument structure.

*Activity 2*

Following the same methodology with the fist activity, we gave the students the second one (APENDIX), which was about floatability. The main question was why the raft had sunk, and what we could do to avoid this situation. A great part of the students argue this situation using the DH between different size surfaces that is in contact with the water with the weight that the raft might support. We present here the most typical arguments of the second task:

Transcript: Paul: "The surface of the raft in comparison with the mammoth is not extensive enough to allow the water to support the mammoth. (...). If the raft had a much larger area than now, this does not happen".

Anna: "... the surface of the raft is not sufficient to support the weight of the mammoth on the water. (...) Our solution is to increase the surface of the raft on contact with water (length and width), but not in height. The more surface has the raft, more weight is able to withstand the mammoth, and the greater the force that causes the raft on the water "

In Paul's explanation, there are two variables in his argument; a quantitative one that is the size of the surface of the raft, and a qualitative notion with only two opposite values, which is in this case the capability of the raft to support or not the mammoth. So, the DH hierarchy that we face here is a type of opposite sides DH, in which the hierarchy under discussion consists of two opposite qualitative situations. The accepted hierarchy of more or less surface permits the student to establish the hierarchy of support or not support capability of the raft, which could be in discussion. In this way, with the present used surface the mammoth cannot float, but with a biggest surface the raft with the mammoth might float. The relationship between these hierarchies is a means (surface) /ends (support, not support) type of relation.

**Table 2. Example 2 of DH argument (activity 2)**

Accepted hierarchy	Relationship	Hierarchy under discussion
Surface -→+	means/ends	Support or not support

In Anna's explanation we have the two series of hierarchies both with a quantitative value. The first is the surface of the raft and the second is the weight that the raft can support in order to float. The relation between the two hierarchies is the same the previous example, the means (surface)/ ends (support the weight) relation. In this second explanation, it is not clear the role of the water in this situation.

**Table 3. Example 3 of DH argument (activity 2)**

Accepted hierarchy	Relationship	Hierarchy under discussion
Surface -→+	means/ends	weight

Both of the two above arguments try to explain that the phenomenon of floatability is related to the extension of the surface. In the first example, we have only one variable, since the second one is a qualitative notion. In that answer, is not clear the role of the water in this situation, so we could make a first comment to students by explaining to them that the water is what supports both the raft's and mammoth's weight. So, after this observation, the situation of the two above arguments is similar and can be refuted using the same way.

1. First of all we can observe that the DH argument has an obvious problem with the relationship between these two hierarchies. According to the above-mentioned ways to refute a DH argument, in this case is recommendable to deny this relation introducing an experiment (second type). For example we can use a piece of “play dough” putting it into the water, once in a form of a cube, and once in a form of an empty cube. So, we can show them that the relation of the floatability with the area of the surface is not correct.
  
2. The second phase of this DH argument refutation consists of introducing the correct first hierarchy's value (third type of refutation), which is the concept of volume that determines the weight that the raft can support. This can happen again introducing to the argumentation procedure another experiment. We can use, for example, a square made of cork that floats and we keep putting different masses above it. We can observe that meanwhile the surface in contact with the water is the same; the volume of the submerged piece of cork is getting bigger with the bigger mass that needs to support. In other words, the height of the cork that is each time is submerged into the water; in order to support the different weights is different. The heavier the object, the grater is the length of the submerged cork. The combination of these two variables are related with the weight that the cork can support, the surface and the length of one of the dimensions of the cork can take us to the idea that the variable submerged volume is what determine the weight that the cork can support. In summary, the combination of these two experiments can modify the argument toward the scientific point of view, by changing the concept of surface with the concept of submerged volume.

## Conclusions and Implications

From the results we confirm our hypothesis that the analysis done is useful both a deep understanding of students misconceptions in physics and to provide a “tool” to contribute to change the incorrect reasoning or ideas and to improve the science knowledge of the students. In fact, the knowledge of the “double hierarchy” structure can be a help for teachers to attack the arguments and so the conceptions of students using the same argumentative scheme the students use themselves and making clear their structure to them.

An implication for this study could be suggestions to introduce the argumentation schemes and especially the DH argument in the process of teaching. So, from problematic situations like, for example, the above activities, the students explain their ideas using argumentative schemes as the DH argument. So, the teacher could insist through a dialogical process, that students need to explicit their arguments. With teaches' synthesis of the different arguments that came out, different refutations can be guided from both sides to find the correct counter-arguments. The final outcome of this procedure could be writing down a text with their first idea and explain why this ideas is the same or different with the final idea of the discussion with the teacher. May be in the future, we can present results of this didactical approach, that show the promising character of using argumentation in a science class.



A deep understanding of the double hierarchies contributes to group previous scientific ideas of students, the knowledge of these groups and of their common scheme by the teachers is necessary if they want to persuade students of the scientific ideas.

On the other hand, by studying and recognising the argumentative schemes in general and particular the DH argument that are used in the students alternative ideas about science, we can better understand the procedure of arguing by identify the different parts of the argument and perhaps relate this arguing procedure with the learning process of the student.

To conclude we can point out that it is true that argumentation theories are not made to analyse arguments in a science context. But we have seen that their argumentative schemes could be a very useful tool to persuade the students and try teachers to find more convincing arguments. Also, a very interesting point that we have not treated until now is the significance of being able to identify and modify arguments to the critical thinking improvement of the students.

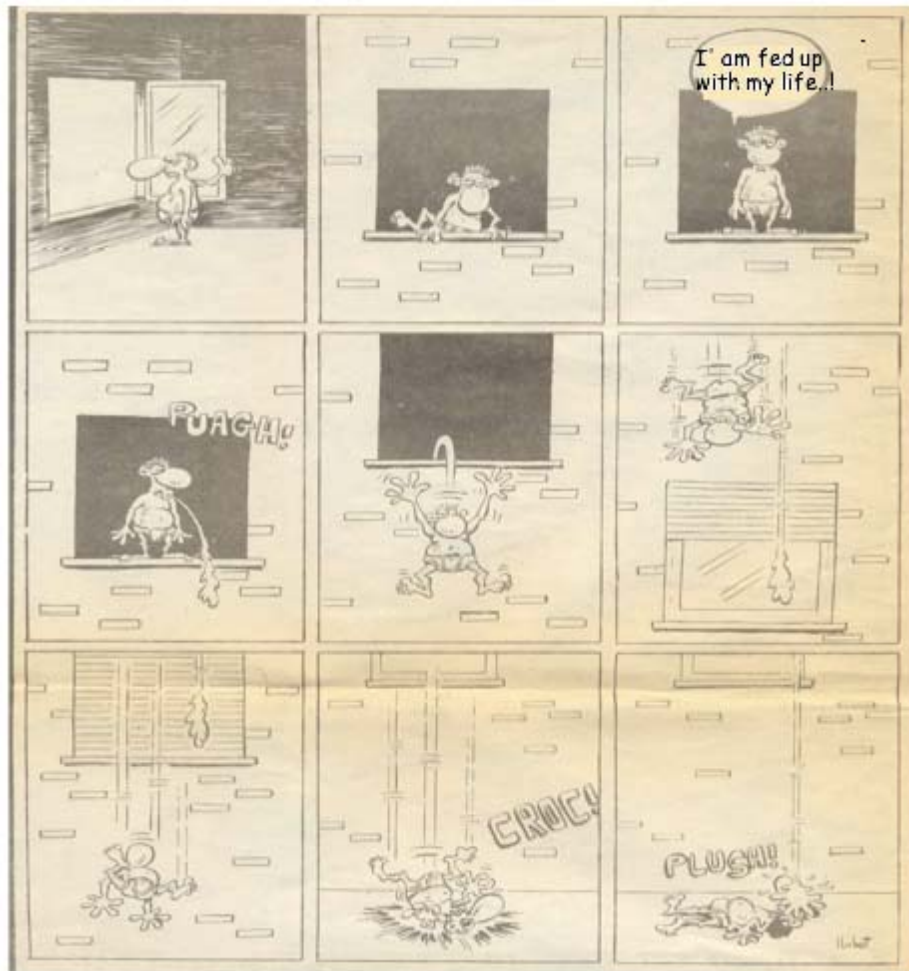
## References

- Aristotle (1928). *The Works of Aristotle Translated into English*, W.D Ross, Oxford, Oxford University Press.
- Castells, M., Erduran, S., Konstantinidou, A. (2008). Proceedings of GIREP Conference 2008, Comparison between Catalan and English students' argumentation discussing about scientific or socioscientific issues. Nicosia, Cyprus
- Driver, R., Newton, P. & Osborne, J. (2000). "Establishing the norms of scientific argumentation in classrooms". *Science Education*, 84, 287-312.
- Driver, R., Guesne, E. & Tiberghien, A. (1985). *Children's ideas in science*, Milton Keynes: Open University Press
- Duschl R. & Osborne, J. (2002). "Supporting and Promoting Argumentation Discourse in Science Education", *Studies in Science Education*. 38, 39-72.
- Erduran, S., Simon S. & Osborne, J. (2004). TAPping into Argumentations: Developments in the Application of Toulmin's Argument Pattern for Studying Sciences Discourse. *Science Education*, 88, (6), 915-933.
- Fahnestock, J. (1999). *Rhetorical Figures in Science*, Oxford University Press
- Hastings, A., (1963). *A Reformulation of the Modes of Reasoning in Argumentation*, Doctoral dissertation, Northwestern University, Evanston, Illinois
- Jimenez-Aleixandre, M.P, Burgalló, & Duschl R.A. (2000). "Doing the lesson": or "doing science": Argument in high school genetics. *Science Education* 84 (6) 1-36.
- Kelly, G. J., Druker, S., & Chen, C. (1998). Students' reasoning about electricity: Combining performance assessments with argumentation analysis. *International Journal of Science Education*, 20 (7), 849–871.
- Perelman, C. & Olbrecht-Tyteca, L. (1969). *The new Rhetoric: A treatise on argumentation*. London, University of Notre Dame Press.
- Perelman, C. (1982) *The Realm of Rhetoric*. Indiana: University of Notre Dame, Notre Dame
- Toulmin, S. (1958). *The uses of argument*, Cambridge, Cambridge University Press
- Walton, D.N. (1996). *Argumentative schemes for Presumptive Reasoning*, New Jersey: Lawrence Erlbaum Associates.
- Walton, D. (2006) *Fundamentals of Critical Argumentation*. New York: Cambridge University Press.

APENDIX

Proposed activity 1:

They students had to argue if the situation that is given to the comic below could happen in reality.



Proposed activity 2:

## Floatability

Read the following story and imagine that you are the narrator.

### THE TRANSPORT OF THE MAMMOTH



*Once, while I was waiting to get into the ferry, I saw that an operator from a rival company in another part of the shore of the river was trying to force a big Mammoth into a plain boat that was roughly of its size. Just when the loaded boat slipped onto the water, it sunk down.*

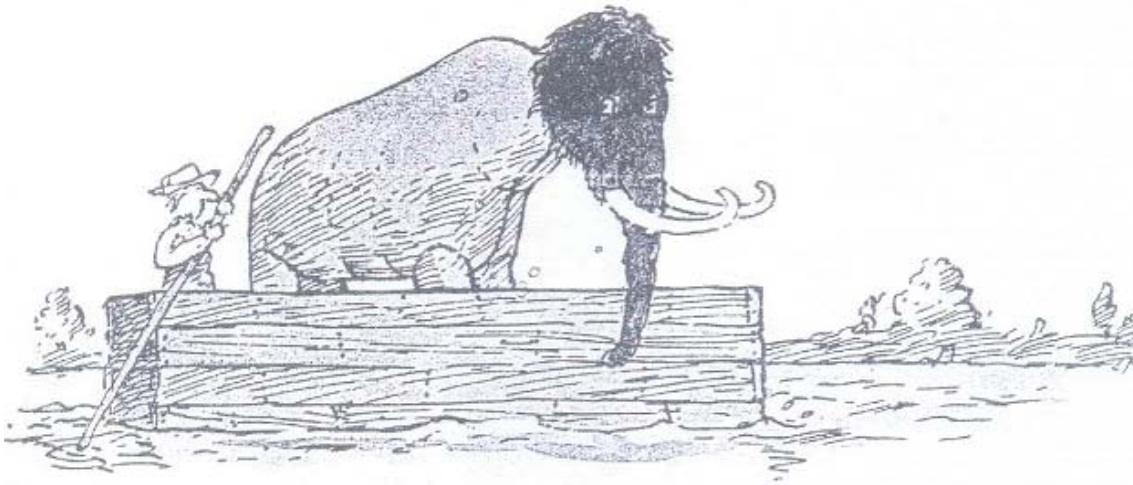
*I was astonished when I saw what happened, and I got out of the boarding queue, in order to try to help. My help was immediately accepted by the wet operator and the Mammoth. After making some questions to the people implicated in what happened, I made a few calculations and I deduced that the spirit of the water was frightened by the weight of the loaded boat and that it moved away from it, that is to say, no water was left under the boat and thus the boat sunk.*

*It was pretty clear that some sort of trick was necessary in order to keep the load floating. Then I advised to hide the Mammoth from the spirit of the water, using a special invention of mine.*



1). What would you advise to the operator to do in order to be able to transport the mammoth from one side of the river to the other safely?

The narrator of the story proposes the following solution:



*I achieved my purpose. All around the plain boat we added a wooden fence and, surprisingly for everyone except obviously for myself, the loaded boat was floating on the river with no problems.*

- 2). Do you agree with the solution proposed by the narrator? Explain your answer.
- 3). If you disagree, propose an alternative solution and justify, using your scientific knowledge, your personal experience or what you have read.
- 4). Share your proposed solutions and try to get an agreement about which of the solutions is the most adequate. You have to do it by presenting and discussing the arguments that each of you has for their solution and the counter-arguments for the solutions of the others.

# THE QUALITY OF STUDENTS' ARGUMENTATION AND THEIR CONCEPTUAL UNDERSTANDING – AN EXPLORATION OF THEIR INTERRELATIONSHIP

Tanja Riemeier

Leibniz University Hannover

Jan Fleischhauer

Justus Liebig University Giessen

Christian Rogge

Justus Liebig University Giessen

Claudia von Aufschnaiter

Justus Liebig University Giessen

## Abstract

*The research project aims to investigate how the quality of students' argumentation depends on their conceptual understanding and vice versa. Data analysis is based upon two different theoretical frameworks: A refined version of Toulmin's argument patterns is used to describe the processes of argumentation and its quality. Students' conceptual understanding is investigated with a coding schema distinguishing between exploration, intuitive rule-based understanding and explicit rule-based understanding. Video data from students of different age working in groups on physics and biology instruction were analyzed with these two frameworks. Results demonstrate that each single argumentation typically contains only few different elements, and elements that are regarded to be of "higher quality" are rare. Argumentations that consist of high structural and high conceptual quality occurred when students were able to utilize everyday-experiences or specific experiences they made during the learning sequences.*

## Rationale

Science educators argue that argumentation is an important aspect of science education in general, and that argumentation promotes the learning of the science content (e.g., Zohar & Nemet, 2002). Conversely, research indicates that students' ability to argue is limited by their content specific knowledge (e.g., Means & Voss, 1996; Sadler, 2004). But research rarely explicitly addresses (details of) the interrelationship between argumentation and conceptual understanding. Research reported in this paper aims to explore the interrelationship between students' argumentations and their conceptual development. In particular, we want to investigate how the quality of students' argumentation depends on students' conceptual understanding and vice versa. Therefore, the project explores the following research question:

What kind of interrelationship can be determined between the quality of students' argumentation and their conceptual understanding of the topic given?

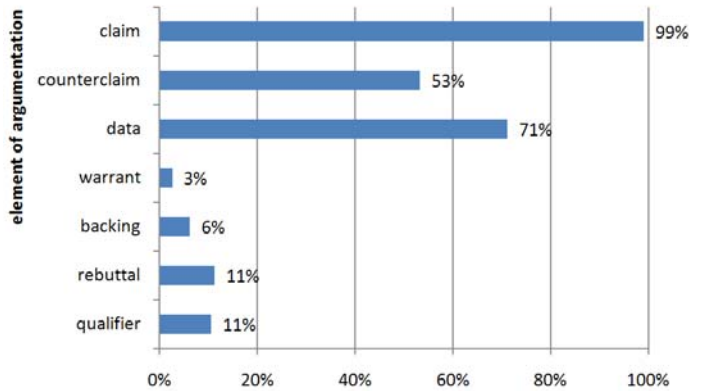
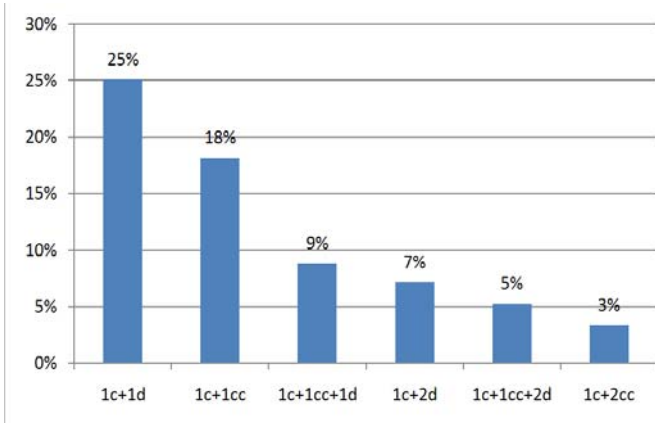
## Methods

In order to explore the interrelationship between argumentation and conceptual development, learning material was developed which aimed at both aspects. Referring to the model of Educational Reconstruction (Duit, Gropengießer, & Kattmann, 2005), four teaching sequences were developed concerning blood pressure, heat transfer, electric circuits and light & shadow. Each sequence comprises two sessions of about 160 minutes in total. The two sessions were subdivided into three phases: The first phase consisted of instruction aiming to establish an understanding of the phenomena which is discussed in the argument-task. The corresponding task was taken from material developed at King's College London (e.g., Osborne, Erduran, & Simon, 2004) and presented in the second phase. Finally, the last phase consisted of instructions addressing the contents which were deployed in the arguments task. All units developed were tested by a sample of 28 students from university who were working in groups of two to three students on one of the units. These students were studying social sciences and did not have a strong background in the topics covered by the units. Videoing of the processes informed us about necessary changes (such as for instruction that was not understood or experiments that did not work as expected). The main study consisted of two samples: 18 students from grade 8 (about 13 years old) and 12 students from grade 11 (about 16 years old). The students worked in groups of three on two out of the four topics. All activities were recorded on video. Data analyses have been based upon two different theoretical frameworks: A refined version of Toulmin's argument pattern (Toulmin, 2003) is used to describe the processes of argumentation and its quality (v. Aufschnaiter et al., 2008b). Our inter-coder agreement usually exceeds 80 % between different raters (cohens kappa between 0.6 and 0.75). Students' conceptual understanding is investigated by a schema which distinguishes between exploration, intuitive rule-based understanding and explicit rule-based understanding (only the latter would be referred to as being "conceptual") (for more details see v. Aufschnaiter, 2006).

## Results

### Structure of argumentation

So far, we have analysed all sessions from heat transfer and electric circuits, and four sessions from blood pressure leading to in total 419 identified argumentations spread over the sessions. Results demonstrate that each single argumentation typically contains only few different elements (Figure 1a). For instance, 25% of students' argumentations investigated so far are built of a claim and one datum and 18% consist of a claim and a counterclaim without any further justifications (all these argumentations are relatively short). Combinations including elements other than claim, counterclaim and data are rare which can be seen in Figure 1b. Nearly all argumentations contain a claim (which is expressed by a frequency being almost 100%), in 53% of all argumentations investigated at least one counterclaim is formulated. In contrast, elements like warrants are only present in 3% of all argumentations.

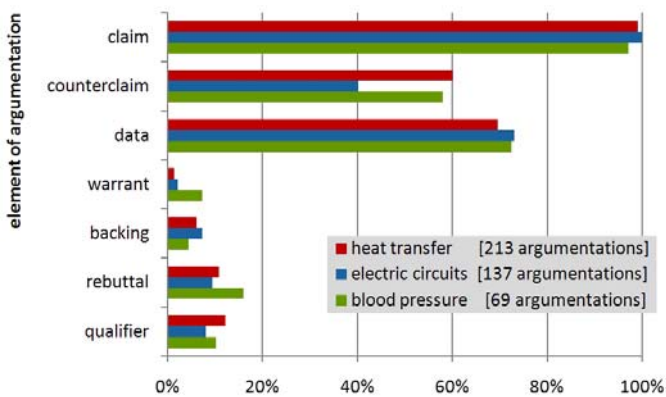


**Figure 1a. Frequency of argumentations consisting of particular combinations of elements** (results based on 419 argumentations taken from the sequences on blood pressure, electric circuits, and heat transfer)

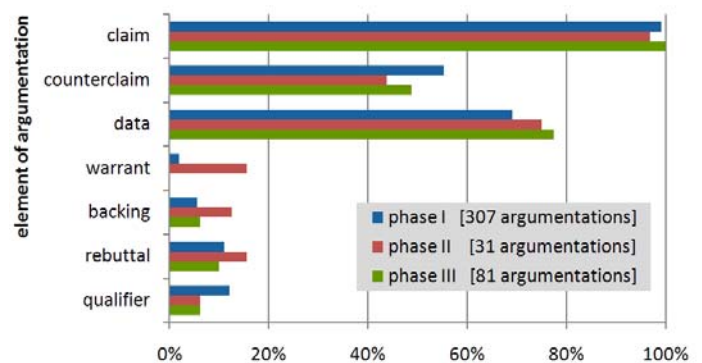
**Figure 1b. Occurrence of each element in students' argumentations** (results based on 419 argumentations taken from the sequences on blood pressure, electric circuits and heat transfer)

In addition to focusing on all argumentations no matter of the units' content, we have also compared the occurrence of each element in students' argumentation within each unit (Figure 2). Even though the students developed less counterclaims during the learning sequence of electric circuits there are only small differences between the units.

By comparing the frequency of elements in students' argumentation during the different phases of the learning sequences results demonstrate only small differences (Figure 3). This means that even though the argument task in phase II explicitly prompted students to argue the students did not develop elements that are regarded to be of higher quality more frequently than without an explicit stimulation.

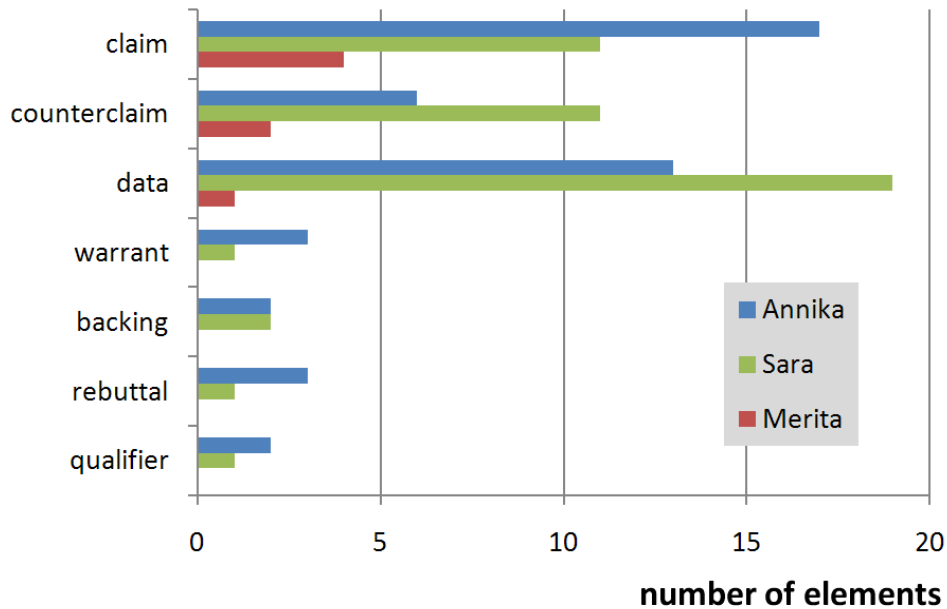


**Figure 2. Occurrence of each element in students' argumentation during the different learning sequences** (results based on 419 argumentations taken from the sequences on blood pressure, electric circuits and heat transfer)



**Figure 3. Occurrence of each element in students' argumentation during phase I, II and III of the learning sequences** (results based on 419 argumentations taken from the sequences on blood pressure, electric circuits and heat transfer)

In addition to our data analysis concerning the frequency of elements employed into students' argumentation, we have also compared how often each group member contributes to an argumentation and which element is used. For instance, for a female group from grade 8 (Figure 4) it is obvious that Merita rarely whereas Annika quite frequently formulates the claim. Sara in contrast offers data very often. Elements of higher quality are, in this group, only developed by Annika and Sara. Similar results can be found in all learning sequences and for all groups, no matter of their age and gender.



**Figure 4.** Number of elements employed by each group member into the group's argumentations (numbers based on 35 argumentations taken from the sequence on blood pressure)

### Conceptual knowledge

Conceptual knowledge has been analysed so far for all groups participating in the sequence on heat transfer and for two groups working on the sequence on blood pressure. Our analyses of these groups show that students mainly construct knowledge which is explorative or intuitive rule-based in nature. Comparing the conceptualisations of grade 8 and 11 (see the example given in Figure 5) reveals that the older students express (significantly) more intuitive rule-based knowledge and slightly more explicit rule-based knowledge than the younger ones. However, it should be noted that not only for this example but also for other groups, variances are high in-between groups.



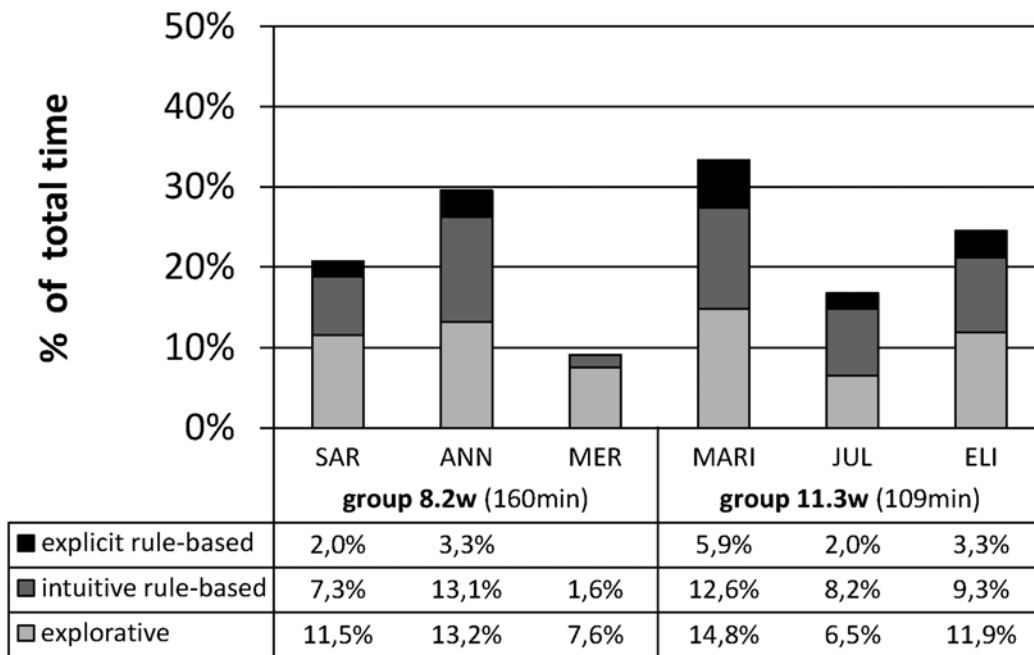


Figure 5. Example of two groups' frequency of conceptual knowledge expressed by each individual group member in relation to the total time of the learning sequence on blood pressure (in brackets)

#### Argumentation and conceptual knowledge

Students that were able to develop an explicit rule-based understanding used more often elements of argumentation that are regarded to be of higher quality (like Annika, see Figure 2 and Figure 3). Even though we were not yet able to identify a systematic interrelationship between the structural quality of students' argumentations and their conceptual understanding, a more detailed analysis of students' argumentations revealed how dominant students' experiences are. Typically, argumentations that consist of both a high structural and a high conceptual quality occurred when students were able to utilize everyday-experiences or specific experiences they made during the learning sequences. However, it should be noted that the way in which students conceptualized some aspects was not intended by the learning material and is scientifically not appropriate. This issue is demonstrated by the following example which is taken from the sequence of blood pressure. Here, a group from grade 8 discusses their ideas about the colour of arteries and veins:

Transcript	TAP	Conceptual level
Annika: I got it: Probably, arteries are warm and veins are cold. / Therefore, arteries are typically coloured red and veins blue. / These colours refer to warm and cold. And the arteries carry the heat into the finger tips. And then the coldness has to go away, and the veins take along the coldness.	claim data 1-4	explicit rule-based (conceptual)
Sarah: In spite of this, I don't get warm.	rebuttal 1	Intuitive rule-based
Annika: Anyway, your finger tips stay warm for a long time.	rebuttal 2	Intuitive rule-based

Transcript 1. Students' argumentation about the functions of veins and arteries

In the further sequence of transcript 1 the students were asked to decide between different reasons why everyone’s face gets redder while exercising (argument-task). Even though being taught about the different aspects of blood circulation, hardly any group who was working on the sequence about blood pressure discussed four theories offered in an appropriate way in order to identify the scientific explanation (“Your blood gets closer to the surface for excess heat to be lost”). Rather, this group of grade 8 students as well as almost all other students interpreted “pressure” in terms of their everyday experiences of “pumping” which they feel when their pulse increases (transcript 2).

<b>Transcript</b>	<b>TAP</b>	<b>Conceptual level</b>
Annika: If you have more [blood], the arteries expand. They expand because there is more pressure and, thus, the surface of your skin gets redder. / The blood pressure increases and then more blood is pumped through, and then everything expands, and then there is more blood and it looks redder.	warrant repeats warrant	intuitive rule-based

**Transcript 2. Students’ argumentation about why the skin gets redder while exercising**

## Conclusions and Implications

The project aims to shed (more) light into the debate on how argumentation and conceptual understanding interrelate. Such an understanding would improve both, the teaching about science and the teaching of science. At first sight, our results seem to be disappointing: Our students did not often argue at a high structural level, nor did they explicitly develop a conceptual understanding very frequently. However, it can be noted that the students argued even though they were not prompted to do so (during the “preparation phase”) and they had not received an instruction on how to argue. Therefore, these students were able to construct argumentations by themselves which can be regarded as a promising result. Also, mean engagement and over all active participation in our sequences was (much) higher than in a typical science classroom. The high variances of individual contributions to an argumentation and of individual frequency of conceptual knowledge, even within the same grade, are one important result as well. It points to the need to understand better what causes these differences and how learning material and tasks prompting students to argue need to be adapted accordingly.

From our results we would conclude that it is not very likely, especially for complex scientific issues, that students will and can address scientific ideas in their argumentation. Rather, they are very likely to engage with everyday experiences (see also v. Aufschnaiter et al., 2008a). Although this may lead to argumentations of higher quality (in terms of both their structural and their conceptual level) these also show a limitation which might have at least two consequences: a) promoting students’ argumentation in school science settings will need a large number of appropriate experiences in order to enable students to engage with scientific concepts (rather than with everyday experiences) and b) any formal training on argumentation may only result in limited competencies to engage in actual scientific debates as this engagement (again) requires a large number of content specific experiences.

## Acknowledgement:

Research reported in this paper has been funded by the German Research Association (DFG AU 155/5-1,2). We are very grateful to Jonathan Osborne, Sibel Erduran, and Shirley Simon for sharing their material and thoughts on argumentation with us.

## References

- Duit, R., Gropengießer, H., & Kattmann, U. (2005). Towards science education research that is relevant for improving practice: The model of educational reconstruction. In H.E. Fischer (eds.), *Developing standards in research on science education. The ESERA Summer School 2004* (pp. 1-9). London: Taylor & Francis Group.
- Means, M. L., & Voss, J. F. (1996). Who reasons well? Two studies of informal reasoning among children of different grade, ability, and knowledge levels. *Cognition and Instruction*, 14(2), 139-178.
- Osborne, J., Erduran, S., & Simon, S. (2004). Enhancing the quality of argumentation in school science. *Journal of Research in Science Teaching*, 41(10), 994-1020.
- Rogge, C., & von Aufschnaiter, C. (2007). Do high-level argumentations consist of sophisticated scientific understanding? Paper presented at the conference of ESERA. Malmö, August 2007.
- Sadler, T. D. (2004). Informal reasoning regarding socioscientific issues: a critical review of research. *Journal of Research in Science Teaching*, 41(5), 513-536.
- Toulmin, S. (2003). *The uses of argument* (updated edition). Cambridge: Cambridge University Press.
- von Aufschnaiter, C. (2006). Exploring the processes of students' development of physics concepts. Paper presented at the conference of NARST, San Francisco, USA, April 2006.
- von Aufschnaiter, C., Erduran, S., Osborne, J. & Simon, S. (2008a). Arguing to learn and learning to argue: Case studies of how students' argumentation relates to their scientific knowledge. *Journal of Research in Science Teaching*, 45(1), 101-131.
- von Aufschnaiter, C., Fleischhauer, J., Rogge, C. & Riemeier, T. (2008b). Argumentation and scientific reasoning - an exploration of their interrelationship. Paper presented at the conference of NARST, Baltimore, USA, April 2008.
- Zohar, A., & Nemet, F. (2002). Fostering students' knowledge and argumentation skills through dilemmas in human genetics. *Journal of Research in Science Teaching*, 39(1), 35-62.



# THE TEACHING OF SOCIO-SCIENTIFIC ISSUES FOR SCIENTIFIC LITERACY AND CITIZENSHIP

Kacem Saida Merghli  
Tunis I University, ISEFC

Simonneaux Laurence  
ENFA, France

Azzouna Atf  
Tunis El Manar University

## Abstract

*This research starts from a relatively optimistic thought based on the fact that the teaching of the socioscientific issues in interdisciplinarity philosophy- biology by the practice of argued debates can contribute positively towards education in scientific literacy and citizenship. Our contribution presents a research in progress. This research questions a protocol of training of future teachers. The principal objective is to train the pre-service to teach socio-scientific issues (SSI). Like Funtowicz and Ravetz (1992, 1993), we think that the SSI belong to "Post-Normal-Science". Accordingly, we will study the contribution of the training in epistemic, social and ethical values in the analysis of socioscientific issues by biology and philosophy future teachers. We will analyze the evolution of the decision-makings after training of future teachers on three socioscientific issues (the oncomice, the baby drug and the therapeutic cloning). Before this training a pre-test on techno-sciences was filled by future teachers of biology and philosophy and analysed. These questionnaires aimed at knowing the opinions of future teachers concerning the selected techno-sciences, and at seeing whether they detected epistemic values and especially social and ethical values related to these knowledge under construction. The results of the analysis of the questionnaire are taken into account in developing the "training-session".*

## Introduction

Can the teachers who evoke with their pupils, within the framework of the program, the genetic diseases, the new capacity potentially offered by the genetic engineering be unaware of the psychological impact and the moral stake of the training which they will give? Could the collaboration between the teachers of biology and of philosophy open prospects? Like Zeidler (1984), we think that, "*to achieve the long acknowledged goal of scientific literacy, it is necessary to include ethical and moral issues in an interdisciplinary science curriculum*".

### 1. Background, Framework

#### ***1.1 Scientific literacy and science education for citizenship***

Socioscientific issues have become important in science education because they occupy a central role in the promotion of scientific literacy (Bingle & Gaskell, 1994; Driver, Leach, Millar & Scot, 1996; Zeidler & Keefer, 2003). The capacity to treat the socioscientific questions fruitfully was identified for example by American Association for the Advance of Science like significant aspect of scientific literacy. The teaching of techno-sciences raises topical questions which interfere in the classroom and at the same time carry scientific and social controversies within which it is possible to anchor the construction of new knowledge and citizen's behaviours.

These controversial issues raise more questions and motivate the pupils more. Setting these topics for debate in the classroom could “restore, if only a little, what” Astolfi likes to call “the taste of knowledge (savoirs) ‘since the two words (saveur and savoir) come from the same Greek root’ *sapere*”, as Astolfi, 2006, marvellously put it in the foreword to the recent book: *L’école à l’épreuve de l’actualité. Enseigner les questions socialement vives*. (How to teach socially acute questions.) (Legardez & Simonneaux, 2006).

The questions dependent on human health or ecological problems belong to the socioscientific questions (QSS) and are characterized scientific questions socially sharp because they raise social, ethical questions and are synonymous with risks of uncertainties and require a decision-making. These often mediatized questions imply challenges with the students and with any citizen because the consensual scientific information (about the risk) which is necessary to carry out the thoughtful decision-making in the traditional direction misses as Kolsto (2004) affirms it. Education with science should thus make it possible to the students to treat such questions (Millar and Osborne, 1998; NRC, 1996; AAAS, 1990).

### **1.2 Framework**

The conceptual framework included a view of science where *the " Post-Normal-Science "* characterized by a high system of uncertainties, significant stakes and significant decision-makings and *the " core science "* equivalent to stabilized academic science (Funtowicz and Ravets (1993) *have* different epistemological characteristics, and where the academic science of the nineteenth century has evolved into the industrialized science of today (Aikenhead, 1994; Ravetz, 1995). Industrialized science is characterized while being closely connected to the industrial and social needs and also includes contract-based research, with the consequence that science and scientific knowledge is more closely intertwined with the power and interests. The study is also based on a view where the decisions are based on contextual information and of the values or the personal preferences. We refer to the contextual empiricism of Longino (1990). In this socioconstructivist approach, the social context takes part in whole share with the act to even know. Scientific knowledge is at the same time socially built and objective; it is always dependent on parties taken theoretical and a value judgment.

## **Rationale**

The important goal of this study was to train future teachers to teach socioscientific issues for scientific literacy and citizenship. By the crossing of two different disciplinary cultures (biology and philosophy) we sought to develop their critical thinking and to train them to develop critical thinking of the pupils, their capacity of autonomous decision-making and their consciousness of the complexity of the SSI. In this teaching based on argued debate, the diversity from the points of view must be respected and one of its goals is to train each one to enrich construction from its own point of view. The objective is not to institutionalize a preformed knowledge but it is the other aspect of the things: to train people able to take an active share with the debates and to learn how to argue rigorously on their subject.

Our research questions are:

- Do the pre-service teachers in biology and philosophy have the same opinions towards the various techno-sciences?
- Do the pre-service teachers detect the failing epistemic values, the social and ethical values on knowledge in construction?
- Will the crossing of two different disciplinary cultures support the construction of sequences which allow analysing the implication of ethics in techno-sciences?

In this work, we focus on the first research question.

## Methods

### 1. The preliminary study

A preliminary study with high school pupils in their final year enabled us to identify the opinions of the pupils on these technosciences and to see whether they base their positions on the scientific aspects or on values. The questionnaire used comprises a short presentation of the technosciences under study. The questions relate to:

- The legitimacy or research to produce oncomice
- The place of man in nature
- The right to make a sorting among the embryos obtained by an IVF to choose a drug baby to cure a sick brother or sister.
- The right to make a sorting among the embryos obtained by an IVF to choose the colour of the eyes
- The research on therapeutic cloning.
- Who decides? Laws or organizations independent of the law: families, doctors, researchers, politicians, philosophers, economists, patients, religious authorities.

### 2. The principal study

It related to pre-service teachers in biology (17) and philosophy (18) and comprises several collections of data. The following protocol was set up.

#### ***2.1 A pre-test on the technosciences:***

Documents explaining the 3 selected technosciences were distributed to future teachers. After consultation and comments on these documents, the questionnaires were filled. These questionnaires aimed at knowing the opinions of future teachers concerning the selected technosciences, and at seeing whether they detected epistemic values and especially social and ethical values related to these knowledge under construction.

#### ***2.2 Didactic Intervention: "Training-Debate"***

Future teachers of philosophy and biology took part in a socio epistemological and ethical training, followed by a debate on the 3 technosciences.

#### ***2.3 Post test:***

The post test aimed to measure the impact of the socio epistemological and ethical training, as well as the interaction between future teachers of philosophy and biology, on the quality of their ethical reasoning and citizenship.

#### ***2.4 Construction of interdisciplinary sequences:***

Construction of interdisciplinary sequences by the future teachers in biology and philosophy to identify the possible impact of the training on their future teaching practices, implementation of these sequences with pupils, analysis of the effective practices of the future teachers and their impact.

## Results and analyses

### 1. First results obtained:

The results of the pretest are summarized in the following table:

**Table 1. Results of the pretest: The opinions of the pupils on the three technosciences**

Questions	future teachers answers	
	Biology future teachers	Philosophy future teachers
Are-you favourable (of agreement) which the researchers work with obtaining oncomice?	Yes : 16/17 No : 1/17	Yes : 17/18 No : 1/18
The place of man in nature?	-Master of nature : 4/17 -a part of nature : 13/17	-Master of nature: 8/18 -a part of nature : 7/18 -Unanswered : 3/18
To choose a drug baby?	-Yes : 15/17 -No : 2/17	-Yes : 11/18 -No : 7/18
To sort a baby according to the colour of his eyes?	-Yes : 0/17 -No : 17/17	-Yes : 0/18 -No : 18/18
The research on therapeutic cloning?	-Yes : 13/17 -No : 4/17	-Yes : 11/18 -No : 7/18
Does legislation must interfere?	-Yes : 15/17 -No : 2/17 -Unanswered : 0%	-Yes : 14/18 -No : 2/18 -Unanswered : 2/18
Do the organizations independent of the laws have to intervene?	-Yes : 14/17 -No : 3/17	-Yes : 13/18 -No : 3/18 -unanswered : 2/18

In what follows B denotes a future teacher of biology and P is a future teacher of philosophy.

The analysis of these questionnaires showed that: the opinions with respect to selected biotechnologies are not homogeneous.

The therapeutic cloning was the least accepted by these teachers (But it is more accepted by the biologists (13/17 against 11/18 by future teachers of philosophy).

The baby drug is fairly accepted (22/37) because it will save its elder But, nobody agrees to sort a baby according to the colour of his eyes.

The oncomice are the most tolerated (by 33/35) because: "*for the good of the man, such a sacrifice is nothing*".

## 2. Results and analyzes

### *2.1. Areas of reference of the arguments:*

We distinguished 4 categories of responses according to frames of reference of arguments. The frames of reference of arguments are:

- ethical
- religious
- connected to **scientific nature:**
  - **scientific knowledge**
  - **uncertainties**
  - **the risks**
- connected with **an ideology of scientific progress** and statute of science



### *Ethical argumentation*

For the ethical argumentation we use the method of ethical analysis used by Bayrhuber (1999). The analysis follows the two systems of fundamental justification of Western ethics:

- The naturalistic reasoning (related to the wellbeing)
- The personalistic reasoning (related to human dignity)

What about ethical justification systems in Tunisia?

The future teachers of biology and philosophy who accepted the conception of the baby drug seemed to adhere to **a naturalistic ethical reasoning**, related to the general wellbeing of those concerned, and with health: "*because it (the drug baby) will cure his/her brother*".

Those who refused this practice adhered to a personalistic reasoning related to human dignity: "*Each one of us is entitled to originality*"; "*the child must be conceived and wanted for himself and not like a drug*".

Concerning **research on the therapeutic cloning**, the future teachers who didn't accept this practice argued by the fact that it touches with human dignity (ethical reasoning **personalistic**). The future teachers favourable to the therapeutic cloning accept it "*provided that the therapeutic cloning represents the only way of possible cure*".

### *The religious field*

Examples of religious arguments:

"*Because we will not be Muslims, it is God who controls creation*".

"*The embryo is alive and the life is a gift from God*", "*a Divine present*", "*to be satisfied with what God gives us*", "*a stage*" (which presupposes another stage or life after death in reference to religion),

"*The life starts at 40 days when God gives to the individual his soul*".

### *The scientific field*

Arguments related to **scientific knowledge**

- **A certain perception of the risks and uncertainties**, "*inventions must be controlled to avoid the risks of irreversible genetic modifications (P12)*".
- a **scientist representation of science**, the laws should not intervene for 4/35: "*but in certain cases, they can be an obstacle for the evolution of science*" (B1);
- Arguments in connection with **an ideology of scientific progress** and statute of science:

"*Because it is necessary to leave the problem to people who can solve it, science is the field of the researchers*» (B3). "*One cannot poster a police officer or a legist in each laboratory supervising the researcher, the laws are forms of restriction which prevent the development of scientific research (P8)*"

## **2.2 Who decides?**

- For the majority, the future teachers are in favour that organizations independent of the laws pronounce opinions. What returns to necessary "the community of pairs widened" required by Post-Normal-Science. However the economic and political fields are ignored.

- The future teachers seem to be unaware of the constraints and the economic guidelines associated to scientific research
- Doctors, researchers, patients, representatives of the religion and families are quoted, economists were quoted only once but never politicians.

## Conclusions and Implications

The opinions towards selected biotechnologies are not homogeneous.

- The first results show that these pupils and these pre-service teachers are very favourable to the oncomice considering the very significant and superior status they accord to the human being, but also because of cancer, which has been causing enormous devastation. The other technosciences are sometimes disputed but generally better accepted by the biologists. Simonneaux et al (2005) already showed that the pupils following a humanity course are more anxious with respect to these practices than those following a scientific course.
- Pre-service teachers are anxious about therapeutic cloning and fear the derivations of researchers. Their fears are in connection with moral values and religions and seldom with the social values of science. Among the latter, it is primarily the value of applicability to human needs which was mobilized.
- These teachers do not understand the complexity in the decision-making on the SSI and the various factors which come into play like the various stakeholders and those with economic and social interests, like the funding bodies of research institutions and the politicians whom they never wish to see intervene in laws concerning these socio-scientific questions.
- Like Kolsto (2005), we underline the need for recalling that science is not the only aspect of the SSI and that economic, legal, ethical and social dimensions are also significant. It raises the need for appreciating their inter-connection and the inseparability of sciences and companies, whereas science is often presented as "neutral".
- These aspects are taken into account in the "training-debate".

## References

- AAAS. (1990). *Science for Alls Americans Project 2061*. New York: Oxford University Press.
- Aikenhead, G. S. (1994). The Social Contract of Science. In J. Solomon & G. AIKENHEAD (Eds.) *STS Education. International Perspectives on Reform* (pp.11-20). New York : Teachers College Press.
- Astolfi, J.P., 2006, Préface, In, Legardez, A. & Simonneaux, L., 2006, *L'école à l'épreuve de l'actualité. Enseigner les questions socialement vives. (How to teach socially acute questions.)* Paris : ESF.
- Bayrhuber, H. (1999). Analyse éthique de la thérapie des cellules germinales. In : Simonneaux, L. (ed). *Les biotechnologies à l'école* (Ethical analysis of germinal therapy. In: Simonneaux, L. (ed). *Biotechnology at school*) (pp. 97-108). Dijon: Educagri.
- Bingle, W. H., & Gaskell, P. J. (1994). Scientific literacy for decisionmaking and the social construction of scientific knowledge. *Science Education*, 78, 185-201.
- Driver, R., Leach, J., Milar, R., & Scot, P. (1996). *Young people's images of science*. Bristol, P A: Open University Press.
- Funtowicz, S. O. & Ravetz, J. R. (1993). Science for the post-normal age. *Futures*, 25(7), 739-755.
- Kolsto, S.D. (2004). Students' argumentation: Knowledge, values and decisions. In E.K. Henriksen & M. Odegaard (Eds.), *Naturfagenes didaktikk – en disiplin i forandring? Det7. nordiske forskersymposiet om undervisning i naturfag i skolen*. Kristiansand: Hoyskoleforlaget AS. 63-78.

- Kolsto, S. D., 2005, « The relevance of values for coping with socioscientific issues in science education ». *ESERA conference 2005*, Barcelona, Spain.
- Legardez, A. & Simonneaux, L. (2006). *L'école à l'épreuve de l'actualité. Enseigner les questions socialement vives (How to teach socially acute questions)*. Paris : ESF.
- Longino, H. E. 1990, *Science as Social Knowledge. Values and Objectivity in Scientific Inquiry*. Princeton: Princeton University Press.
- Millar, R., & Osborne, J. (Eds.). (1998). *Beyond 2000: Science education for the future*. London: King's College School of Education.
- NRC. (1996). *National Science Education Standards*. Washington DC : National Academy Press.
- Ravetz, J. R. (1995). *Scientific Knowledge and its Social Problems* (2<sup>nd</sup> ed.). New Brunswick, NJ: Transaction Publishers.
- Simonneaux, L.; Ducamp, C.; Albe, V.; Simonneaux, J. & Hirtzlin, N. (2005). La perception des sciences par les lycéens est-elle modifiée par la présentation par des chercheurs de leurs travaux ? *Quatrième rencontres de l'ARDIST*, pp.347-354, Lyon, 12-15 octobre 2005 (Is students' science perception changed by researchers' presentation? *Fourth meetings of the ARDIST*, pp.347-354, Lyon, 12-15 october 2005).
- Zeidler, D. L., & Keefer, M. (2003). The role of moral reasoning and the status of socioscientific issues in science education: Philosophical, psychological and pedagogical considerations. In D. L. ZEIDLER (Ed.). *The role of moral reasoning and discourse on socioscientific issues in science education*. Netherlands: Kluwer.
- Zeidler, D. L. (1984). Moral issues and social policy in science education : Closing the literacy gap. *Science Education*. 68. 411-419.
- Zimam, J. (1968). *Public Knowledge : An Essay Concerning the Social Dimensions of Science*. Cambridge University Press.



# PRE-SERVICE TEACHERS' IDEAS AND KNOWLEDGE ABOUT THE NOTION OF ARGUMENT - A METACOGNITIVE APPROACH

Nicola Mittelsten Scheid  
Queen's University, Kingston, Ontario, Canada

## Abstract

*Argument is central to sciences and science education since it represents a crucial strategy for knowledge generation and sciences are knowledge generating in nature. Argument is underpinned by two main metacognitive components: Epistemological understanding (EPU) refers to the nature of knowledge and knowledge generation. Metastrategical knowledge (MSK) refers to knowledge about knowledge strategies available, their accomplishments and limits and appropriate application. Little research has been done on teachers MCK. Recent studies on teacher education show that teachers do not have sufficient MCK in order to teach MCK-oriented effectively. (However, there are promising teacher development projects as well as useful, metacognitively underpinned argument models.) This is why this study focuses on measuring teacher candidates' (TC) ideas of and knowledge about argument. An open-ended questionnaire has been given to 50 Canadian TC. The TC were asked to develop statements about argument by the use of 9 given essential terms regarding argument (such as "evidence", "theory", and "analogy"). Four components of MCK have been identified: Knowledge about argument or argument components' (1) attributes, (2) function, (3) interrelations, and (4) criticism. Moreover, the components 2, 3 and 4 show levels of MCK. The findings might provide a basis for further teacher education.*

## Introduction

Body text will be Garamond 11 pts Argument is a crucial strategy of knowledge generation in sciences since sciences generate both scientific and ethical knowledge by argumentative processes (Dietrich, 2005; Kuhn, 2001). Yet since science education is about science itself argument should assume an equally central role in science classrooms (Duschl & Osborne, 2002) and broad support exists within the science education community for the incorporation of the skill of argument in both science curricula and science teacher education (e.g., Erduran & Jiménez-Aleixandre, 2008; Zeidler, 1997). However, the skill of argument does not only require cognitive performance but also **metacognitive knowledge (MCK)** about the nature of argument and evidence (Kuhn & Pearsall, 1998) that increases the quality of argument (Kuhn, 2001). Yet students and teachers often do not show MCK to a sufficient extent in order to teach argument in an appropriate and effective way and, thus, hardly integrate metacognitively guided argument into classroom instruction (Simon, Erduran & Osborne, 2006; Zohar & Nemet, 2002). It follows that it is a crucial objective of science education to measure and foster teachers' MCK about argument.

This study aims at contributing to this objective by defining and measuring teacher candidates' MCK regarding argument in order to provide a basis for further research. In order to do this MCK and its underlying components epistemological understanding (EPU) and metastrategical knowledge (MSK) will be described from a general point of view (section 1). After this general approach, argument-specific MCK will be derived considering selected argument theories and models that focus on the structure and quality of argument (section 2). The design of the empirical study will be presented (section 3) as well as the findings on components and levels of MCK (section 4). Finally, the findings will be discussed and conclusions for further research will be drawn (section 5).

## Metacognitive knowledge

Following Kuhn (1995), scientific activities and thinking such as argument refer to a “mechanism of knowledge acquisition based on metacognition”. In particular, MCK implies an understanding of the nature of knowledge and knowledge generation and it allows for the control and management of knowledge generation and of one’s own thinking. Thus, it increases the quality of argument (Kuhn, 2001). It is underpinned by two main components. First, **epistemological understanding (EPU)** refers to an understanding of the nature of knowledge and knowledge generation and “how one comes to know” (Kuhn, Katz, & Dean, 2004). It involves a broad understanding of thinking and knowing in general. **Metastrategical knowledge (MSK)** represents a competence and more specifically refers to knowledge about the methods of knowledge generation (Kuhn, 2001) and to awareness and management of one’s own thinking (Kuhn & Dean, 2004). EPU and MSK are pointed out in the following.

### Epistemological understanding (EPU)

Epistemological understanding (EPU) is about the understanding of the nature of knowledge and knowledge generation, of the nature of one’s own and others’ knowledge (Kuhn, Black, Keselman & Kaplan, 2000), of “how one comes to know” (Kuhn & Dean, 2004). Kuhn (2001) and Kuhn et al. (2004) report on the following four developmental levels of EPU that (might) occur across lifespan. From the naive *realist’s* perspective (preschool age) beliefs are “faithful copies of reality”, “they are received directly from the external world, rather than constructed by the knower”. This view does not allow for conflicting beliefs. The *absolutist* (before adolescence) still believes in knowledge as objective and absolute truth and as derived from authorities. But the absolutist recognizes that knowledge is constructed by a knower, though nevertheless the product of knowing is still more attached to the known object than to the knower. The *multiplist* (also called relativist) (adolescence) assumes that knowledge is based on equally right and not disputable personal opinions. Knowledge is seen as “emanating from knowers, rather than the known. This lack of discriminability “is equated with tolerance”. The most likely source of this belief is to discover that even experts disagree. Many adults remain absolutists or multiplists for life, yet many adults progress to the next level. At the *evaluativist* level (adulthood) the objective dimension of knowledge has been reintegrated. The evaluativist considers knowledge as underlying judgment, evaluation and argument and, thus, as not equal opinions. Accordingly, everyone has a right to their opinion but some opinions are in fact more right than others, “to the extent they are better supported by argument and evidence”. This represents a more powerful basis than personal preference. Kuhn (1994) states: “Only people in the evaluative stage understand how informed opinions are based upon weighing of alternative claims in a process of reasoned debate and understand the depth of argumentation as a process involving alternative views and evidence”. The evaluativist level is the only level “that supports sustained intellectual inquiry and analysis” (Kuhn, 2001).

### Metastrategical knowledge (MSK)

On the other hand, metacognition involves the awareness and management of one’s own thinking (Kuhn et al., 2004). This second component of metacognition is called **metastrategical knowledge (MSK)** since the awareness and the management of one’s own thinking require strategic organization – of processes such as to know “how, when and why capabilities are engaged in the course of work”, which strategies are available and when useful to apply (Kuhn, Cheney, & Weinstock, 2000; Kuhn & Pearsall, 1998; White & Frederiksen, 2005; Zohar, 2004; 2006). MSK masterminds the attention “to the general structures that are embedded in specific situations and contexts” and, thus, is “regulative” and guides to the correct application of cognitive processes. Similarly, Moshman and Shraw (1995) state that MSK refers to knowledge about the execution of strategic skills. Zohar (2006) describes MSK more detailed as “making generalizations and drawing rules regarding a strategy; naming the strategy; explaining when, why, and how such a strategy should be used, when it should be used, what the disadvantages are of not using appropriate strategies, and what task characteristics call for the use of strategy”. Summarizing, MSK implies the awareness of knowing strategies available (White & Frederiksen, 2005), knowledge about their

accomplishments as well as about their appropriate application (Kuhn, 2001). Considering the **development** of MSK, research shows that MSK is relevant to all ages. “People of all ages routinely construct structures of knowledge that include, but go beyond, available facts.” (Moshman, 2004). But the degree of awareness increases. This will be shown in the following in terms of the knowing strategy “inference” (cf. Moshman, 2004). Adults are aware that they make inferences in general thought they might sometimes be unaware of the inferences they make right now. In contrast, preschool children are able to make inferences and do it not less likely than adults but preschool children seem to be unaware of the notion of inference itself and fail to make a distinction between premises and conclusions. Only at age 6 they become aware of inference “as a potential source of knowledge” and only at this age children can imagine inferences within other persons’ thinking. The awareness of inference becomes also more detailed with age, that is, there are more metalingual distinctions: By age 6, children are only aware of deduction and guesses and have more confidence in deductive inferences than in guesses; children at the age of 8-10 are aware of deduction, induction, and guesses and they prefer deduction to induction and induction to guesses; even more detailed, adults prefer deduction to induction, induction to informed guesses, and informed guesses to uninformed guesses. Moshman emphasizes that who lacks detailed awareness of the nature of inferences cannot evaluate arguments. For instance, a deductive argument that contains a false (i.e., not true) premise and, accordingly, a false conclusion cannot be recognized as valid as long as truth and validity or content and form cannot be separated as different constructs. This distinction is not possible until adolescence and at about age 11. This is a finding of particular importance for argument research. Summarizing, metastrategical consciousness, control of logic, and rationality increase with advancing age. Unfortunately, within the scope of this paper the author cannot describe the meaning of EPU and MSK for teaching and learning more detailed (but see e.g. Hofer & Pintrich, 1997). After outlining MCK and its components EPU and MSK from this primarily general perspective, argument-specific MCK will be elaborated in the following section 2.

## **Argument-specific MCK**

Following According to section 1, we find for **argument specific-EPU**: EPU is a precondition for high quality arguments since only the evaluativist level allows for considering knowledge as underlying judgment, evaluation, and argument and, thus, as not equal opinions. Similarly, only the evaluativist considers some opinions to be more right than others based on argument and evidence and understands argumentation as involving alternative views. Moreover, EPU should imply to know about the nature of opinions as subjective knowledge representations that, nevertheless, underlie convincing arguments when they are evidence-based.

Closely related, there is highly relevant research from cognitive, educational psychology that contributes to defining EPU about arguments. Following Kuhn (2001) EPU refers to the nature of knowledge and knowledge generation and, thus, to (the nature of) evidence as knowledge basis. And both the notion of “evidence” as an epistemic justification and an adequate understanding of its nature and function are central for metacognitive argument. In particular, Kuhn (2001) puts emphasis on the distinction between explanation and evidence as argument-related issues. Evidence represents the outcome cue and can be referred to within empirical studies by the question “How do you know?”. Explanation represents the theory-generating cue and can be referred to within empirical studies by the question “Why is it so?”. The ability to distinguish between evidence and explanation develops across life span. Children below the age of 6 are not able to distinguish justifications of different epistemic status (e.g. explanation – evidence, theory – evidence) (Kuhn, 2001). Similarly, Carey and Smith (1993) as well as Driver, Leach, Millar and Scott (1996) find that within naive epistemological beliefs theory, hypothesis, and evidence are not adequately distinguished.

Analogously, **MSK about argument** can be concluded from section 1 and from further literature as follows. MSK about argument implies to know about knowledge generating strategies available in general and about argument as one crucial strategy of knowledge generation. More specific, argument-specific MSK is about sub-strategies of argument. For instance, there is argument from sign, from expert opinion or from analogy (Walton, 1996). Moreover, MSK about arguments implies knowledge about what the argument strategies' accomplishments are. For instance, the strategy "argument from expert opinion" supports the strength of an argument and, thus, its effect on the audience by making the argument appear more objective and knowledge-based. Argument MSK also refers to the limits of knowledge generating strategies: Even an expert status has to be critically examined (Walton, 1996) and is limited e.g. if the other experts disagree with the opinion of the expert you are citing. Similarly, the argument strategy "deduction" has its limits in the clash between form and content: A deductive argument can be valid though its content is not true (Toulmin, 2003). Accordingly, MSK should imply the knowledge that form is to be distinguished from content, that there are two specific concluding argument strategies, induction and deduction, and that validity refers to these strategies: An argument is inductively or deductively valid and validity can be accomplished by induction and deduction. Similarly, Kuhn and Felton (2000) distinguish nonepistemic, content-related characteristics that refer to the content of the argument, e.g., its in-/ correctness (see also Zohar & Nemet, 2002, for coding of correct and incorrect scientific knowledge), and epistemic, meta-level characteristics. Epistemic characteristics refer to the form of argument (or theory or evidence) such as its strengths and weaknesses and, thus, apply to any argument. Accordingly, there are nonepistemic responses at a low level and epistemic responses at a high level when asked why an argument appears to be stronger than another argument. It should be noted that knowledge about form, of course, depends on the capacity for abstract thinking (Alexander, 2006). Similarly, Kuhn and Dean (2004) state that metacognition is closely related to critical thinking. Finally, MSK implies knowledge about when the argument strategies are useful to apply. For instance, to refer to argument in general does only make sense if you can provide evidence for your claim; to refer to "comparison" as a specific strategy to support your argument does only make sense if there is a truly similar issue; finally, to refer to moral argument is not useful if the topic at issue is merely scientific.

Furthermore, there are epistemological argument studies and models that contribute to defining argument MCK. For the sake of brevity only the contribution to argument MCK of two of these studies and models can be described in the following.

Jiménez-Aleixandre, Rodríguez, and Duschl (2000): *epistemic operations*. When it comes to argument in the science classroom, the nature lesson is expanded from a simple procedural display to a scientific dialogue: "doing school" becomes "doing science" (Jiménez-Aleixandre, Rodríguez, & Duschl, 2000). By making this distinction Jiménez-Aleixandre et al. (2000) emphasize that learning is not to be reduced to scientific contents. Rather argument as a core strategy for knowledge generation in sciences implies, e.g., analytical approaches for the evaluation and communication of knowledge claims (van Eemeren et al., 1996) and, thus, represents a metacognitive approach to sciences and scientific knowledge. This can be demonstrated by the following statement: "From a science education perspective, when we set the capacity to develop an argument as a goal, that means an interest not only in the students *solving* the science problems (cognitive or strategic level), but also implies attention be given to the *criteria* which leads to one or another solution, why some solutions have been discarded, how this process of comparison is understood, which analogies or metaphors led to this understanding (epistemic level), as well as in students' monitoring their own learning (metacognitive level)." (Jiménez-Aleixandre et al., 2000). Besides providing this metacognitive science education background Jiménez-Aleixandre et al.'s (2000) study does have the following practical meaning for this article. The authors provide a list of and definitions of **epistemic operations** (see table 1) for that students' arguments can be coded. Jiménez-Aleixandre, Diaz, and Duschl (1998) define these operations as "practices related to science" and "scientific culture" (and oppose them to "procedural operations" such as the use of instruments and apparatus). Like the distinction of "doing school" and "doing science", these epistemic operations represent a metacognitive approach to science as opposed to procedural activity. In particular, to have knowledge about these operations and to know that knowledge can be generated by these epistemic operations can



be interpreted as argument **MSK**. On the other hand, these epistemic operations show **EPU**-underpinnings. For instance, “appeal to authority” as one epistemic operation can take shape on a low EPU-level when this operation implies a “black-white” thinking and the attitude that a lack of information leads to “wrong” opinions. On a higher level authorities can be recognized more distinctly as providing better or worse evidence. Moreover, knowledge about these operations implies to understand that knowledge is generated by the individual that chooses operations and, accordingly that knowledge is not merely objective and fact-based.

Kelly and Takao (2003): *epistemic levels of propositions within argument*. A further explicit metaapproach is given by Kelly and Takao’s (2002) **epistemic levels** of propositions in an argument (see table 2). This epistemic approach is based on the assumption that following cognitive psychology research that teaching and learning requires a metacognitive approach. In particular, inference, judgment, and mental construction are pointed out as metacognitive underpinning of teaching and learning. “(...) the traditional three Rs” – reading, writing, and arithmetic – “involve important components of inference, judgment, and active mental construction. Thus, the traditional view that the basics can be taught as routine skills, with thinking and reasoning to follow later, can no longer guide the educational practice” and “Thinking is applied to all learning” (instead of mere accumulative knowledge generation) (Kelly & Takao, 2002; following Resnick & Resnick, 1992). Kelly and Takao’s level approach was developed based on the following epistemic finding: While developing arguments scientists appear to focus on induction. They “try to move rhetorically from the particular contingencies of their actual experiments (i.e., very specific, grounded claims) to more generalized statements (i.e., theoretical claims) (...) moving low induction facts using the pictures, figures, and numbers to progressively higher induction, more abstract assertions” (Kelly & Takao, 2002; following Latour (1987) and Knorr-Cetina, 1995). Accordingly, Kelly and Takao’s epistemic levels increase in the generality of the knowledge referred to (tab. 2). In particular, data can be regarded from a more abstract perspective when features and relations are elaborated that lead to a theory or model supported by examples. This theory or model, in turn, can lead to an even more general model that is not specific to data. Thus, disciplinary-specific knowledge and data as well as general, abstract knowledge is central to argument. Regarding **EPU**, this approach defines data, theory and model as knowledge representations that are central to argument. This approach also points out the representations’ interrelation. Moreover, knowledge generation is described as directed towards abstractness and generality. Interpretation is emphasized as the instrument and scaffold of knowledge generation. Knowledge is described as to be generated actively. Regarding **MSK**, this approach reconstructs how to produce knowledge stepwise: Knowledge generation starts with observations and data and goes on with identifying trends, abstracting from data or knowledge towards theory. The approach also shows how to accomplish specific knowledge representations such as theory.

Finally, Walton (1996; 2007) discusses *knowledge sources* such as experts, Toulmin (2003) describes the structure and levels of nonethical argument and Dietrich (2005) the structure of ethical argument. For further information see these studies.

## Methods

According to the discussion of MCK about arguments, an opened questionnaire has been developed that investigates teacher candidates’ MCK about arguments. One part of the questionnaire is of relevance for this article. In this part nine crucial terms regarding metacognitive argument are presented: claim, justification, evidence, facts, moral rules, analogy, example, expert, theory. These terms are derived from the above mentioned argument theories and studies by that they have proven to be highly relevant to argument. The teacher candidates were asked to use and combine these terms into at least four sentences about argument, to use all of the terms and to discuss all of the possible ways in which these terms interrelate to one another.

Using the software excel data have been transcribed analyzed by Qualitative Content Analysis (Mayring, 2003) in order to develop a classification scheme that structures the MCK of the teacher candidates. Qualitative Content Analysis seeks to seek patterns that underlie the data. The researcher describes these patterns by a system of main

and sub-categories. Accordingly, this kind of analysis is summarizing and reducing in nature. Analysis can take place inductive, that is, primarily oriented on the data themselves, and/ or deductive, that is, guided by a pre-existing theoretical framework. For this study both approaches are true since theories about metacognition and argument guided the analysis and at the same time categories were also developed directly from data. The categories developed altogether present MCK about arguments, the single categories present single components of MCK. Categories should be as independent as possible. However, overlaps may occur depending on the data. For this study some overlaps occurred as pointed out below.

## Results

Four main components (=main categories) of MCK about arguments have been identified when the teacher candidates make statements about arguments with the given eight terms (tab. 5). These components refer (1) to attributes of the given terms (e.g., “moral rules are individual”), (2) to their function (e.g., “facts support a claim”), (3) to interrelations of the terms (e.g., “experts refer to facts”), and (4) criticism (e.g., “experts opinions still have to be backed up”). Additionally, the components (2) function, (3) interrelations, and (4) criticism show levels (tab. X).

**Table 1. Components and levels of MCK about argument.**

Component (= main category)	Levels
(1) MSK about <b>attributes</b> of the given terms	n.a.
(2) MSK about the functions	I Simple function II More complex, detailed (partly addressing) function
(3) MSK about interrelations	I Simple common interrelation: support function II 2 <sup>nd</sup> grade interrelation: logical and structural chains III Abstract interrelation: conceptual considerations
(4) MSK regarding criticism	I Simple unreasoned claim or reasoned claim regarding justification per se II Detailed, reasoned claim on (quantity or) quality III Comparison and evaluation of evidence

In the following the findings regarding these components and levels will be pointed out. The **component (1) “attributes”** implies comments on the nature of the terms given, on their features. (These attributes are non-functional. Functions of the terms given are described in the next component (2)). TC describe, e.g., that moral rules are “individual”, (dis-)proved by argument, are “not universally accepted”, that experts are familiar with theories and facts and are “well versed” in their subject, that experts are considered as evidence-providing since they have background knowledge, and that facts are knowledge sources that are found by research, that facts stem from experts, that facts are “clearly and universally defined”, that analogies are relevant “if you come to research that is comparable to your theory”, that analogies are “good” if the topic at issue “is too emotional”, that analogies draw to familiar moral rules and theories, that theories are presented by experts and are based on facts etc.

In order to classify these findings for EPU and MSK the author finds the following: EPU takes shape within the component “attributes” by an awareness of argument components as knowledge representations and, in particular, as knowledge sources (e.g. facts are knowledge sources) and by an understanding of both the specific nature of these knowledge representations (e.g., facts are universally defined, theories are presented by experts). To know about attributes also implies to recognize the possibility of varying strength within evidence (e.g., experts justify properly). On the other hand, MSK can be identified when TC know about knowledge generating strategies, that is, when they know how to generate knowledge (e.g., facts are found by research, analogies are made by drawing to familiar theories) and when they know why and when a specific argument component or strategy should be used (e.g., expert opinion is considered to give evidence since experts have background knowledge, analogies are to be used for comparable theories and if the topic at issue is too emotional).

The **component (2) “function”** describes what the given issues such as analogy are good for and what their effect is like. **On a lowest level I**, the teacher candidate simply states that an argument component supports, strengthens, backs up, or gives evidence for a claim EPU (understanding of evidence)/ MSK HOW. They do this by single sentences for each term such as “By this you support this. Use this to ... This backs up ... .” or by more complex grouping like “Facts and examples support ...”. The TC, thus, refer to the basic function of argument components. The teacher candidates refer to a more complex effect **at level II** when they do not only mention this support function but also further, more detailed functions: analogies help to make the issue clear, provide a “real-life perspective”, “show how similar and related to current time” the argument is; moral rules guide the justification and control experts’ research; an argument presents a theory. Though closely related to the component (1) “attributes” there is no function described within the attributes of component (1) but only characteristics and features. Moreover, this complex effect of level II is varied and/ or expanded when the teacher candidates explicitly emphasize an **addressing effect** on the listener/ reader as a particular facet of function. For instance, they state that an analogy can be understood by a wider audience, that examples help to get the arguer’s point across to the reader, or that analogies and moral rules allow for relating to the topic or argument in a personal way. In order to classify these findings for EPU and MSK the author finds the following: At level I, EPU is low since there is no differentiated understanding of evidence. Rather the TC recognize only a general support function of evidence. In contrast, they understand evidence and its function more specifically when they recognize the function of argument components more specifically at level II (e.g., analogies makes the issue understandable, moral rules control experts’ research). MSK takes shape when TC know how to give evidence and support a claim (e.g., by facts) at level I and II and when they know about the accomplishment of strategies at level II (e.g., moral rules guide the justification). The TC also show MSK when they recognize the way and direction of an argument component’s effect (e.g., addressing effect) at level II and reflect upon possible improvements of the effect (e.g., the use of analogy enhances understanding by a wider audience).

The **component (3) “interrelation”** and its levels can be visualized by the following figure 3 that at the same time provides a horizon of expectation. This figure also demonstrates the component (2) “function”. There is a logical chain within the given terms where a claim is backed up by evidence and evidence is generated by justifications. Justifications in turn can be based on facts or moral rules. And facts and moral rules can be put forward in the form of experts, theories, analogies or examples.

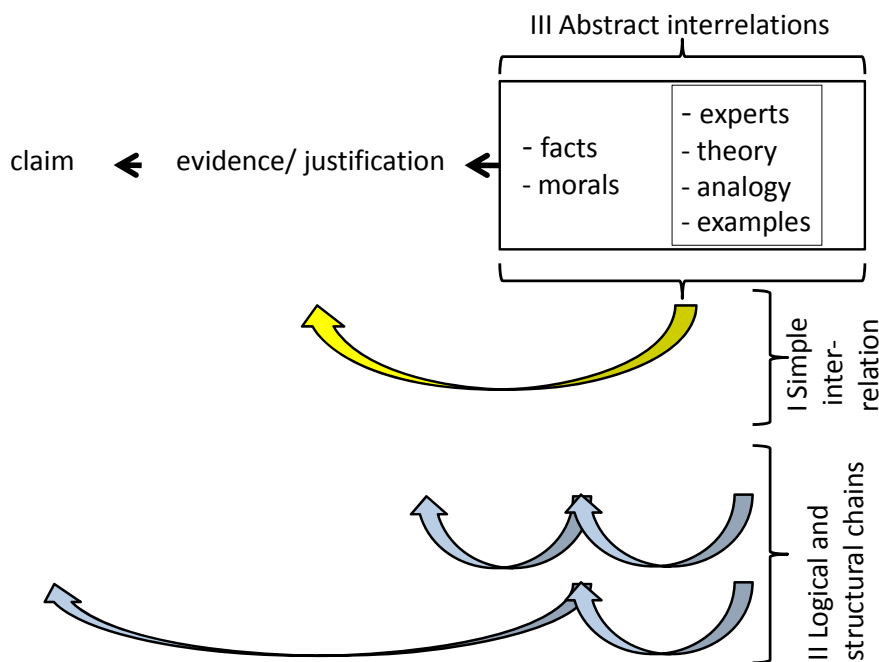


Figure 1. Interrelation of argument components.

Accordingly, **at level I** the TC state that some or all given terms belong together, are related since all support argument: “Facts, evidence, examples, analogies are all ways of backing up and justifying your claim or theory”. All given terms or those mentioned by the TC mostly appear to be considered as equal (regarding this nature). These findings primarily mirror MSK because the TC refer to strategic thinking when they recognize the application of the given issues as a strategy to justify a claim (e.g. facts support a claim). However, these findings are also underpinned by EPU since a precondition for this MSK is to know from a more general epistemological perspective about the nature of justification, that is, to know that claims require justification and that justification requires evidence-providing elements. These EPU-aspects of knowledge appear to increase throughout level II and III.

**At level II**, the TC identify more complex interrelations. They describe logical and structural multistage chains by that the argument elements are interrelated. For instance, one teacher candidate states that moral rules and theories represent a basis from that analogies can be drawn and that analogies, in turn, strengthen the claim/argument. While each single interrelation is only of 1<sup>st</sup> grade (e.g., analogy supports claim), to combine moral rules/theories-analogies-claim/argument interrelates more than two elements and, thus, represents a 2<sup>nd</sup> grade interrelation. Regarding MSK, there is more detailed and more complex strategy knowledge about argument justification and interrelations of argument components (e.g. examples strengthen moral rules that support a claim) – in opposite to level I. This enhanced MSK necessarily refers to a deeper understanding of evidence and justification (EPU).

At the **highest level III**, the author finds conceptual considerations that structure the terms in an abstract way. Some selected examples will be presented as follows. For instance, one concept implies that there are 1<sup>st</sup> and 2<sup>nd</sup> order argument components: Facts, moral rules, expert opinion are evidence-providing, 1<sup>st</sup> order components while examples and analogies represent 2<sup>nd</sup> order components. Similarly, another teacher candidate distinguishes between arguing components and aids: “The terms claim, moral rule, theory are things that arguments and the terms evidence, example, analogy, facts or expert are things that can aid in proving an argument.” Within these findings, EPU is highlighted in a particular way since there is an abstract, deep understanding of the different nature of different knowledge representations (e.g. facts and morals, science and philosophy) and of the conceptual framework of knowledge representations, that is, how they go together (e.g. 1<sup>st</sup> and 2<sup>nd</sup> order). This more complex EPU allows for an increase in MSK since argument can be developed and structured now more strategically, more thoroughly by considering that the given terms differ, have specific functions, group, either support or are to be supported, might have to take shape differently depending on the context, or that they due to a different nature can sometimes not be related to each other.

Finally, within the **component (4) “criticism”** the teacher candidates emphasize specific conditions, weaknesses or accomplishments of argument components and they comment on quality criteria of argument (components). At the **lowest level I** teacher candidates only state an argument (component) to be weak without giving reasons for their claim, e.g. “Arguments should not just be based on facts.”. **At level II**, the teacher candidates make a reasoned and detailed statement on the quality of argument (components). Quality statements give detailed descriptions of the conditions of the use of arguments (components) such as that analogies are only allowed/ good if their issue is comparable to the argument case Moreover, quality statements take a critical stance such as that moral rules are currently lacking, vary individually and are too emotional for argument. In addition, and potentially **at a level III**, the author finds statements in that the argumentative strength of argument components is evaluated or even compared, sometimes with sometimes without giving reasons, e.g. that analogies and moral rules are less important within an argument since they are individual and are often incorrect and that the best arguments are those that come from experts since these have background knowledge. Because of the abstractness of evaluations and comparisons these statements are considered to belong to level II, too. EPU is highly relevant to the component (4) “criticism” since as reported above only the highest level of EPU allows for reducing a relativistic view, recognizing better and worse opinions based on the evidence provided, and, thus, criticizing argument profoundly. Regarding MSK, there appears to be only rudimentary MSK at level I since the TC cannot reason why an argument (component) or its use is good or bad. But at level II, they show a lot of MSK regarding the correct use

of argument (components) (e.g. there should be a broad range of experts), its accomplishments (e.g. scientific analogies allow for rational argument; one does not have to be an expert to make a good argument) and limits (e.g. moral rules are currently lacking and not universally accepted).

## Conclusions and Implications

The findings presented might provide a basis for further teacher education on argument. In particular, they show components of TC's MCK and their knowledge about levels of MCK. However, there are several starting points for further research. First, EPU and MSK represent an analytical distinction. Yet they appear to help to better understand data. Further research might prove this. Secondly, the interrelation of metacognition and cognition should be discussed more detailed (e.g. see Kuhn & Pearsall, 1998). Thirdly, subjective conceptions occur e.g. regarding the nature of theory. These misconceptions might interfere with the level of MCK of a TC. Furthermore, it should be discussed whether a TC has to and/ or is able to show the highest levels of MCK. A bigger sample was useful. A second study on the TC's detailed understanding of the argument terms used was helpful. Similarly, more information about the abstract concepts the TC show was useful. Conclusions for teacher education regarding PCK are still to be drawn. Finally, item development might take place regarding the levels identified.

## References

- Dietrich, J. (2005). Ethisch-Philosophische Grundlagenkompetenzen: ein Modell für Studierende und Lehrende. In: Mayring, M. (Hrsg.) (2005). *Ethisch-Philosophisches Grundlagenstudium, Ein Studienbuch* (pp. 15-32). Münster: LIT Verlag.
- Driver, R., Leach, J., Millar, R., & Scott, P. (1996). *Young people's images of science*. Philadelphia: Open University Press.
- Driver, R., Newton, P., & Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science Education, 84*, 287-312.
- Duschl, R. A., & Osborne, J. (2002). Supporting and promoting argumentation discourse in science education. *Studies in Science Education, 38*, 39-72.
- Eemeren, F. H., van, Grootendorst, R., & Snoeck Henkemans, F. S. (1996). *Fundamentals of argumentation theory*. Mahwah, NY: Lawrence Erlbaum Associates.
- Erduran, S., & Jimenez-Aleixandre, M. P. (Eds.). *Argumentation in Science Education: Perspectives from Classroom-Based Research*. (pp. 245-268) Science and Technology Education Library 35. Berlin: Springer.
- Erduran, S., Simon, S., & Osborne, J. (2004). TAPping into Argumentation: Developments in the Application of Toulmin's Argument Pattern for Studying Science Discourse. *Science Education, 88* (6), 915 - 933.
- Hofer, B. K., & Pintrich, P. R. (1997). The development of epistemological theories. *Review of educational research, 76* (1), 88-140.
- Jiménez-Aleixandre, M. P., Diaz de Bustamante, J., & Duschl, R. A. (1998). *Scientific Culture and School Culture: Epistemic and Procedural Components*. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching. San Diego, CA, April 19-22, 1998.
- Jiménez-Aleixandre, M. P., Rodriguez, A. B., & Duschl, R. A. (2000). „Doing the lesson“ or „Doing Science“: Argument in High School Genetics. *Science Education, 84*, 757-792.
- Kelly, G. J., & Takao, A. (2002). Epistemic levels in argument: An analysis of university oceanographic students' use of evidence in writing. *Science Education, 86*, 314-342.
- Kuhn, D. (1995). Scientific thinking and knowledge acquisition. *Monographs of the Society for Research in Child Development, 60* (4), 152-157.
- Kuhn, D. (2001). How do people know. *Psychological Science, 12* (1), 1-8.
- Kuhn, D., Black, J., Keselman, A., & Kaplan, D. (2000). The Development of Cognitive Skills To Support Inquiry Learning. *Cognition and Instruction, 18* (4), 495-523.
- Kuhn, D., & Dean, D. Jr. (2004). Metacognition: A bridge between cognitive psychology and educational practice. *Theory Into Practice, 43* (4), 268-273.

- Kuhn, D., Katz, J. B., & Dean, D. Jr. (2004). Developing reason. *Thinking & Reasoning*, 10 (2), 197-219.
- Kuhn, D., & Pearsall, S. (1998). Relations between metastrategic knowledge and strategic performance. *Cognitive Development*, 13, 227-247.
- Mayring, P. (2003). *Qualitative Inhaltsanalyse, Grundlagen und Techniken*. Weinheim/ Basel: Beltz Verlag.
- Moshman, D. (2004). From inference to reasoning: The construction of rationality. *Thinking & Reasoning*, 10 (2), 221-239.
- Moshman, D., & Shraw, G. (1995). Metacognitive Theories. *Educational Psychology Review*, 7 (4), 351-371.
- Newton, P., Driver, R., & Osborne, J. (1999). The place of argumentation in the pedagogy of school science. *International Journal of Science Education*, 21 (5), 553-576.
- Osborne, J., Erduran, S., & Simon, S. (2004). Enhancing the quality of argumentation in school science. *Journal of Research in Science Teaching*, 41 (10), 994-1020.
- Sadler, T. D. (2004). Informal reasoning regarding socioscientific issues: A critical review of research. *Journal of Research in Science Teaching*, 41, 513-536.
- Simoneaux, L. (2001). Role-play or debate to promote students' argumentation and justification on an issue in animal transgenesis. *International Journal of Science Education*, 23 (9), 903-927.
- Simon, S., Erduran, S., & Osborne, J. (2006). Learning to teach argumentation: Research and development in the science classroom. *International Journal of Science Education*, 28, 235-260.
- Toulmin, S. E. (2003). *The uses of argument*. Cambridge, UK: Cambridge University Press.
- Treml, A. (2000). Sprache der Ethik – Ethik der Sprache, Möglichkeiten und Grenzen sprachanalytischer Reflexion im Ethikunterricht. *Ethik & Unterricht*, 4, 14-21.
- Walton, D. N. (1996). *Argumentation Schemes for Presumptive Reasoning*. Mahwah, NJ: Lawrence Erlbaum.
- Zeidler, D. (1997). The central role of Fallacious Thinking in Science Education, *Science Education*, 14, 483-496.
- Zemal-Saul, C., Munford, D., & Crawford, B. (2002). Scaffolding preservice science teachers' evidence-based arguments during an investigation of natural selection. *Research in Science Education*, 32, 437 - 463.
- Zohar, A. (1999). Teachers' metacognitive knowledge and instruction of higher order thinking. *Teaching and Teachers' Education*, 15, 413-429.
- Zohar, A. (2004). *Higher order thinking in science classrooms: Students' learning and teachers' professional development*. Dordrecht, The Netherlands: Kluwer Academic.
- Zohar, A. (2006). The Nature and Development of Teachers' metastrategic knowledge in the Context of Teaching Higher Order Thinking. *The Journal of the Learning Sciences*, 15 (3), 331-377.
- Zohar, A. (2008). Science Teacher Education and Professional Development in Argumentation. In: Erduran, S., Jimenez-Alexandre, M. P. (Eds.). *Argumentation in Science Education: Perspectives from Classroom-Based Research*. (pp. 245-268) Science and Technology Education Library 35. Berlin: Springer.
- Zohar, A., & Nemet, F. (2002). Fostering students' knowledge and argumentation skills through dilemmas in human genetics. *Journal of Research in Science Teaching*, 39, 35-62.

**PART 2**  
**SCIENTIFIC LITERACY**





# A FRAMEWORK FOR PRACTICAL WORK, ARGUMENTATION AND SCIENTIFIC LITERACY

Ros Roberts

Durham University, UK

Richard Gott

Durham University, UK

## Abstract

*The debate on practical work in science, and more recently on scientific literacy and argumentation, has not been notable for its clarity. In this theoretical paper we should like to contribute to the debate on these issues by proposing a framework within which practical work, scientific literacy and, in particular, argumentation (or at least elements of each) can be located. We shall deal with the underlying ideas behind evidence in science and its place as a stand-alone topic of some importance, its role in the accumulation and defense of evidence from practical investigative work in science, and as the basis for key elements of scientific literacy in socio-scientific contexts related to the development and analysis of an argument based on that evidence. The framework is built up from a series of descriptive models which serve to frame the ideas we consider to be important and to act as a guide to both research in the area as well as informing curriculum and pedagogical developments.*

## Introduction

Our research interest lies in the framing of ideas related to evidence in science and how they might be taught and assessed, used to solve practical problems and act as a structure to look at issues to do with evidence in scientific literacy.

The debate on practical work in science, and more recently on scientific literacy and argumentation, has not been notable for its clarity. In this theoretical paper we should like to contribute to the debate on these issues by proposing a framework within which practical work, scientific literacy and, in particular, argumentation (or at least elements of each) can be located.

We will outline how our research has been informed by the framework and its constituent models and will suggest further lines of research that could be followed.

## Scientific Literacy and Evidence

The area of scientific literacy is so broad and diffuse that almost any topic in science education can be included in the debate. Two decades ago Roberts (1988, p28) pointed to problems associated with phrases such as ‘scientific literacy’:

“These phrases have often commanded a remarkable amount of consensus yet they are educational slogans rather than definitions ... Such slogans cannot automatically shape what counts as science education.”

DeBoer (2000) and Laugksch (2000), amongst others, attest to these problems while, more recently, Braund and Reiss (2006) suggest that sufficient agreement exists about the meaning of the term for it to be used profitably. Lang et al. (2006) cite the increasing calls for the science curriculum to reflect the real world needs of students so that they can participate in science debates.

In a recent paper Gott and Duggan (2007) have argued that, whatever the definition one chooses to adopt, the role of evidence plays some part. In some views of scientific literacy (outlined for instance in Longbottom & Butler (1999) and Davies (2004)) an understanding of evidence is seen as a necessary part of understanding decisions

made by others - a rather 'passive' role. At the more 'empowered' end of the spectrum, there is a view that understanding evidence, and equally importantly the experimental design which produced the evidence, is necessary to participate in decision making and to challenge the science that affects people's lives - a more 'active' role (Ryder 2001, Davies 2004). We position ourselves at this end of the spectrum and have researched students' willingness to ask sensible questions (Roberts & Gott 2007a, b). This critical appreciation of science is founded on a belief that evidence (not a claim) is of the essence: as the Royal Society motto has it – 'Nullius in Verba' ('On the words of no one' or, more colloquially, 'Take nobody's word for it') - indicating a commitment to establishing the truth through experiment and observation rather than through the citation of authority (Wikipedia, 2008).

'At the core, science is fundamentally about establishing lines of evidence and using the evidence to develop and refine explanations using theories, models, hypotheses, measurements and observations' (Duschl et al. 2006, chap 1 p 6).

Recent curriculum frameworks around the world have reflected science as more than a body of facts (see for example Duschl et al. 2006; the UK's Qualifications and Curriculum Authority, undated; Western Australian Curriculum Council 1998). Students are now expected also to engage with the central role of evidence in science.

## **The Concepts of Evidence and Procedural Understanding**

The procedural component of the curriculum has been conceptualised and articulated differently in the literature by researchers with different research agendas (outlined in Glaesser et al 2009a). In science education in the UK and in our work, the term procedural understanding has been used to describe the understanding of ideas about evidence, which underpin knowing how to proceed.

It is this perspective that underpins our research. The procedural component is seen to be underpinned by a set of ideas about evidence, termed the *concepts of evidence*. It requires the learner to construct meaning, specifically about validity and reliability, from specific ideas about evidence. The focus is on a set of ideas that are an integral part of science and that can then be learned, understood and applied, rather than a set of skills that develop implicitly by practice. These ideas can be applied and synthesised in open-ended investigations, together, of course, with the traditional substantive ideas of science.

We have listed the concepts of evidence (Gott, Duggan and Roberts 2003) which enables us to clearly articulate the ideas to be taught and assessed in a curriculum, and it is these ideas that help to frame our research.

The specification and teaching of the traditional substantive ideas of science is not the focus of this paper. That is not to down-play its importance in science education. Our focus is on the procedural component of the curriculum.

The framework that we discuss in this paper focuses on the role of evidence in practical work, argumentation and scientific literacy.

## **Empirical work, argumentation and scientific literacy**

Our framework (shown in Figure 1) attempts to include elements of these issues and will be defined and outlined in what follows. It is basically built up from a series of descriptive models which serve to frame the ideas we consider to be important and to act as a guide to both research in the area as well as informing curriculum and pedagogical developments.

We shall deal with the underlying ideas behind evidence in science and its place as a stand-alone topic of some importance; its role in the accumulation and defense of evidence from practical investigative work in science; and as the basis for key elements of scientific literacy in socio-scientific contexts related to the development and analysis of an argument based on that evidence.

In the first model (the left hand box in Figure 1) we shall attempt to show how various types of practical work have a common basis in the ideas needed to understand scientific evidence. These ideas we have discussed elsewhere as 'concepts of evidence' (Gott et. al., 2003). We shall show how these ideas, structured by experimental design, culminate in a conclusion or claim.

In the second (middle section), we use Toulmin's (1958) work on argumentation (an area researched by others including, for example, Erduran et al. (2004), Zohar and Nemet (2002), Kim and Song (2003) and Zion et al. (2004)), to provide us with a theoretical perspective which links data collection and verification, argumentation and

(elements of) scientific literacy (Gott and Duggan 2007). To do this, we shall look at the central role of the ‘claim’ and suggest that Toulmin’s model can be used as a structure both for constructing a claim (looking forward) and for a post hoc examination of the claims of others (looking back) which we see as a crucial element of scientific literacy.

In the final element of the framework (the right hand box) we consider how scientific claims become just one element in the debate in a socio-scientific context (Ratcliffe and Grace 2003, Levinson 2006).

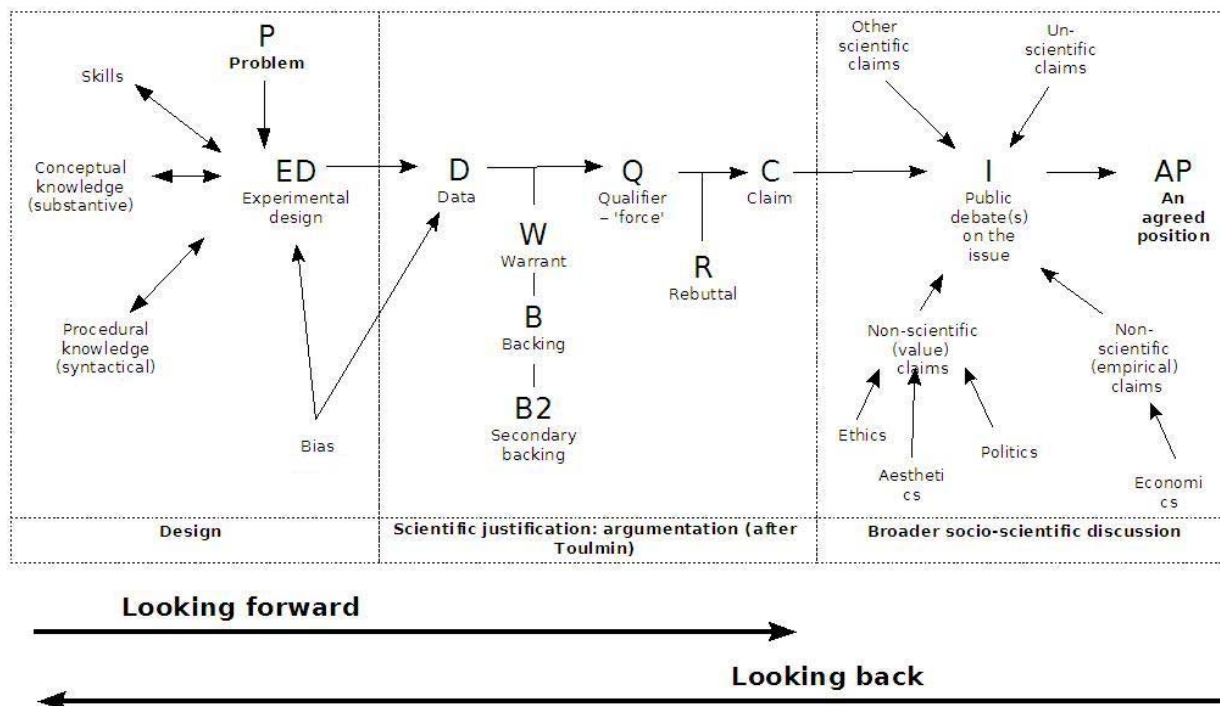


Figure 1. Empirical work, argumentation and scientific literacy (Gott and Roberts 2008)

## Practical investigations

The left hand box in Figure 1 represents the ‘doing’ of an investigation, which leads to a claim being made. Both substantive and procedural knowledge (of the concepts of evidence) are brought to bear, along with manual skills, in the solution of a practical problem. At each stage of an investigation, the quality of the evidence must be considered. Is it answering the questions? And how much do I trust the data?

Practical work in school science takes many forms with different curriculum purposes. We are particularly interested in practical work that enables students to understand and apply ideas about evidence. Many school practicals are organized so that, in effect, they reduce the focus on such a procedural understanding; they often act as illustrations of the substantive ideas of science. On the other hand, open-ended investigations are those in which students are unaware of any ‘correct’ answer, where there are many different routes to a valid solution and where different sources of uncertainty lead to variations in repeated data so that students reflect and modify their practice in the light of the evidence they have collected. The evidence produced, then, is messy rather than the laundered version common in practical work contrived to illustrate ideas to students. Such investigations should play an important role in ‘inquiry’ based approaches to science curricula across the world (Abd-El-Khalick et al. 2004). They reflect ‘science as practice’ and are important for understanding not just the practice of scientific investigation but also provide a context for understanding why science needs empirical evidence (Duschl et al. 2006).

Practical work provides excellent practice in the ‘hands-on’ doing of science, encouraging pupils to ‘look forward’ through the investigation, using their understanding of the concepts of evidence to design an investigation and collect, analyse and interpret data, and present their justified claim. But if school science is to equip pupils to be scientifically literate then it also needs to encourage pupils to ‘look back’ from the scientific public claims which they are likely to meet in daily life.

## Argumentation

We shall briefly describe here Toulmin's framework for argumentation, which constitutes the middle box of Figure 1, but refer the reader to the original (in particular) and to the other work previously cited for further amplification.

### 'Looking forward'

Firstly, we will examine the framework from the perspective of the investigator making a claim (looking forward). A scientist collects evidence in a reliable and valid manner and makes claims as a consequence; in effect moving from left to right through the middle box of Figure 1, implementing the phases of an argument. Toulmin's key terms which, he suggests, constitute the elements of rational argument are described by Kelly and Chen (1999, p902):

"Data (D) are the facts the proponent of the argument explicitly appeals to as a foundation for the claim. The claim (C) is the conclusion whose merits are sought to establish. The warrant (W) is the rules, principles, or inference license that demonstrate that the step to the claim from the data is a legitimate one. The strength of the warrant may be indicated by modal qualifiers (Q). The rebuttal (R) indicates the circumstances for which the general authority of the warrant is not merited. The backing (B) establishes the general conditions which give authority to the warrants."

We exemplify how ideas these procedural ideas about evidence can be used in argumentation to make a claim.

### *The Warrant*

The procedural warrant is concerned with the experimental design from which the data has emerged. Is it valid and reliable? And, stemming from that, the validity and reliability of any and all measurements, and of the methods of data collection, reduction and analysis are each open to question.

The procedural warrant is at a general level – it is the encapsulation of the very essence of science: its knowledge structures and its ways of employing data to validate these knowledge structures.

### *Backings, qualifiers and rebuttals*

Backings, on the other hand, are the detailed elements of the warrant which apply in a particular case. They too draw on the concepts of evidence. We will explore the procedural backings, qualifiers and rebuttals a little further. The procedural backings are the detailed procedural decisions made during the investigation: the variable structure, the evaluated quality of the instruments used and the resultant data, the sample of readings and its selection, the interpretation of the relationship etc. The qualifiers provide an indication of the strength of the claim: 95% confidence, for instance. The rebuttals delimit the generalisability of the claim by pointing to the conditions the claim applies to, which will be dependent on the circumstances of the investigation. Thus an investigator uses the ideas about evidence to justify the claim.

### 'Looking back'

Scientific literacy, on the other hand, requires the student to 'look back' from the scientist's claim (moving from right to left in Figure 1) and is, of course, more complex, not least because the student has not actually designed the investigation(s) or collected the data first hand. In judging the strength of the claim, a student would need to 'look back' at the rebuttals and qualifiers as well as the primary backings for the data; how the data were collected i.e. the experimental design, methods of measurement and empirical data collection. To do this, they have to understand that experimental design and empirical measurement are significant elements and need to be examined carefully. By asking meaningful questions about the scientist's claim the student starts to demonstrate this understanding and shows the critical scepticism of a scientifically literate person.

Our focus on these procedural ideas is not to suggest that substantive ideas are of lesser importance of course – in designing an investigation they may well be at the forefront. But in defending a claim the quality of the data is the critical factor since, on rare occasions, its lack of consonance with established theory can constitute a scientific breakthrough. And when questioning the basis for a claim it is these details that may be of greater relevance since the substantive science issues are not within the range of most people, including those who wish to be actively involved.

## Socio-scientific issues

Socio-Scientific Issues (SSI), by definition, involve both societal components as well as scientific (the right hand box of Figure 1). Decision-making in SSI is affected by these multiple factors. Some research suggests that both the general public (Pompe, Bader, & Tannert, 2005; Thagard, 2001) and undergraduate students (Halverson, Siegel and Freyermuth, 2009) often overlook the science embedded in these issues when making decisions. However, Tytler, Duggan and Gott (2001a, b) have shown that when the public engaged with the claim by scientists in a local SSI, ideas about evidence were accessible and important.

The right hand box is where the scientist's claim from a specific piece of empirical work and other experiments and 'non-science' sources of knowledge are put together into a forum where an argument or debate is to be had. The broader debate should wish to inspect the claim critically before taking it into the decision-making process. But the debate will often have to deal with other, possibly competing, scientific claims on the same issue. Added to that will be 'value' claims linked to ethics, or aesthetics, or politics and empirically based economic claims, to say nothing of totally unscientific and even irrational claims based on prejudice and ignorance.

A scientifically literate person ought to be able to engage with the science in such SSI, by 'looking back' through the elements of Figure 1.

## Framing research

We have found this framework useful for research. By delimiting and articulating the theoretical perspective we have been able to ask, and attempt to answer the following research questions:

1. Does teaching the ideas of evidence – looking forward - improve students' understanding of evidence? (Roberts and Gott 2004, 2006)
2. Does teaching the ideas of evidence – looking forward - improve students' open-ended investigations? (Roberts 2009; Roberts, Gott and Glaesser, accepted)
3. What are the necessary and sufficient conditions for success in an open-ended investigations? (Glaesser et al 2009a, b)
4. How do students use the ideas of evidence in an investigation? (Roberts 2009; Roberts, Gott and Glaesser, accepted)
5. Does teaching the ideas of evidence – looking forward - enable students to question others' claims – looking back? (Roberts and Gott 2007a, b)
6. What sort of questions do they ask and which ideas of evidence do they draw on when questioning claims? (Roberts and Gott 2007a, b)

We have recently used Toulmin's argumentation pattern to analyse the sorts of questions asked in SSI.

In the future we hope to find out whether students who are explicitly taught the Toulmin argumentation pattern will better justify the claims they make in their own empirical work and also the questions they ask in a SSI.

We welcome discussion about any of our work and suggestions for future work.

## References

- Abd-El-Khalick, F., Boujaoude, S., Duschl, R., Lederman, N G., Mamlok-Naaman, R., Hofstein, A., Niaz, M., Treagust, D. and Tuan, H. (2004) Inquiry in science education: International perspectives. *Science Education*, 88(3):397–419.
- Braund, M. and Reiss, M. (2006) Validity and worth in the science curriculum: learning school science outside the laboratory. *The Curriculum Journal*, 17(3) 213-228.
- Davies, I. (2004) Science and citizenship education. *International Journal Science Education*, 26(14), 1751-1763
- DeBoer, G. (2000) Scientific literacy: another look at its historical and contemporary meanings and its relationship to science education reform. *Journal of Research in Science Teaching*, 37(6), 582-601

- Duschl, R.A., Schweingruber, H.A. and Shouse, A.W. (editors) (2006) *Taking science to school: Learning and teaching science in grades K-8*. Technical report, Committee on Science Learning, Kindergarten Through Eighth Grade. Board on Science Education, Center for Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.
- Erduran, S., Simon, S. and Osborne, J. (2004) TAPPING into argumentation: Developments in the application of Toulmin's Argument Pattern for studying science discourse. *Science Education*, 88, 915-933.
- Glaesser, J., Gott, R., Roberts, R. and Cooper, B. (2009a) The roles of substantive and procedural understanding in open-ended science investigations: Using fuzzy set Qualitative Comparative Analysis to compare two different tasks. *Research in Science Education*, 39, (4), 595-624.
- Glaesser, J., Gott, R., Roberts, R. and Cooper, B. (2009b) The roles of substantive and procedural understanding in open-ended science investigations: Using fuzzy set Qualitative Comparative Analysis to compare two different tasks. *Research in Science Education* 39 (4) 595-624
- Gott, R. and Duggan, S. (2007) A framework for practical work in science and scientific literacy through argumentation. *Research in Science and Technological Education*, 25(3), 271-291
- Gott, R., Duggan, S. and Roberts, R. (2003) *The concepts of evidence*.  
<http://www.dur.ac.uk/rosalyn.roberts/Evidence/cofev.htm>
- Gott, R. and Roberts, R. (2008) *Concepts of evidence and their role in open-ended practical investigations and scientific literacy; background to published papers*.  
[http://www.dur.ac.uk/resources/education/research/res\\_rep\\_short\\_master\\_final.pdf](http://www.dur.ac.uk/resources/education/research/res_rep_short_master_final.pdf)
- Halverson, K.L., Siegel, M.A., and Freyermuth, S.K. (2009) Lenses for Framing Decisions: Undergraduates' decision making about stem cell research. *International Journal of Science Education*, 31(9), 1249-1268
- Kelly, G.J. and Chen, C. (1999). The Sound of Music: Constructing Science as Sociocultural Practices through Oral and Written Discourse. *Journal of Research in Science Teaching*, 36(8), 883-915
- Kim, H. and Song, J. (2003) Peer argumentation as an authentic feature of scientific enquiry in schools. *ASERA*. Melbourne, Victoria.
- Lang, M., Drake, S. and Olson, J. (2006) Discourse and the new didactics of scientific literacy. *Journal of Curriculum Studies*, 38(2), 177-188.
- Laugksch, R.C. (2000) Science literacy: a conceptual overview. *Science Education*, 84(1), 71-94
- Levinson, R. (2006) Teachers' perceptions of the role of evidence in teaching controversial socio-scientific issues. *The Curriculum Journal*, 17(3), 247-262
- Longbottom, J.E. and Butler, P.H. (1999) Why teach science? Setting rational goals for science education. *Science Education*, 83(4), 473-492
- Pompe, S., Bader, M., & Tannert, C. (2005). Stem-cell research: The state of the art. *European Molecular Biology Organization Reports*, 6(4), 297-300.
- Qualifications and Curriculum Authority. (undated) *GCSE criteria for science. Specification for GCSEs from 2006*.
- Ratcliffe, M and Grace, M (2003) *Science education for citizenship: teaching socio-scientific issues*. Open University Press, Maidenhead
- Roberts, D.A. (1988) What counts as science education? In Fensham, P (ed) (1988) *Development and dilemmas in science education*. London/New York The Falmer Press
- Roberts, R. (2009) Can teaching about evidence encourage a creative approach in open-ended investigations? *School Science Review* 90 (332) 31-38
- Roberts, R. and Gott, R. (2004) A written test for procedural understanding: a way forward for assessment in the UK science curriculum? *Research in Science and Technological Education* 22 (1) pp 5-21
- Roberts, R. and Gott, R. (2006) Assessment of performance in practical science and pupil attributes. *Assessment in Education* 13 (1) pp 45-67
- Roberts, R. and Gott, R. (2007a) Evidence, investigations and scientific literacy: what are the curriculum implications? *Proceedings of National Association for Research in Science Teaching (NARST) conference*, New Orleans, April 2007.
- Roberts, R. and Gott, R. (2007b) Questioning the Evidence: research to assess an aspect of scientific literacy. *Proceedings of European Science Education Research Association (ESERA) conference*, Malmo, Sweden, August 2007.
- Roberts, R., Gott, R. and Glaesser, J. (accepted) Students' approaches to open-ended science investigation: the importance of substantive and procedural understanding. *Research Papers in Education*
- Ryder, J. (2001) Identifying science understanding for functional scientific literacy. *Studies in Science Education*, 36, 1-44

- 
- Thagard, P. (2001). How to make decisions: Coherence, emotion, and practical inference. In E. Millgram (Ed.), *Varieties of practical inference* (pp. 335–371). Cambridge, MA: MIT Press.
- Toulmin, S. E. (1958) *The uses of argument*, Cambridge [Eng.] University Press.
- Tytler, R., Duggan, S. and Gott, R. (2001a) Dimensions of evidence, the public understanding of science and science education. *International Journal of Science Education*, 23, 815-832.
- Tytler, R., Duggan, S. and Gott, R. (2001b) Public participation in an environmental dispute: implications for science education. *Public Understanding of Science*, 10, 343-364.
- Wikipedia, (2008), [http://en.wikipedia.org/wiki/Royal\\_Society](http://en.wikipedia.org/wiki/Royal_Society).
- Western Australia Curriculum Council (1998) *Science learning area statement*.  
<http://www.curriculum.wa.edu.au/files/pdf/science.pdf>.
- Zion, M., Slezak, D., Shapira, E., Link, E., Bashan, M., Brumer, M., Orian, T., Nussinowitz, R., Court, D., Agrest, B., Medolovici, R. and Valanides, N. (2004) Dynamic, open inquiry in biology learning. *Science Education*, 88(5), 728-753.
- Zohar, A., and Nemet, F. 2002 Fostering students' knowledge and argumentation skills through dilemmas in human genetics. *Journal of Research in Science Teaching*, 39, 36-62.





# THE FOOD-ENVIRONMENT RELATIONSHIP: A SOCIO-SCIENTIFIC ISSUE IN THE PERSPECTIVE OF SUSTAINABLE DEVELOPMENT

Laurence Simonneaux  
ENFA, Toulouse Univeristy

Jean Simonneaux  
ENFA, Toulouse Univeristy

## Abstract

*This paper describes an experiment carried out with trainee teachers, as part of their initial training. Our objective was to develop their ability to question the way in which scientific knowledge is constructed. To do this, we used a series of didactic games, based on the impact that providing food has on the environment. The games were designed to expose them to disconcerting “evidence” taken from different scientific studies. These studies raise questions about the methodologies and the indicators used and at the same time reveal that the evaluation of the food-environment relationship is only possible in specific contextualised cases, and cannot be generalised. This strategy enabled the trainee teachers to improve their capacity for critical analysis. They questioned the hypotheses and indicators chosen for the scientific demonstration. They understood that because reality is complex, it is necessary to remain cautious. It is impossible to reduce the complexity of reality to the “artefacts” selected for the different studies. At the end of the training session, the trainee teachers questioned their preconceptions of the kind of behaviour to be encouraged in order to limit the negative impacts of food provision on the environment. They thought about the scientific issue raised, the legitimacy of choosing different methodologies in the construction of knowledge. In particular, they considered the possibility of using disconcerting didactic games in class in order to stimulate their pupils’ critical rationality.*

## Background, Framework and Purpose

The work presented here falls within the scope of the teaching of socio-scientific issues (SSI) which cause controversy amongst specialists in the disciplinary fields and/or the producers of non-academic knowledge (professionals, associations, consumers...). Some SSI may be used as a support for Sustainable Development Education (SDE). This is the case with question of the food-environment relationship. As far as SSI are concerned, both the status and recognition of the evidence are fundamental factors. Chateauraynaud (2004) gives us some clues as to what the *tangibility* of evidence may be. According to Chateauraynaud, we can consider evidence *tangible* if it resists “*the perpetual instrumental and argumentative variations to which the actors, doted with diverging representations and interests, submit it*” p.168. Until the evidence is considered *tangible*, it will be surrounded by doubt and controversy.

In literature, debate is considered a very valuable method for dealing with SSI. However, the use of didactic “games” (Sensevy, 2007), which focus on confronting pupils with disturbing “evidence”, seems, to us, to play an important role in the nurturing of epistemic questioning. This “evidence” may be based on (more or less consolidated) scientific knowledge, pertaining to various fields of science, social sciences and humanities, not only because the questions raised are by nature often interdisciplinary but also because they are based on social knowledge as well as social and professional practices. Emphasis has been placed on the difficulties pupils and students encounter when evaluating knowledge and “evidence” in the sciences (Jiménez-Aleixandre, 2008 ; Sandoval & Millwood, 2005). What we are concerned with here is the epistemological training of teachers, not only in the evaluation of “evidence” but also in the construction of scientific knowledge. Our research question is :

Can we observe any development in the understanding of the construction of scientific knowledge amongst teachers who are confronted with the results of disconcerting research?

## Method

This didactic situation was set up with trainee teachers of animal husbandry, agronomy and economic and social sciences. During the course of this didactic strategy, we prepared a few unexpected turns of events or « coups de théâtre » (Tiberghien et al., 2007) using :

- a) the ranking of the activities linked to providing food, according to their contribution to greenhouse gas emissions,
- b) the presentation of “surprising” data on the environmental impact of the different aspects of a kilo of bought vegetables,
- c) the comparison of the regional and global supply chains for lamb, in terms of final energy consumption,
- d) the presentation of the scientific controversy surrounding the results analysed previously.

The framework of analysis was defined *a priori*, as it was equated to the analysis of each didactic game. It consisted in identifying, in the teachers’ discourse, the effects of the didactic games and of the programmed unexpected turns of events. This was done using their reasoning and arguments and the evolution of this reasoning and these arguments; the signs that they were disconcerted; their epistemic distancing. Both authors analysed, independently, the written answers and the transcription of the debates. The visible discrepancies in the authors’ analyses were easily dealt with. In the interest of preserving the validity of the results, we used a double triangulation process seeking the point of convergence via the analysis of different sources of data (open questionnaires, debates) and via the analysis of this data by two researchers.

## Results

### ***The ranking of activities linked to providing food, according to their contribution to greenhouse gas emissions***

We compared the trainee teachers’ answers with the results of a study by Kjer *et al.*, (1994), quoted by Redlingshöfer (2006) as being the latest one available. None of the participants ranked all the answers correctly. There was a general tendency to overestimate the “polluting” effects of distribution and processing based on the idea that these activities are carried out by industrialists and big companies who are “major” polluters. Household activities (heating, refrigerating....) were underestimated.

Surprisingly, for example, not all the animal husbandry teachers rated animal production as the biggest contributor to greenhouse gas emissions although its actual contribution is 44%. In the answers, we observe that the trainee teachers reveal a tendency to transfer responsibility onto the actors who are the furthest removed from their own personal references. The trainee teachers reject or tone down the results that call their professional interests into question.

### ***The environmental impact of the different aspects of a kilo of bought vegetables.***

What surprises the trainee teachers about the environmental impact of the functional units involved in buying a kilo of vegetables in Switzerland, as expressed in points on the Eco-indicator 99?

If the indicators of energy consumption and greenhouse gas emissions help shed some light on the situation, they are not sufficient in the case of agricultural and food production systems. Many other environmental aspects are influenced by farming activities such as the pollution of the soil, the air and the water resulting from the use of agricultural inputs, the erosion and acidification of the soil or the damage caused to biodiversity. It is necessary to carry out “ecological assessments”. Faced with the complexity of the “ecological assessments” Jungbluth (2000) developed the modular concept, a simplified approach based on five modules of the lifecycle (production, origin/provenance, processing/conservation, packaging and consumption) to evaluate the different variants of a product in terms of its impact on the environment.

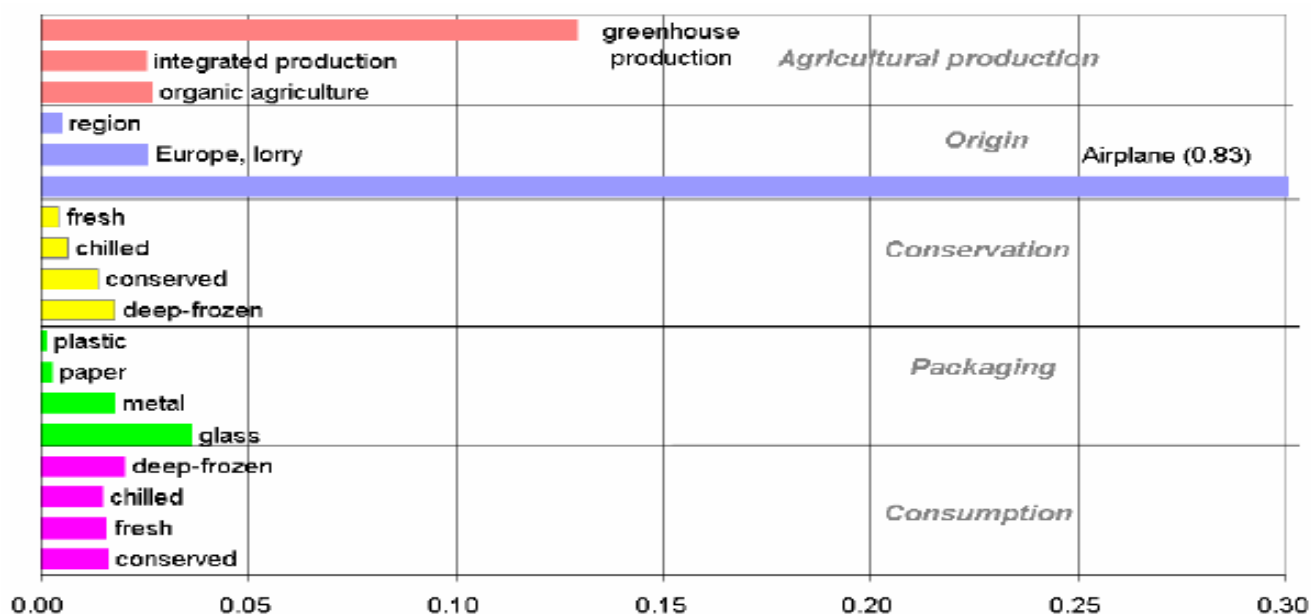


Figure 1 : Environmental impact, expressed in points on the Eco-indicator 99 scale, attributed to the different characteristics of a kilo of bought vegetables, according to five functional units studied. Source : Jungbluth, 2000 ; updated by Jungbluth in 2004.

Confronted with figure 1, the trainee teachers were surprised by the score for organic agriculture and the use of glass for packaging. We cannot give a detailed account of their responses in this synopsis. To summarise, they deduced from these results that they should shop at the local market for fresh vegetables grown locally, products cultivated in the field using an integrated farming system and packaged in plastic.

***The comparison between the regional and global supply chain for lamb, in terms of final energy consumption.***

At this stage, the teachers had experienced several socio-cognitive conflicts by being confronted with data opposed to their “common sense” or to media coverage of environmental questions. So, when they were asked to justify which production-processing-distribution chain was the least costly in terms of final energy: lamb produced “locally” or New Zealand lamb, they hesitated in giving the answer that had always seemed the most obvious to them: New Zealand lamb is more costly in terms of final energy consumption! They were worried about getting another surprise and this encouraged them to study the question more closely, scrutinizing the documents provided. They fail to form a well-founded point of view. This is revealed in the following exchanges. Our comments are in italics.

**Researcher : So, what do you think about this?**

**P1 : In fact, personally, I think things are pretty equal because the problem in New Zealand is more likely to concern feeding. Maybe on the production level, the energy consumption will be insignificant, on the other hand, they will consume more during transport, and in the regional case it will be the opposite, there is less transport involved however, consumption will perhaps be higher on the production side of things.**

**P2 : Take the shepherd who for 7 months makes several trips a day from his home to the station and in the winter he’ll be feeding them in the stables, from an energy point of view...**

Researcher: So, in your opinion it’s.....?

P2 : To me it would be....at the beginning I put down that it must be quite similar in both cases but as I was writing , I began to think....well things changed. We’re talking here of the impact in terms of energy, and only energy, nothing else, I think it’s even greater in the case of regional lamb.

*Quotes the indicator used to back up his decision.*

P3 : Me too.

P2 : Regional lamb might have a bigger impact than New Zealand lamb because the amount of energy consumed during transport is actually diluted between, I can't remember exactly how many, 2,500 containers of products that makes 6,000 and something tons, no 2,000, a net weight of 2,066 tons of lamb.

P3 : I think New Zealand lamb production is less....

P2 : Yes, definitely, definitely.

P3 : Consumes less energy

P2 : Exactly. There's a good chance that that's right.

P3 : Don't you think that, regarding the method of production, which we said just now weighs the heaviest in the balance in relation to greenhouse gas emissions (52% for the production method in farming compared to greenhouse gases which are only part of the question), don't you think that we might be tempted to say that in fact, in New Zealand, they farm on a super extensive basis, which actually consumes less energy, I mean produces a smaller quantity of greenhouse gases and less...?

*P3 refers back to the results on the contribution of production to the greenhouse gas effect, results which had surprised him earlier. He identifies a limit to the earlier reasoning due to the fact that in New Zealand they use "super extensive" farming methods.*

P2 : Yes but here we're talking only in terms of energy.

*P2 reminds the others that in this part the indicator is energy and not the Eco-indicator 99.*

P3: Yes but it's still an important factor in relation to final energy consumption.

Researcher: P4, what do you think?

P4: Personally, I hesitated for a long time but after careful thought I put [ ] I focussed perhaps more on the transport, what's more it's refrigerated transport which suggests excessive energy consumption. But, in so saying, regarding energy consumption at the production level, I also think that the consumption linked to producing feed is a lot lower than in the regional case. In fact, it's difficult to decide between the two.

Researcher: A subsidiary question, what do you think the pupils would say?

P2: That regional production consumes less energy than....yes, definitely!

*P2: thus reveals everyone's position on the subject prior to their participation in the disconcerting didactic situation.*

However, when they analysed the results, they were extremely surprised to discover that the difference in energy consumption between the two chains was so significant: 1.5 kWh/kg for locally produced lamb against 0.3 kWh/kg for New Zealand lamb (Schlich *et al.*, 2006).

### ***Presentation of the scientific controversy surrounding the results analysed previously.***

These results run counter to the very widespread idea that locally produced products consume less energy. This sparked a heated debate among scientists and ecologists in Germany, over the validity of the results as well as the way in which they had been interpreted and presented to the public. Other researchers (M. Dermeler, N. Jungbluth...) attacked the publication in a letter to the editor. Among other things, criticism was made of the fact that Schlich had isolated a single criterion, final energy consumption. Researchers deplored the fact that the multiple functions of agriculture had not been taken into account (in terms of the role it plays in the local economy, tourism and landscape management). Schlich rejected the criticism in a reply published in the same journal.

The presentation of this controversy at the end of the activity, led the teachers to use critical thinking of an epistemological nature. They realised it would be well worth helping pupils to identify the stages involved in the

construction of scientific knowledge, the impact of the choice of indicators used to demonstrate results and that this choice may betray political orientations. What do we want to encourage and promote in society? Is it the local economy, tourism, landscape management, the limitation of energy costs alone or a combination of different interests?

## Conclusion and implications

Socio-professional identity, here a teacher of a given discipline, has an influence on the way we analyse the food-environment relationship. The prevailing culture, notably media coverage of this question, had an influence on their reasoning. They had taken the advice given in the media, for example concerning the consumption of local products, as a benchmark and were convinced that glass pollutes less because of the incitation to recycle it. The didactic strategy functions on the basis of a series of scientific studies that question the chosen methodologies and indicators and at the same time show that the evaluation of this relationship can only be carried out using specific contextualised cases; it is impossible to generalize. The aim was not to lead the teachers to adhere to a “tangible” result. The strategy allowed them to improve their critical analysis of the products of research. They questioned the hypotheses or the indicators retained in the scientific demonstration. They understood that it is necessary to remain cautious because reality is complex and cannot be reduced to the “artefacts” selected for the different studies.

Within the framework of SDE, a behaviouristic angle is encouraged through involvement in the action and its exemplary nature. This experiment reveals the difficulties encountered in taking the “totality” or the complexity of reality into account. We see here the need to associate critical reasoning with the promotion of those eating habits that are considered “respectful” towards the environment. From an educational perspective, this type of strategy appears to us to be transferable. We can imagine a simplification of the data in a school context. However, we assume that critical epistemic thinking will emerge more easily after having experienced several disconcerting didactic games.

## Bibliography

- Chateauraynaud, F. (2004). La croyance et l'enquête. Aux sources du pragmatisme. *Raisons Pratiques*, 15, 167-194.
- Jiménez-Aleixandre, M. P. (2008). Designing argumentation learning environments. In S. Erduran & M. P. Jiménez-Aleixandre (Eds.), *Argumentation in science education: perspectives from classroom-based research*, (pp. 91-115). Dordrecht: Springer.
- Sandoval, W. A. & Millwood, K.A. (2005). The quality of students' use of evidence in written scientific explanations. *Cognition and Instruction*, 23 (1), 23-55.
- Jungbluth, N. (2000). Conséquences environnementales de la consommation alimentaire : évaluation des caractéristiques du produit au moyen d'un éco-bilan modulaire. Thèse ETH n°13499, Oko-Institut, Freiburg.
- Sensevy, G. (2007). Des catégories pour décrire et comprendre l'action didactique, In G. Sensevy & A. Mercier (dir.) *Agir Ensemble – L'action didactique conjointe du professeur et des élèves*. Presses Universitaires de Rennes. 13-49.
- Schlich, E. et al. (2006). La consommation d'énergie finale de différents produits alimentaires : un essai de comparaison, *Courrier de l'environnement de l'INRA*, 53, 111-120
- Redlingshöfer, B. (2006). Vers une alimentation durable ? Ce qu'enseigne la littérature scientifique ? *Courrier de l'environnement de l'INRA*, 53, 83-102.



## SCIENTIFIC LITERACY AND NATURE OF SCIENCE IN EARLY GRADES USING CARTOONS

Eleni Kolokouri

University of Ioannina, Greece

Katerina Plakitsi

University of Ioannina, Greece

### Abstract

*This paper is part of a wider study concerning scientific literacy and awareness of Nature of Science which have become a priority for all educational levels, including the early grades. An innovative method of introducing natural concepts in the early grades is using interdisciplinary means such as comics and cartoons-animations. A series of researches worldwide has shown that using cartoons-animations in classroom activities encourages creative thinking, stimulates children's interest, combines knowledge with every-day actions and finally enhances understanding concepts of different fields as well as concepts of Natural Sciences. In this paper, following the adventures of Bob Sponge Square Pants, prospective teachers approach the concepts of floating and sinking. They make predictions about which objects float or sink, test their predictions, provide reasons and try to overcome their cognitive obstacles. Moreover, they practice the skills of scientific method and finally they design classroom activities, according to NOS basic principles. The research data collection follows a variety of methods used in a case study and seeks to prove the appeal this didactical strategy has in pre-primary school classrooms. Preliminary findings confirm that this innovative practice a) enhances understanding natural concepts in the early grades, b) makes NOS a horizontal axe to both natural and social sciences, and c) pushes forward the boundaries of scientific literacy.*

### Introduction: Background-Framework

Scientific literacy has become a priority for educational experts and institutions in many European countries and worldwide. From a socio-cultural perspective (Vygotsky, 1978, Roth & Lee, 2004), it is important to provide learners of all educational levels with an appropriate science teaching curriculum in order to achieve scientific literacy. Understanding natural concepts and developing scientific argumentation concerning various natural phenomena will lead future citizens to a life of responsibility and decision making in a contemporary society. According to Miller (1983), "in a democratic society, the level of scientific literacy in a population has important implications for science policy decisions" (p.29). His efforts were concentrated on defining scientific literacy, contributing on its measurement in the United States and Europe, examining the results for 34 countries, and discussing the implications of the results for education policy, science policy, and democratic government in the 21<sup>st</sup> century. (Miller, 2007). Laugksch (2000) refers to four groups of scientists and researchers who promote scientific literacy as a whole or as a part of the community. These "interest groups" include the science education community, social scientists and public opinion researchers concerned with scientific and technological issues, sociologists of science and science educators concerned with a sociological approach to scientific literacy. UNESCO has declared 2003-2012 as United Nations Literacy Decade developing an 'Information for All' program, in which science awareness is considered vital (Unesco, 2008). Within the frame of this action it stresses the importance of designing curricula that provide a multidisciplinary approach to science and technological education, basic knowledge and scientific literacy for all. Accordingly, AAAS and NRC have taken initiative to advance scientific literacy and modern aspects of Nature of Science (AAAS, 1989, NRC, 1996).

According to Bravo (2005), it emerges as a social imperative that all people need to know science and also know about science. Moreover, scientifically literate citizens who are aware of selected topics from the philosophy of science make decisions about science and technology. An important tool, which many scientists consider vital for science education in the early grades, is studying Nature of Science (NOS). Scientists share certain beliefs and adopt a series of attitudes connected with nature of science basic principles Mc Comas (2005) pointed out 9 basic NOS principles:

- 1) Science demands and relies on empirical evidence.
- 2) Knowledge production in science shares factors, habits of mind, norms, logical thinking and methods.
- 3) Scientific knowledge is tentative, durable and self correcting.
- 4) Laws and theories are related but distinct kinds of scientific knowledge. Hypotheses are special, but general, kinds of scientific knowledge.
- 5) Science has a creative component.
- 6) Science has a subjective element.
- 7) There are historical, cultural and social influences on the practice and direction of science.
- 8) Science and technology impact each other, but they are not the same.
- 9) Science and its methods cannot answer all questions.

These principles are a powerful methodological tool in order to design natural science activities in the early grades. Furthermore, NOS offers a humanistic approach to science as it helps starters realize that Science is a human activity with social applications (science as culture). Taking this into account, this study is based on using NOS to promote scientific literacy from the early grades. At an international level great importance is placed on the child's education even from the first steps of his life. The fact that infants try to explore their surrounding environment by using their senses and try to satisfy their natural curiosity provides a foundation for developing scientific concepts. As international research documents point out (AAAS 1989, NRC 1996, NAEYC 2002, UNESCO 2008) education in Natural Sciences must start at a very early stage. At this level learning in Natural Sciences is connected with exploring in authentic environments, practicing skills of observation, classification, communication e. t. c. and making sense of the world around us.

Science educators agree that not everybody needs to know how to repair a car, how to build a house or how to grow plants but most of them insist that everybody needs to obtain basic knowledge of scientific concepts. (Roth, Lee, 2004). These concepts will be a guide in order to lead a life of responsibility and decision making in a technologically advanced world. Consequently, prospective teachers feel more confident to teach Natural Sciences and make decisions concerning scientific matters (Lederman, 1992, Mc Comas 1998, Plakitsi, 2007).

An innovative method of introducing natural concepts in the early grades is using interdisciplinary means such as comics and cartoons-animations (Bongco, 2000). Educators have stressed the importance of using art in classroom activities from Dewey (1934) who supports every child's right to art to Gardner (1983) who promotes different types of intelligence (e.g. spatial intelligence by the use of visual arts). Horn (1980), states that "cartoons have the ability to make a point without the semantic ambiguities inherent in the written words. He also characterizes cartoons a universal language that develops the imagination of the readers. Keogh and Naylor (1999) support teaching and learning scientific concepts by using concept cartoons. Thus, they offer an alternative method of science teaching which involves discussion, investigation and motivation for learners of all educational levels. Gene Yang (2003), in his site Comics in Education presents the strengths of comics in education as motivating, visual, permanent, intermediary and popular. Scott McCloud (1993) sees a different perspective: "In learning to read



comics we all learned to perceive time *spatially*, for in the world of comics, *time and space are one and the same*” (p. 100). Humor, exaggeration, symbols, emotions are all elements that provide learners with very interesting types of knowledge presented in a familiar context. It is a fact that both comics and cartoons-animations are related to ideas we already know or have directly experienced, which makes learning concepts meaningful (Mayer, 1996). Furthermore, they engage early starters in exploring a variety of scientific concepts, in experimenting, in creative thinking and providing solutions to problems without restraint. For example, the cartoon program “Dora the explorer” seems to have an impact on pupils concerning geographic education as it offers a variety of skills and capabilities that can be a basis for learning geography, orientation and developing problem-solving strategies. (Carter, 2008). Research about using comics and cartoons as an educational tool is widespread. The British Cartoon Archive (in British Cartoon Archive <http://www.cartoons.ac.uk/teachingaids>) encourages research about cartoons and supports groups of people who wish to exchange views about using cartoons in learning and teaching and also get ideas and inspiration. Accordingly, in the web page of Comic Life (in Comic Life <http://plasq.com>), visitors can discuss about comics in education and find information to create their own stories.

The New York City Comic Book Museum (in <http://www.nyccomicbookmuseum.org/education.htm>), offers educators an opportunity to bring comic books into the classroom. They become involved in comics literacy, the history of comics, and useful information to create comic books.

## Purpose

This study seeks, to:

1. Assess the effects of an alternative teaching method on prospective teachers.
2. Determine the extent to which the certain teaching method enhances understanding of natural concepts in the early grades.
3. Provide motivation to teachers and prospective teachers to develop innovative science activities for their pupils.
4. Provide early starters the foundation for meaningful learning and literacy development.
5. Contribute to scientific literacy and decision making of prospective teachers.

## Rationale

The rationale for this study was based on the observation that both teachers and prospective teachers present to be not very well informed about teaching Natural Sciences in the early grades. This makes them hesitant at adopting suitable didactic strategies for introducing the content knowledge and applying didactic transformations. Many researches (e. g. Bravo 2005, Lederman 1992, Plakitsi, 2007) on teacher education have reported the fact that teachers have their own ideas about science and Nature of Science. These ideas are on the one hand different from the scientific views and on the other, seem to cause anxiety to teachers. As a result, they need to become familiar with teaching methods that will help them overcome worrying images of sciences and design stimulating classroom activities. From the principles of Mc Comas we have stressed the importance on the following 5 principles:

- 2) Knowledge production in science shares factors, habits of mind, norms, logical thinking and methods.
- 5) Science has a creative component.
- 6) Science has a subjective element.
- 7) There are historical, cultural and social influences on the practice and direction of science.
- 9) Science and its methods cannot answer all questions.

These principles are a powerful methodological tool in order to design natural science activities in the early grades. This study presents an application of NOS in classroom in which certain abilities are practiced concerning floating and sinking concepts. Production of scientific knowledge is a result of various factors. Initially, by using their senses, prior knowledge and cause-effect reasoning, students are led to making predictions about the behavior of materials when they are in water. Then, they make hypotheses, test them through experimenting and finally make their decisions about floating and sinking concepts. This way, scientific knowledge is tested and it includes subjective elements such as personal beliefs. For example, during the workshop practice, students could hardly believe that an orange floats even after experimenting as they had difficulty in releasing their thought from the cognitive obstacle that the weight of an object does not define its floating and sinking behavior.

## Methods

The methodology of the study is divided in three parts: **A.** The first part concerns a workshop within the frame of a university lesson entitled ‘Didactics of Natural Sciences’ which includes a series of natural science activities and the proper didactic strategies to teach floating and sinking concepts. Prospective teachers attended the workshop and practiced during the following sections:

1. Narration of the adventures of Sponge Bob Square Pants (in <http://www.spongebob.games.biz>), a popular cartoon who lives in a city under the sea who faces unexpected problems of floating and sinking.
2. Predictions of which items float or sink.
3. Testing of predictions.
4. Providing reasonable causes for floating or sinking.
5. Overcoming cognitive obstacles.
6. Identifying skills of scientific method.
7. Designing classroom activities.
8. Connecting didactic strategies with NOS.

**B.** The second part concerns the didactical scenario which was designed following certain techniques of drama in education in combination with science education techniques. University students had to adopt this scenario in order to teach floating and sinking concepts in pre-primary school classrooms. As students move on from one stage to the other they exchange roles in order to find the solution of problem concerning floating and sinking concepts. They define the place and time and through role-playing, argumentation, conduct of experiments, evaluation they reach the conclusion.

**1. The letter.** Students receive a two-page letter from Bob Sponge. The letter describes everyday life in Bikini Bottom which was normal until the day the wicked witch Lavinia the Maze changed the rhyme of Bob Sponge Squarepants’ song as well as the substance of water. As a result, certain parts of the city started to float while others sank and Bikini Bottom was led to destruction. It is in Bob’s hands to save the city so he asks for help. Looking in his great-grandmother’s books he found a plan. He has to find out which items float and which ones sink in water and build a model-city using these materials. The letter is accompanied by photos of Bikini Bottom and of Bob and his friends, a sticker album and a magazine in which students can see the adventures of Bob Sponge.

**2. Teacher in role.** Teacher in Bob Sponge role discusses the problem with students and provides information about the city and the situation described in the letter. Students ask questions and try to find a way to help Bob save his city.

**3. Painting.** Students draw the city of Bikini Bottom in a big piece of paper.

**4. Argumentation.** Students are divided in two groups, the floating group and the sinking group. Each group has to discuss about the behavior of certain materials when put in water and present argumentation of why some of them sink and others float. A representative of each group announces estimations and provides reasons.

They make predictions about the behavior of each material in water and then, they fill in the following board of predictions.

**5. Prediction board. Material:** stone, nail, button, potato, orange....**Sinks:** YES ....NO....**Floats:** YES NO

**6. Experiment.** Students put the different materials one by one inside the water and observe what happens. They classify the materials in two categories according to their behavior inside the water. Finally they test their predictions, and discuss about the cognitive obstacles, the skills of scientific method used and they provide ideas for extra activities.

**7. Telephone conversation.** Students listen to one part of a telephone conversation. The teacher in the role of Bob receives a telephone call from Patrick, his best friend in Bikini Bottom. Bob writes down four key phrases that he hears from Patrick and tries to find out with the aid of students what they mean. Each phrase leads to an experiment which is performed in class.

Phrase 1: A whole peanut or half of it floats or sinks you will see!

Phrase 2: Put peanuts in carbon dioxide, they will perform amazing tricks by your side!

Phrase 3: Cut the potato, cut the potato!

Phrase 4: Step in a boat of plasticine and travel away through the ocean.

**8. Evaluation.** Students draw in a sheet of paper divided in two horizontal parts the items that float on top and those that sink at the bottom.

**9. Game.** Students find a way to make their racing boats move in water without touching them.

**10. Frozen Pictures.** Students present scenes of Bikini Bottom city using their body.

**11. Discussion in circle.** Teacher in role discusses with students about the knowledge they have obtained so far as well as the prospects of saving the city of Bikini Bottom.

**C.** The third part of our study is an application of the previous activities in pre-primary school classrooms. The research plan for students is to follow the steps they have already practiced during the workshop and teach floating and sinking concepts to three school classrooms with approximately 25 pupils each. The research data collection follows the methods of a case study which are extensively applied in social sciences and in research education (Cohen, Manion 1994). Observation by two external observers is conducted in order to record the evolution of the didactic strategies and the emergence of spontaneous ideas from pupils. Video-tape recording of the classroom activities provides material for discussion and evaluation of the teaching process. Finally, a semi-structured interview with the students responsible for each classroom is another source of evidence in which apart from the questions answered, suggestions are made and solutions are proposed.

Three pairs of third-year students were identified from a sample of 80 students all of which participated in the workshops concerning a variety of scientific concepts. Selection was based on questionnaires designed to explore students' scientific knowledge about floating and sinking concepts as well as mini-projects and discussions about socio-scientific issues. The students had the opportunity to teach floating and sinking concepts over the course of two weeks in three different classrooms. (Several pupils were highly interested in learning about other adventures of Bob Sponge and his friends so we decided to continue the study for about two more weeks). Students had little previous experience in real classroom situations so they were willing to put the knowledge and skills they had obtained into practice.

The schools in which the study was conducted were situated in the area of Ioannina and each classroom had about 20-25 pupils. Two cases of children with hearing problems were reported, three with difficulty in speaking and four cases of foreign children, all of which participated actively during the whole procedure.

Teachers of the schools collaborated with students on providing all the relevant information about their science program and the children's cultural and social background. They also provided them with materials needed for the activities and encouraged them to prepare teaching activities on a low budget. Nursery school teachers were generally enthusiastic about exchanging views on scientific matters with both students and our research team.

Three members of our research team played the role of the observant in order to record the evolution of the didactic strategies and the emergence of spontaneous ideas from pupils. The classroom activities were video-taped, photographs were taken and we all had a meeting at the end of each day in order to evaluate the process and prepare for the following session.

Video-tape recording of the classroom activities provided material for discussion and evaluation of the teaching process. Finally, a semi-structured interview with the students responsible for each classroom was conducted in which apart from the questions answered, suggestions were made and solutions were proposed.

## **Results**

### **A. Preparatory training of prospective teachers**

- **Questionnaires:** The questionnaires contain two parts: in part A students express their scientific views in an extract of the research instrument VOSTS 'Views on Science- Technology- Society' (Aikenhead, 1989). The questions concern definition of science and the scientific method, science in the community, understanding of science, social lives of scientists, the role of errors in the advance of science e. t. c. In part B they provide the right answers about sinking and floating concepts related with skills of the scientific method. The three pairs that were finally selected provided views which showed that they had attended most of the STS lessons and workshops during their studies so far as well as the right answers of part B of the questionnaire.

- **Interview:** The interviews were conducted with the university students that implemented this didactical scenario in class in pairs. Questions at this point concerned the experience of teaching and playing different roles, the attitude of pupils towards the cartoon as well as towards the whole didactical scenario, evaluation of using cartoons in a classroom and connecting them with Natural Sciences e. t. c. Answering the questions one by one, revealed students' orientation to a more confident way of handling scientific views in class. They faced some difficulty in role-playing and insisted on having more practice in it. Using cartoons in science activities made them feel that they had a powerful means for keeping pupils' interest vivid during the whole procedure. They also felt familiar with alternative teaching methods which will help them design stimulating classroom activities. Finally they felt more confident about investing in their future profession as they gradually became capable of overcoming their anxiety and dealing successfully with scientific matters in class.

**B. Early Grade Pupils:** the results of the video analysis follow the steps of the didactical scenario used to teach floating and sinking concepts in the three pre-primary school classrooms.

**-The letter.** In all three classes the arrival of a letter from a popular cartoon hero was met with mixed feelings of enthusiasm and wonder about the contents of the envelope. Pupils were already familiar with the hero as they had been watching his adventures on television. Most of them sang the song along with the teacher and provided specific information about the city of Bikini Bottom and the other citizens apart from Bob Sponge. They found it hard to believe that Bob Sponge was actually addressing to their class but when they realized that he corresponded with other children as well through his magazine, this was overcome. The appearance of a witch had a great impact on them and apart from the suggestions they made for helping Bob they offered to extinct her! Finally they provided some initial information about floating and sinking behavior of several items in Bikini Bottom.

**-Teacher in role.** Initially there was a lot of hesitation as far as the teacher in role of Bob Sponge was concerned but when the teacher explained that this was part of a game of exchanging roles in order to help Bob Sponge they were willing to participate. This appealed in the two classes while in the third pupils wanted to be put in the role themselves. The questions/suggestions that they made to the teacher in role are of great significance as they reveal not only pupils' knowledge about the properties of water but also expand to other fields such as language skills, expressing opinions, decision making, geography, pollution of the environment e. t. c.

We provide several examples of pupils' questions below: - where is the Pacific Ocean? – is the water very cold down there? –how are you able to breath and talk at the sea bottom? –what language do you speak? –why is your nose so different from ours? –why does the jellyfish stick on you? –do you know that certain people take sponges like you from the sea bottom and sell them in shops? - is the sea bottom where you live polluted?– how have you traveled to Greece? - what do you want us to do? – we are willing to help you save your city! Finally in one class the pupils stated clearly that they already know materials that flow and others that sink but experimenting would help a lot.

**- Painting.** Painting the city of Bikini Bottom was the result of group working, role-playing and decision making in all classes as the pupils slowly created the place where the hero and his friends live. This activity gave pupils the chance to improve their creativity and imagination as well as oral expression as they worked. The pupils with hearing problems as well as those with difficulty in speaking participated equally and were encouraged to do so by the whole class.

**- Argumentation -Prediction board.** In this part pupils were encouraged to express their opinion about the behavior of each material when put in water and to fill in the prediction board. They did so by the aid of pictures which represented each material as at this stage most of them have not fully conquered reading and writing skills. They also used alternative vocabulary to refer to floating and sinking such as it swims, it goes up, it falls down the water which was accepted because at such an early age children must be encouraged to describe scientific concepts the way they can.

**- Experiment.** The experiment was the crucial point in all classes as it would provide the information needed for helping Bob Sponge and was conducted with great interest. Pupils saw their predictions come true or false and provided explanations for each case. The following examples give an idea of how pupils try to come close to the scientific truth and become little scientists themselves: - the potato is heavy so it sinks – the candle does not sink because it is light – the tomato is inside the water but it does not sink, it swims – the wooden toy floats because it is made of wood and wood floats – if we put a lifejacket around the potato it must keep it on the surface because it has air inside. At this point the pupils' observations show their efforts to provide scientific explanations and offer the field for further experiments.

- **Telephone conversation.** This drama technique added a lot of enthusiasm and expectation to all classes as pupils could hardly believe that a cartoon had actually called them to give further instructions. The experiments that were conducted at this point showed that pupils had obtained a basic vocabulary of floating and sinking concepts as well as an ability to organize the experiment by suggesting what they should do, bringing the appropriate materials and providing explanations.

- **Evaluation- Discussion in circle.** At this final stage there was a retrospection of the whole procedure in which the scientific terms used by pupils to describe floating and sinking concepts showed that they had obtained basic knowledge and that they had developed skills of creative thinking and problem solving.

## Conclusions and Implications

Implementation of this study reveals that scientific literacy is a collective property with lifelong participation and learning (Roth & Lee, 2004). In this sense, results came out with the contribution of several groups. School teachers who teach Natural Sciences in the early grades saw this didactical intervention as a chance for improving science teaching in their classes. They suggested that their ideas about science teaching in combination with the curriculum and the connections of science to society will help them overcome worrying images of sciences and direct to their professional development. Collaboration with the students at the workshop has shown that adopting interdisciplinary means such as comics and cartoons-animations bridges the gap between science education and public knowledge, awareness about science. They also had the opportunity to investigate on the way it works in a real classroom situation and discuss their data collection with other students as well as with nursery-school teachers. It seems that at the end of the whole procedure they have reached the three dimensions that Miller recognizes in scientific literacy: 1. an understanding of the norms of the methods of science (i. e. the nature of science), 2. an understanding of key scientific terms and concepts (science content knowledge) and 3. an awareness and understanding of the impact of science and technology on society (Miller, 1983). Data analyses of the questionnaires and discussions about the mini-projects have shown that scientific literacy is achieved by taking an active role in learning. Furthermore, we are quite certain that this method is much more motivating than the traditional ones as it is closer to everyday life. This makes learning natural concepts meaningful and at the same time keeps away worrying images which hinder progress. On the grounds that interdisciplinary and innovative teaching is a priority for education in the early grades, this study contributes to engagement with science and pushes forward the boundaries of scientific literacy. At the end of this study, we feel certain that we have provided pupils a strong knowledge base that will become the foundation for meaningful learning and scientific literacy achievement. It is our duty to build on this from such an early age and to intervene in students' thought so as to help them approach the scientific truth. Thus, we invest on the socio-cultural background of the citizen that will learn science and also make decisions about scientific and technological matters. Implications and recommendations for further research concerning this study suggest a holistic understanding of the world by means of education, science, culture and communication. Furthermore, the research could indirectly contribute to inter-connection between action research methods and socio-cultural ones.

## References

- Aikenhead, G. S., & Ryan, A. G. (1989), *The development of a multiple-choice instrument for monitoring views on science-technology-society topics*, Ottawa: Social Sciences and Humanities, Research Council of Canada.
- Adúriz-Bravo, A. (2005). *An Introduction to the Nature of Science*, Fondo de Cultura Económica, Buenos Aires (in spanish)
- American Association for the Advancement of Science (AAAS). (1989). *Science for all Americans: Project 2061*. Washington, DC: AAAS.

- Bongco, M. (2000). *Reading Comics: Language, Culture and the Concept of the Superhero in Comic Books*, New York: Garland Publishing Inc.
- Carter, J., (2008) Dora the Explorer: Preschool Geographic Educator, *Journal of Geography*, 107:3, 77-86
- Cohen, L., & Manion, L. (1994, 4<sup>th</sup> ed.). *Research Methods in Education*. London: Routledge.
- Dewey, J. (1934). *Art as experience*, New York: Capricorn.
- Gene, Y. (2003) Comics in Education [www.humblecomics.com/comicsedu/index.html](http://www.humblecomics.com/comicsedu/index.html) (downloaded on 15/12/2008).
- Gardner, H. (1983). *Frames of Mind: The theory of multiple intelligences*. New York: Basic Books.
- Horn, M., (1980) *The world encyclopedia of cartoons* (Vol. 1), New York: Chelsea House.
- Keogh, B., Naylor, S., (1999), Concept Cartoons, teaching and learning in science: An initial evaluation. *Public understanding of Science*, 8,1-18.
- Laugksch, R., (2000).Scientific Literacy: A Conceptual Overview. *Science Education*, 84(1), 71-94,John Wiley&Sons,Inc.
- Lederman, N. (1992). Students' and teachers' conceptions of the nature of science: A review of the research. *Journal of Research in Science Teaching*, 29, 331-359.
- Mayer, R.. (1996). Learners as information processors: Legacies and limitations of educational psychology's second metaphor, *Education Psychology*, 31, 151-161.
- McCloud, S. (1993). *Understanding comics: The Invisible Art*, Northampton, MA: Kitchen Sink Press.
- McComas, W. (ed.) (1998). *The nature of science in science education. Rationales and strategies*. Dordrecht: Kluwer.
- McComas, W. (2005). *Teaching the Nature of Science: What Illustrations and Example Exist in Popular Books on the Subject?* Paper presented at the IHPST Conference, Leeds (UK), July 15-18, 2005.
- Miller, J. D. (1983). Scientific Literacy: A conceptual and empirical review. *Daedalus*, 112(2), 29-48
- Miller, J. D. (2007).The Public Understanding of Science in Europe and the United States. A paper presented to the 2007 annual meeting of the American Association for the Advancement of Science, San Francisco, California.
- National Association for the Education of Young Children (NAEYC), (2002). Conezio, K. &French. Science in the pre-school classroom. Capitalizing on Children's Fascination with the Everyday World to Foster Language and Literacy Development. *Young Children*,, downloaded on 15/03/2009 from [www.naeyc.org/resources/journal](http://www.naeyc.org/resources/journal).
- National Research Council (NRC). (1996). *National science education standards*. Washington, DC: National Academy Press.
- Plakitsi, K. (2007). *Didactic of Natural Sciences in Pre-primary and Primary Childhood: Contemporary Trends and Prospective*, Athens: Patakis, (in Greek).
- [Roth, W.-M.](#) (2005). *Doing Qualitative Research*, Canada: Sense Publishers.
- [Roth, W.-M., Lee, S.](#) (2004). Science education as/for participation in the community *Science Education*, 88, 2, 263-291.
- Unesco, (2008). *The Global Literacy Challenge*. Paris, Unesco.
- Vygotsky, L.S. (1978). *Mind in Society*, Cambridge, MA: Harvard University Press.
- Sites**
- Bob Sponge Squarepants <http://www.spongebob.games.biz> (downloaded on 24/03/2009).
- British Cartoon Archive <http://www.cartoons.ac.uk/teachingaids> (downloaded on 30/09/2009).
- Comic Book Museum <http://www.nyccomicbookmuseum.org/education.htm> (downloaded on 5/08/2009).
- Comic Life <http://plasq.com> (downloaded on 1/10/2009).





# LEARNING CHEMISTRY AND MIMICKING POLITICAL DECISION-MAKING PROCESSES – A PARTICIPATORY ACTION RESEARCH STUDY EVALUATING A LESSON PLAN ON BIOETHANOL AS A FUEL

Timo Feierabend  
Universität Bremen

Ingo Eilks  
Universität Bremen

## Abstract

*This paper presents a study evaluating a lesson plan about bioethanol for 10th/11th grade German Chemistry pupils. The lesson follows the socio-critical and problem-oriented approach to Chemistry teaching. It was cyclically developed and evaluated by a partnership of practicing teachers and university researchers using the Participatory Action Research model. The lesson plan focuses on both the basic chemistry of alcohols and the use of bioethanol as an alternative fuel source. Aside from teaching basic chemistry through a cooperative mode, the lesson plan also encompasses a role-playing element, which simulates political decision-making processes in parliament's various commissions and committees. The use of role-playing aims to teach pupils about how political decisions on scientific and technological questions are made. This presentation gives an overview of the lesson plan's intentions and its structure. Results are presented from the accompanying research, based on teachers' reflections, students' written questionnaires and students' behavior during role-playing, including meta-reflection on the role-playing. The results show that this approach provides a very motivating and challenging framework for learning chemistry, thus supporting findings from related studies using the same approach to address other topics. This approach shows potential for promoting students' communication and critical-thinking skills.*

## Introduction

In modern science education two of the central questions remain *what* and *how* students should learn (e.g. Eilks, Marks, & Feierabend, 2008). These questions touch upon the topic of making science education more relevant, an issue which has often been discussed since the 1980s. For the past decades, science education (i.e. in the physical sciences) has frequently been perceived as being irrelevant to the majority of its students (e.g. Hofstein & Yager, 1988; Ryan & Aikenhead, 1992; Holbrook, 2005; Hofstein, Eilks & Bybee, in preparation). This lack of relevance is caused by a dominant orientation towards the acquisition of pure knowledge instead of an aim to generate applicable knowledge or an orientation on general educational objectives (Holbrook, 1998; Gräber, 2002; Holbrook & Rannikmae, 2007). This has led to low levels of achievement in developing higher order cognitive skills, e.g. communication and evaluation (Holbrook, 2005). Such chemistry lessons also tend to cause both low levels of motivation among students and a general lack of interest in chemistry as a discipline (Osborne, Driver & Simon, 1998; Morell & Lederman, 1998; Osborne, 2007; Hofstein, Eilks & Bybee, in preparation).

One solution which has been suggested many times is the stronger inclusion of societal issues in the teaching of chemistry, thereby refining the objectives of science education (e.g. Hofstein & Yager, 1988; Solomon & Aikenhead, 1994; Sadler, 2004; Holbrook, 2003; Holbrook & Rannikmae, 2007; Marks & Eilks, 2009). Science education was thought to be better oriented, if it focussed on the value it could have for learners' future lives in a democratic society. This concept is now covered by the term 'Multidimensional Scientific Literacy' (MSL) (e.g. Bybee, 1987; 1997). This orientation of science education towards scientific literacy (deBoer, 2000; Roberts, 2007) can be grounded on different theoretical positions, for example, the German concept of *Allgemeinbildung* ("general education") (e.g. Klafki, 2000) or van Aalsvoort's (2004) *Activity Theory* as discussed in Marks and Eilks (2009) or Hofstein, Eilks & Bybee (in preparation).

Such reforms have also influenced educational policy in Germany in recent years and led to demands for the stronger inclusion of societal viewpoints in science teaching through national science education standards (KMK, 2004). These standards are described in four separate domains: scientific knowledge, the generation of knowledge in science, communication, and evaluation. The last two domains explicitly call for stronger inclusion of socio-scientific issues in the science education framework. For example, level three in the standard domain 'evaluation' prescribes an ability to "*weigh arguments for the evaluation of an issue from different perspectives and to reflect upon decision-making processes*". Together with selected standards from the Chemistry domain, e.g. standard B5 "*The pupils discuss and evaluate societal relevant statements from different perspectives*", science teaching lacking a societal approach is no longer appropriate (KMK, 2004).

Science teaching in Germany, however, particularly in the fields of Chemistry and Physics, is still highly criticised. It is consistently characterised as being too strongly oriented on the inner content structure of the subjects, while ignoring everyday life and societally relevant knowledge and skills to a large degree (Gräber, 2002; Ostermeier & Prenzel, 2005; Eilks, Marks & Feierabend, 2008). Although there have been concepts and ideas published by various science educators and teachers, e.g. in science teachers' journals, the application is still rare. The dominant practice in German Chemistry and Physics education is still guided by a conceptual knowledge approach. Such an approach orients itself on the structure of the related science domain and is organised along the inner systematics of the respective academic field.

To overcome this gap, Eilks (e.g. 2000, 2002) introduced a new conceptual approach to Chemistry teaching in Germany some ten years ago entitled "*A socio-critical and problem-oriented approach to chemistry teaching*" (e.g. Eilks, Marks & Feierabend, 2008; Marks & Eilks, 2009). The main foci were:

1. to increase students' interest in science and technology and to reveal the relevance of science in societal discussions and decision-making,
2. to make students aware of their own personal interest and motivate them to promote and protect their self-interest (either as consumers or within political decision-making processes); to provoke and develop decision-making processes within the individual,
3. to promote students' skills in the critical use of information and increase their self-reflection on *why*, *when* and *how* science-related information is used by effected groups and/or for public purposes, and
4. to promote student-active science learning which is motivated using relevant, current and controversial socio-scientific issues.

Using various topics, several key issues of this approach were refined and a common structure outlined for the development of respective lesson plans (e.g. Marks & Eilks, 2009): All of these lesson plans start with actual, authentic and controversial problems being debated within society and being present in different authentic media sources, e.g., newspaper articles, brochures from pressure groups, advertisements, reports on TV, etc. These media-based materials are then used to introduce the lesson plan and to provoke preliminary questions and discussions. Only issues allowing authentic differences of opinion which have been expressed in public debate by stakeholders or pressure groups are chosen. Inappropriate issues are those which allow only one-sided solutions or which would be viewed as unacceptable due to scientific, ethical, or sociological reasons by a majority of the class, teachers or parents. The

lessons aim at challenging students to make up their own minds and express their opinions in an open forum. The lesson ensures that learners can express their personal points-of-view without judgment, censorship or condemnation as outsiders by the group or the teacher. All lesson plans include the objective of teaching learners basic chemistry theory, including the use of student lab-work and open methods of learner-centered instruction. They encompass discussion techniques geared to draw out different points-of-view, to recognize how contrary these can be, and to see how such opinions are presented, promoted and manipulated within society at large (Eilks, Marks & Feierabend, 2008; Marks & Eilks, 2009a and b).

In short, the teaching approach must start with societally-relevant, current, authentic and controversial issues from within society. These issues must aid in the learning of basic chemistry content knowledge, while simultaneously opening up group discussion and promoting open decision-making processes. This is in line with Sadler (2004), who described the most fruitful settings for science education as:

*“... those which encourage personal connections between students and the issues discussed, explicitly address the value of justifying claims and expose the importance of attending to contradictory opinions.”*

## Method

For the planning and implementation of such innovative lesson plans, approaches must be chosen which sustainably implement STS-oriented teaching in the classroom. The development should take care of hindering teachers from automatically falling back into habitual patterns when they are confronted with new teaching strategies in in-service course designs only (Pedretti & Hodson, 1995; Rannikmaa, 2006). It therefore seems useful to directly integrate experienced teachers into all phases of lesson plan development, testing and implementation (Eilks, Parchmann, Gräsel & Ralle, 2004). Such a design model is that of Participatory Action Research (PAR; Eilks & Ralle, 2002). PAR combines university-level educational research with the professional experience and views of practicing teachers. This allows the method to constructively incorporate educators' contrasting professional focuses and productively develop new and authentic teaching practices. In PAR, teachers and researchers jointly develop lesson plans, teaching methods and materials based on a systematic analysis of research reports, didactical and methodological analysis, or reflections on chemistry content structure. This occurs in connection with the practical and personal experiences of the teachers, including explicit reflection and discussion. Based on this, first-draft lesson plans are developed. Details are negotiated within the action research group until all practitioners agree that the new lesson can potentially improve their teaching practices. In subsequent cycles of development, testing, evaluation and reflection/revision, the lesson plans are further developed and refined step-by-step. This process is accompanied by different kinds of evaluation. This allows the group to build up a baseline to better understand the effects of the lesson plans and the implemented changes.

The development of the lesson plan called ‘Bioethanol – Use As a Fuel’ as presented in this paper began with a group of 10 teachers in various West-German schools. The evaluation and reflection periods during lesson plan development took place on two meetings. Further meetings were used to collect more evidence as later cycles of testing progressed. Table 2 gives an overview of the development stage. Data were collected from the teachers' feedback, written student questionnaires and artifacts from the students' role-playing phase.

**Table 1. Overview on the developmental stage.**

Time	Stage of development
Start of the project	First ideas for a lesson-plan based on bioethanol incorporating role-playing as a method; teaching sequence is structured and methods are chosen
Group meeting after roughly 4 weeks	First meeting of the group: ideas are presented; structure, method and content are critically analysed, partially changed and improvements proposed
Developmental phase	Advancement of the material; proposals from the action group are included; texts and figures are integrated
Group meeting after another 4 weeks	Second meeting of the group: First version of the plan is presented; some points still criticised and changed
Preliminary testing	Short-term reviews of the requests for changes and preliminary testing in three learning groups
After one school year	Further testing in another two learning groups

## The Lesson Plan

The lesson plan presented in this paper (Feierabend & Eilks, 2009) was developed as an introduction to the basics of organic compounds for 10<sup>th</sup> grade lower secondary pupils. The structure orients itself on the 5-step-plan used the socio-critical and problem-oriented approach to Chemistry teaching as described in Marks and Eilks (2009) and Eilks and Marks (2009). The lesson consists of approximately 10 classroom periods of 45 minutes each.

**Table 2. The lesson plan**

Phase	Content	Time needed
Introduction	Authentic text 'Fuel for the world' is read and discussed	1 lesson
Jigsaw puzzle classroom (expert round)	3 groups (structure of alcohol, alcohol in everyday life, fermentation)	1 lesson
Learning-at-stations phase	6 stations (solubility/combustion behavior, energy content of fuels, combustion engine, ignition behavior, fermentation, distillation)	2 lessons
Jigsaw puzzle classroom (teaching round)	9 central questions concerning the jigsaw classroom and the learning-at-stations plus 1 question for practical application	1 lesson
Role development and performance of the role-playing exercise	Material and Internet sources provided for development of separate roles (committee, agriculture, engineering, development aid, economy), then the role-playing phase is performed	4 lessons
Evaluation and reflection	Questionnaires are handed out and the role-playing segment is evaluated as a group	1 lesson

The lesson plan begins with an authentic text taken from a German magazine. This article introduces the problem of skyrocketing corn prices in numerous developing countries due the conversion of large quantities of food corn into bioethanol for fuel. After this, students discover the basic chemical principles behind the topic through the combination of a jigsaw-classroom and a lab phase structured around the learning-at-stations method. The "round of experts" phase during the jigsaw puzzle part of the exercise introduces the various lab exercises to be used later in the learning-at-stations segment. The experimental results of the labwork are afterwards evaluated during the teaching round of the jigsaw. Finally, a role-playing phase is initiated by forming into several "parliamentary committee" groups. This committee must discuss the benefits and drawbacks of a fictitious law proposing an increase in the percentages of bioethanol allowable as a fuel additive. The discussion helps bringing unanticipated side-effects of

changing limits to the fore: fuel quality, fuel price differences, (un)realistic effects on air quality, possible price manipulation and monopolistic business practices by large corporations, and the (un)availability of environmentally-friendly alternative fuels. A survey of the different phases with the time needed for each is given in Table 2.

## Findings

The lesson plan was developed and tested within a single school year using the Participatory Action Research design. A total of five learning groups totaling ninety-three 10th and 11th grade German students took part. The teachers gave oral feedback in which they referred to the progress of the lesson plan and also proposed potential improvements to the process. From the teachers' point-of-view, the students were very interested as they entered into the teaching unit. They emphasised the intensity and quality of the discussion phase. The students included facts and arguments which they had learned in the unit, extracted from the Internet or even brought along with them from outside sources. This led one teacher to comment: *'Even teachers can learn much in the discussion, not only about the students, but also about the topic'*. All in all the level of argumentation was rated as unexpectedly high by the teachers and they could see clear indications that the socio-critical approach had been well-elaborated. It was emphasised that the closing meta-reflection phase must make it clear to pupils that the obligatory decisions emerging from political debates are made through the evaluation of the entire committee. Even if new arguments arise after the discussion ends, these will normally not be listened to after a decision has been finalized.

Independently from the feedback of the teachers, student opinion was canvassed with open questions and a follow-up Likert-questionnaire. In the open part of the feedback process, pupils were asked for their estimation of what the essential content had been and also what they had learned during the teaching unit (Eilks, 2002). Most of the students listed scientific content such as 'the characteristics of alcohols' or 'fermentation'. The functioning of a combustion engine seemed to be a completely new topic to some of the learners and so they named this theme as well. However, there were also many pupils who noticed that they had learned something about the procedure of valuation. Some students answered: *"critical reconsideration of aspects which seemed to have an easy solution before"* or *„think about the environment and social problems“*. In contrast to Eilks (2002), a large number of pupils concentrated their self-reflection on the question of cognitive-scientific contents.

The second open question dealt with the level of personal appreciation of chemistry teaching during the unit. Words that appeared again and again were: *"interesting"*, *"informative"* and *"fun"*. The overall statements showed that most of the students really liked the approach to the unit. In many cases, the learners emphasized the chance to independently formulate ideas and to work in groups. Nevertheless, some students' answers also showed some signs of insecurity, for instance: *'...I don't know exactly if it suits Chemistry education...'* or *'...differs from conventional chemistry education regarding the content, which means that a lot of knowledge is concerned with other subjects'*. Although unintentionally, these students had pinpointed the multidimensional character of the topic and teaching approach.

The third question asked the students whether they would fill their gas tanks with bioethanol if it was priced the same as "non-bio" fuels. The majority replied that they would convert to bioethanol. Arguments included profitability, ecological compatibility and also the overall convincing arguments in the progress of the discussion phase. But some students were indecisive and did not want to give a clear answer. One female student wrote: *'Both of the two possibilities have advantages and disadvantages! I don't care as long as the environment and the human race are considered.'* Such equivocal statements occur quite often and indicate that some pupils had developed a critical attitude. This corresponds with other observations on similar lessons (Eilks, 2002).

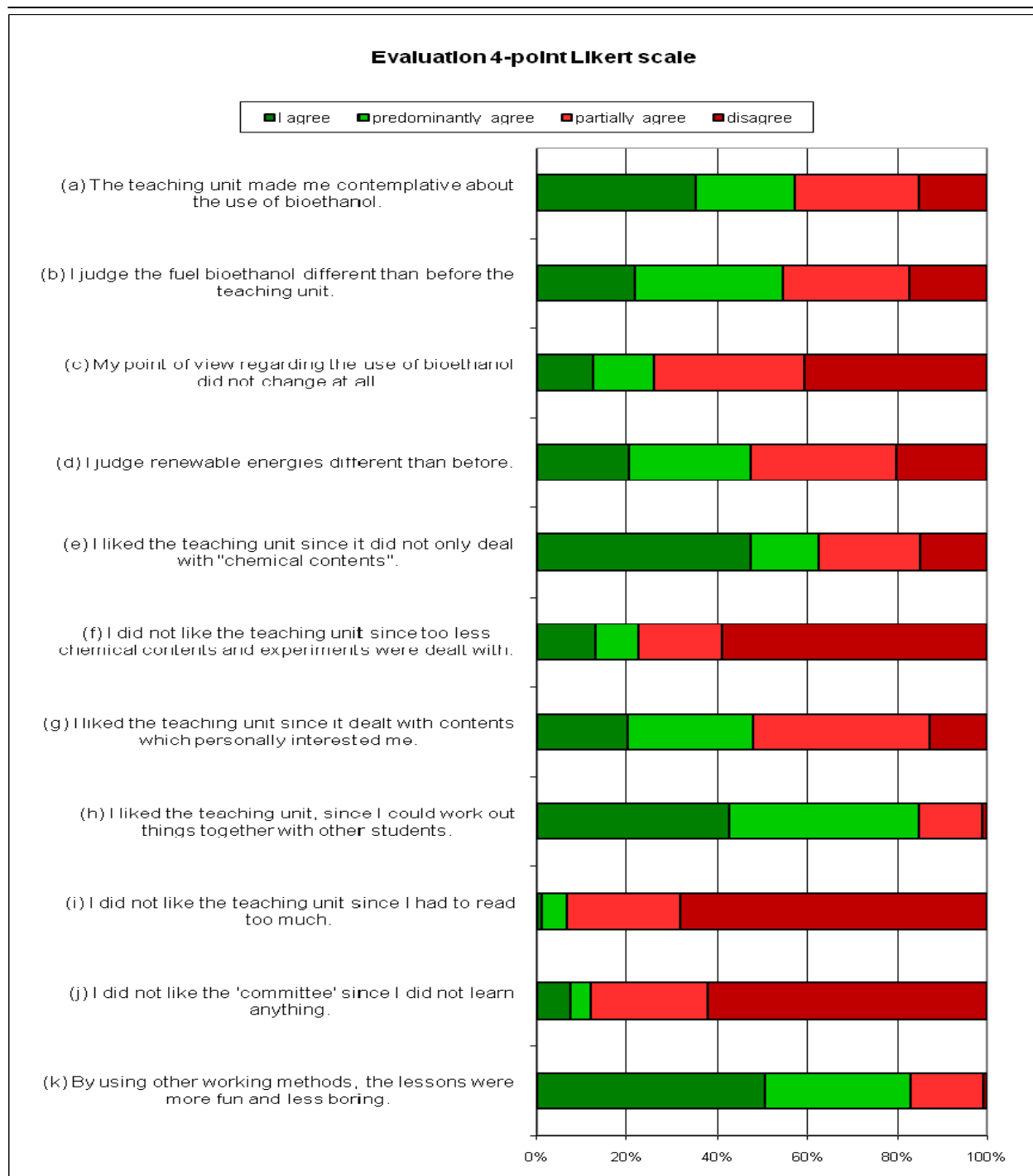


Figure 1. Answers from the Likert questionnaire (N=93).

Answers to the questions rated by the 4-point Likert scale support the conclusions of the open-ended questions. The students rated the aspect of group work especially positively. This also turned out to be the case with the co-operative learning methods used at the beginning of the unit. Here, the pupils agreed - at worst only partially - that they liked the teaching unit, since it allowed them to work out answers in common with the other students. The same picture emerged for the statement that teaching is more fun/less boring when other methods are applied. The open questions revealed that lessons on valuation were perceived as strange for students in chemistry classes. Even so, less than 10% of the pupils stated that they did absolutely did not like the role-playing phase, mainly stemming from a feeling that they had not learned anything. But almost 65% of the students did see the role-playing as useless or negative, and they stated that they did not feel that way at all. There was a similar positive picture regarding the

content direction of the unit. More than 85% of the participants agreed (at least partially) that the lessons dealt with content that interested them personally. Roughly the same percentage agreed at least partially that the teaching unit made them particularly thoughtful about the use of bioethanol. Additionally, more than 80% of the pupils agreed at least in part that they viewed bioethanol differently after going through the teaching unit.

All in all the teaching unit was rated positively by students and teachers. It was recognisable that many students had been motivated to think critically about renewable resources. Only a small percentage of the students were of the opinion that their views on bioethanol had not changed at all.

## Conclusions

This lesson plan shows how Chemistry education can be broadened in a motivating and interesting fashion. Including a structured discussion about a social controversy aids teachers in motivating their students to learn about chemistry. It also broaches the issue of valuation and leads pupils to reflect upon such processes within Chemistry education. We believe that such an approach can enrich education by using carefully selected topics. The concept of the socio-critical and problem-oriented to Chemistry education therefore raises a theoretical and practical framework, which has proved its worth in series of cases. The present study therefore supports the previous findings reported in Eilks (2002), Marks, Bertram & Eilks (2005), and Marks & Eilks (2008; 2009; submitted).

The need for such an approach to education becomes even clearer if we focus on one single utterance. Several students critically mentioned that too little “Chemistry“ appeared in the unit. Such a critique should make us look more closely at learners' perceptions of what exactly Chemistry education represents and what it actually *is*. We need to be sure that we are not creating false perceptions in our pupils' minds when we point out that the subject of Chemistry includes far more than a simple, pigeonholed collection of facts, formulas and theories (Marks & Eilks, 2009). Aspects of multi- and interdisciplinary considerations and the valuation of their effects are an imminent problem, regardless of whether we are speaking from the viewpoint of chemistry as a science, chemistry as an industrial branch or chemistry as a socially-relevant factor. This should be reflected in students' Chemistry education through selected applications (e.g. Hofstein, Eilks & Bybee, in preparation).

## References

- Aikenhead, G. S., & Ryan, A. G. (1992). The development of a new instrument: Views on science-technology-society (VOSTS). *Science Education*, 76, 477-491
- Bybee, R. W. (1987). Science education and the science-technology-society (STS) theme. *Science Education*, 71, 667-683.
- Bybee, R. W. (1997). Towards an understanding of scientific literacy. In W. Gräber & C. Bolte (Hrsg.): *Scientific Literacy* (S. 37-60). Kiel: IPN
- DeBoer, G. (2000). Scientific Literacy: another look at its historical and contemporary meanings and its relationship to science education reform. *Journal of Research in Science Teaching*, 37(6), 582-601.
- Eilks, I. (2000). Promoting scientific and technological literacy: Teaching Biodiesel. *Science Education International*, 11(1), 16-21
- Eilks, I. (2002). Teaching 'Biodiesel': A sociocritical and problem-oriented approach to chemistry teaching and students' first views on it. *Chemical Education: Research and Practice in Europe*, 3(1), 67-75
- Eilks, I., & Marks, R. (2009). Promoting scientific literacy by integrating authentic and controversial socio-scientific debates into science lessons. Paper presented at the ESERA Conference, Istanbul.
- Eilks, I., Marks, R., & Feierabend, T. (2008). Science education research to prepare future citizens – Chemistry learning in a socio-critical and problem-oriented approach. In B. Ralle & I. Eilks (eds.): *Promoting successful science learning – The worth of science education research* (pp. 75-86). Aachen: Shaker 2008.
- Eilks, I., Parchmann, I., Gräsel, C., & Ralle, B. (2004). Changing teachers' attitudes and professional skills by involving teachers into projects of curriculum innovation in Germany. In B. Ralle & I. Eilks (eds.): *Quality in practice oriented research in science education* (pp. 29-40). Aachen: Shaker.
- Eilks, I., & Ralle, B. (2002). Participatory Action Research in chemical education. In B. Ralle and I. Eilks (eds.): *Research in chemical education - what does this mean?* (pp. 87-98). Aachen: Shaker.

- Feierabend, T., & Eilks, I. (2009). Bioethanol – Bewertungs- und Kommunikationskompetenz Schulen in einem gesellschaftskritisch-problemorientierten Chemieunterricht [Bio-ethanol – Promoting competencies in evaluation and communication within the socio-critical and problem-oriented approach to chemistry lessons]. *Der Mathematische und Naturwissenschaftliche Unterricht*, 62, 92-97.
- Gräber, W. (2002). Chemistry education's contribution to Scientific Literacy – An example. In B. Ralle & I. Eilks (Eds.): *Research in chemical education – what does this mean?* (pp. 119-128). Aachen: Shaker.
- Hofstein, A., Eilks, I., & Bybee, R. (in preparation). Societal issues and their relevance for science education.
- Hofstein, A. & Yager, R. E. (1988). Social issues as organizers for science education in the 80's. *School Science and Mathematics*, 82(7), 539-547.
- Holbrook, J. (1998). Operationalising scientific and technological literacy - a new approach to science teaching. *Science Education International*, 9(2), 13-18.
- Holbrook, J. (2003). Increasing the relevance of science education: The way forward. *Science Education International*, 14(1), 5-13.
- Holbrook, J. (2005). Making chemistry teaching relevant. *Chemical Education International*, 6 (1), retrieved August 01, 2009, from the World Wide Web at [http://old.iupac.org/publications/cei/vol6/06\\_Holbrook.pdf](http://old.iupac.org/publications/cei/vol6/06_Holbrook.pdf).
- Holbrook, J., & Rannikmae, M. (2007). The nature of science education for enhancing scientific literacy. *International Journal of Science Education*, 29, 1347-1362.
- Klafki, W. (2000). The significance of classical theories of Bildung for a contemporary concept of Allgemeinbildung. In I. Westbury, S. Hopmann & K. Riquarts (Eds.): *Teaching as a reflective practice: the German Didaktik tradition*. Mahwah: Lawrence Erlbaum.
- KMK (Hrsg.) (2004): *Bildungsstandards im Fach Chemie für den Mittleren Schulabschluss*. München: Luchterhand.
- Marks, R., Bertram, S., & Eilks, I. (2008). Learning chemistry and beyond with a lesson plan on potato crisps, which follows a socio-critical and problem-oriented approach to chemistry lessons – a case study. *Chemistry Education: Research and Practice*, 9, 267-276.
- Marks, R., & Eilks, I. (2008). Kommunikations- und Bewertungskompetenz entwickeln in einem gesellschaftskritisch-problemorientierten Chemieunterricht über Alcopops – Eine Reflektion aus einem Projekt Partizipativer Aktionsforschung [Developing communication and evaluation competencies in a socio-critical and problem-oriented approach to chemistry teaching on Alcopops – A reflection from a project of Participatory Action Research]. *Chimica etc. Didacticae*, 34, Nr. 101, 48-77.
- Marks, R., & Eilks, I. (2009). Promoting scientific literacy using a socio-critical and problem-oriented approach to chemistry teaching: concept, examples, experiences. *International Journal of Science and Environmental Education*, 4 (4), in print.
- Marks, R., & Eilks, I. (submitted). A case study on a chemistry lesson on shower gels following a socio-critical and problem-oriented approach: Teachers' and students' views. Under review.
- Ostermeier, C., & Prenzel, M. (2005). What can we learn from different forms of evaluation? Experiences from a quality-development program in science and mathematics instruction. In J. Benett, J. Holman, R. Millar & D. Waddington (Eds.): *Evaluation as a tool for improving science education* (pp. 145-158). Muenster: Waxmann.
- Pedretti, E., & Hodson, D. (1995). From rhetoric to action: implementing STS education through action research. *Journal of Research Science Teaching*, 32, 463-485.
- Rannikmae, M. (2006). Using socially derived teaching approaches in science classes – a longitudinal study on teachers learning in a research based curriculum innovation. In I. Eilks & B. Ralle (eds.): *Towards research-based science teacher education* (pp. 137-146). Aachen: Shaker.
- Roberts, D. A. (2007). Scientific literacy/science literacy. In S. K. Abell & N. G. Lederman (eds): *Handbook of research in science education* (pp. 729-780). Mahwah: Lawrence Erlbaum.
- Sadler, T. D. (2004). Informal reasoning regarding socioscientific issues: A critical review of research. *Journal of Research Science Teaching*, 41, 513-536.
- Solomon, J., & Aikenhead, G. (eds.) (1994). *STS education: international perspectives on reform*. New York: Teachers College Press.
- Van Aalsvoort, J. (2004). Activity theory as a tool to address the problem of chemistry's lack of relevance in secondary school chemistry education. *International Journal of Science Education*, 26, 1635-1651.



# WAYS TO PROMOTE ESSENTIAL ELEMENTS OF A DEVELOPED SCIENTIFIC LITERACY IN SCIENCE EDUCATION

Chair:

Ingo Eilks

University of Bremen, Germany

Discussant:

Jack Holbrook

University of Tartu, Estonia

Contributions:

Rachel Mamlok-Naaman

Weizmann Institute of Science, Rehovot, Israel

Ingo Eilks and Ralf Marks

University of Bremen

Claus Bolte, Birgit Kirschenmann and Sabine Streller

Free University of Berlin, Germany

Miia Rannikmäe and Anne Laius

University of Tartu, Estonia

## Abstract

*While the enhancement of scientific literacy is a commonly accepted goal for science education, there is no single accepted concept of scientific literacy. At the centre to this confusion is the place of science content. For some people, scientific literacy means an acquisition of so-called 'basic knowledge' often under the guide of process-oriented competencies. On the other hand, curricula have been developed where content is not the target, but the vehicle to achieve process-oriented competencies, e.g. competencies of communication and argumentation, exploitation of evidence in science, or valuation and decision making in a socio-scientific context. The symposium supports the later interpretation. The symposium will bring together different approaches of how to promote scientific literacy through the application of specific innovations to the learning of science at secondary level. All presentations will pay special emphasis to the promotion of students' skills in decision making based on strong conceptual science, skills and values. Each of the presentations will put a special focus on the issue. These foci will cover introducing the history of science, authentic and controversial debates from within the society, extra-curricular courses in a university's laboratory, or socially derived lesson plans aiming at the promotion of creativity.*

## Aims and Scope

While the enhancement of scientific literacy is a commonly accepted goal for science education, there is no single accepted concept of scientific literacy itself. At the centre of this confusion is the place of science content. For some people, scientific literacy means an acquisition of so-called 'basic knowledge', often under the guide of

process-oriented competencies. On the other hand, curricula have been developed where content is not the target, but rather the vehicle for achieving process-oriented competencies, e.g. competencies of communication and argumentation, exploitation of evidence in science, or valuation and decision making in a socio-scientific context. The symposium supports the later interpretation. We support a quote from OECD-PISA defining the essential part of scientific literacy to be the identification of questions related to science and technology as well as to develop skills *“to draw evidence based conclusions in order to understand and help make decisions about the natural world and the change made through it through human activity”*.

The symposium will bring together different approaches of how to promote scientific literacy through the application of specific innovations to the learning of science at the secondary level. All presentations will pay special emphasis to the promotion of students' skills in decision-making, based on strong conceptual science, skills and values. Each of the presentations will put a special focus on the issue. These foci will cover introducing the history of science, authentic and controversial debates from within the society, extra-curricular courses in university laboratories, and socially derived lesson plans aiming at the promotion of creativity.

All four of the projects focus on the development of scientific literacy with a special accent on the development of students skills in decision making, i.e. in the fields of communication and valuation. Each paper is based on a research-based development of interventions and an appraisal of their effectiveness by evaluating different sources of data. The symposium seeks to strengthen the comparison of these related projects and their respective strategies. But the symposium also will look for a potential inclusion of essential elements from each of the approaches into complex settings for an effective promotion of scientific literacy.

# ENHANCING THE SCIENTIFIC LITERACY OF STUDENTS BY EXPOSING THEM TO A HISTORICAL APPROACH TO SCIENCE

Rachel Mamlok-Naaman

The Weizmann Institute of Science, Rehovot, Israel

## Abstract

*Nowadays, at the outset of the twenty-first century, the idea that each person should have some familiarity with the nature of science is becoming more and more accepted. For example, notions such as 'scientific literacy for all' are beginning to play an important role in considerations pertaining to educational goals. Contrary to the situation at the beginning of the 19th century when science was viewed as important, interesting and exciting, the image of science today is rather negative. It is therefore reasonable to assume that this lack of interest can hinder students' motivation in getting involved in science studies. The objective of the present study was to test whether using the module: "Science: An Ever-Developing Entity" (Mamlok, 1995), which uses a historical approach to teaching science, would affect the attitudes of non-science-oriented students towards science.*

## Introduction

In recent years we have become increasingly aware of the need for people to understand the nature of science in order to make decisions posed by new developments in both science and in technology. However, many students, even those who intend to become scientists, are unaware of the true nature of science (Irwin, 1996). Nevertheless, students both in high school and at the college level generally have positive views regarding the nature of physical reality and scientific inquiries. Although they may regard science as a systematic gathering of facts and laws, very often they are not aware of the roles of science and scientists in building models and theories as tools to understand nature (Jungwirth, 1987; Hayes & Perez, 1997). Arons (1984) claimed that many science teachers do not devote time to discuss the nature of the scientific process and, as a result, miss opportunities to instill critical and investigative thinking, towards the education of a scientific literate citizen. Notions such as 'scientific literacy for all' are beginning to play an important role in considerations pertaining to educational goals. However, these ideas pose many problems, both regarding the actual meaning of the term 'scientific literacy for all', as well as the ability to provide all students with some background in science. In this paper we will describe an attempt to use a historical approach to science teaching in order to improve the attitudes of non-science-oriented students (those who did not choose to major in any of the scientific disciplines) towards science and science studies. More specifically, the objective of the present study was to test whether using the module: "Science – An Ever-Developing Entity" (Mamlok, Ben-Zvi, Menis & Pennick, 2000), which uses a historical approach to teaching science, would affect the attitudes of non-science-oriented students towards science.

## Rationale

"Science: An Ever-Developing Entity" is a module (a teaching unit) aimed at non-science-oriented high-school students. It interweaves aspects of science, technology, and society, related to the development of the concept "structure of matter". It was designed in order to encourage a change in students' views regarding science in general and the structure of matter in particular by studying the evolution of man's thinking and investigations. The module surveys the development of our understanding of the structure of matter. It attempts to develop models that can explain the accumulated observations regarding matter and chemical reactions, which is a process that is as old as

science itself (another parallel subject is, for example, astronomy). Ideas concerning the structure of matter and the way models are used to explain it, which changed throughout history, constitute a good example of the representation of the history of science to students. Thus, the module was developed with the following objectives in mind: (1) to enable students who did not choose to major in any of the scientific disciplines to familiarize themselves with the nature of science, (2) to enable students to understand the interplay between science and technology, and (3) to change students' attitudes towards science in general and more specifically towards science taught in school.

## Research Methods

The participants were 10<sup>th</sup> grade students from high schools located in the central part of Israel. The group of students consisted of 90 non-science-oriented students (students who chose not to major in science) in three classes - one in each school. All students were between 15 and 16 years old and came from middle to upper socioeconomic levels. They studied about the structure of matter using the module "*Science: An Ever-Developing Entity*" (Mamlok, 1995), for 40 periods (50 minutes each) during the school year. The three teachers were experienced teachers (having more than 15 years of experience in teaching chemistry, physics, or biology for high-school students).

As mentioned before, the objective of the study was to test whether using the module: "*Science – An Ever-Developing Entity*" (Mamlok, 1995), which uses a historical approach to teaching science, would affect the attitudes of non-science-oriented students towards science. Three kinds of data sources were used: (1) interviews with students, (2) observations of classroom activities, and (3) informal conversations. All these data sources, which were originally in Hebrew, were translated into English. The translation was done by professional translators, and was critically read for validation by the first and the second authors of this paper.

*Interviews* - The interviews were conducted by the first author of this paper at the beginning and after the study were completed. The researchers asked each teacher from the three classes to choose four students for the interviews. Two students were low achievers and the other two were high achievers. The teachers categorized their students according to their achievements in a mathematics test which was conducted at the beginning of the school year. David, Sarah, Nadav, Orit, Gila, and Aric were categorized as low achievers, and Alon, Elana, Danny, Nora, Leora, and Ron (pseudonyms) were categorized as high achievers.

The interviews were semi-structured and the discussions were carried out around questions such as the following:

1. What do you do when a program that deals with a scientific issue appears on television?
2. When you read newspapers, are you interested in articles about science?
3. In your opinion, is science related to everyday life?
4. How, in your opinion, do the scientific inventions influence society?
5. What do you think is a scientists' daily routine?
6. How do you feel about studying science using a historical approach?

We are aware of the fact that questions 3 and 4 might look a little leading. However, the way in which non-science-oriented students perceive these issues was very central to this study, and unfortunately, we could not find a better way to phrase these questions.

*Observations* – The first author of this paper observed and videotaped three specific lessons that were given in each class, which centered around three events: (1) presenting mini-projects to all the students in the class, (2) participating in a scientific conference in school, and (3) debating on the subject: "For and against basic research".

*Informal conversations* – The informal conversations were held by the first author of this paper with students during the breaks, and were summed up later. These discussions added insights and understanding about the

students' feelings and attitudes toward learning the module "*Science: An Ever-Developing Entity*" (Mamlok, 1995), and served as another tool for validating the data collected from the semi-structured interviews.

The data analysis was based on basic methods of qualitative data analysis (Tobin, 1995; Glaser & Strauss, 1967). We constantly compared the data from the interview with the data from the observations, and refined them. When clarification was needed, we collected more data by informal conversations.

Prior to studying the module, during informal discussions with the twelve students, statements such as the followings were heard:

- *"The science studies in junior high school bored me."*
- "I am not good at it."
- ***"Science programs on television don't interest me. Science studies scare me because I have to learn so many formulas."***
- ***"I don't understand anything about science because I am not good in mathematics."***

Some also expressed negative attitudes towards science in general, for example:

- "It might cause disasters, like Chernobyl and Hiroshima, or may cause damage, like the hole in the ozone layer, pollution, and disease."
- "Why does the man in the street have to invest in order to satisfy the curiosity of scientists or research institutions?"
- "Why don't scientists concentrate on what is really needed: development of medicine to fight severe illnesses, materials to fight pollution or developing better safety mechanisms for cars to decrease the number of accidents?"

The quotations were from both low and high achievers. Interestingly, in these two diverse groups of students, we could not point out any meaningful differences regarding their attitudes towards science. Based on their statements, we concluded that the decision of many of the twelve students from the non-science-oriented classes not to continue in their science studies was influenced by their past experiences.

After the study was completed, the interviews were audio-recorded, transcribed, and analyzed according to four main categories that emerged from the teachers' answers:

- a. Students' attitudes towards science and science studies.
- b. Students' perceptions of the world of the scientists.
- c. Students' understanding of the nature of science and of technology.
- d. Students' attitudes towards studying science using a historical approach

## Results and Discussion

The main objective of the study was to examine the effect of learning the module "*Science – An Ever-Developing Entity*" on 10<sup>th</sup> graders who did not choose to study science (grade non-science-oriented students). The research question was examined through observations in class, interviews with twelve students, and informal conversations.

Before studying the module, the students expressed negative attitudes towards science studies. They could not see the importance of learning science, and the fact that science arouses curiosity and enthusiasm, and encourages thinking. After studying the module, however, their attitudes changed towards science and science studies. Moreover, they became interested in the scientific world, in the interaction between science and of technology, and they expressed positive attitudes towards studying science using a historical approach. There was almost no difference between the attitudes of the low achievers and the high achievers before studying the module

**Table 1. Examples of students' quotations during the interviews conducted after the completion of the study**

Characteristics of students' responses	Quotations from low achievers	Quotations from high achievers
Students' attitudes towards science and science studies.	David: Perhaps, in the end, I'll become a scientist, who knows?  Sarah: My enthusiasm to do work in science proves that I became "closer" to this sphere and actually it interests me!	Nora: The projects I prepared gave me an understanding and an overall comprehension of the subject and thus my approach to science studies has changed. I began to like science and became interested in it.
Students' perceptions of the world of the scientists.	Orit: Galileo was an exceptional man but there are many others like him and we don't know much about them but they are responsible for all innovations.  Alon: Scientists' curiosity and desire to know are beyond boundaries. It appears that their way of thinking leads them to discoveries and inventions that ultimately help to improve life.	Elana: Scientists' greatest achievement nowadays is their ability to cooperate with each other and to publish their work, so that other scientists all over the world will benefit from that knowledge.
Students' understanding of the nature of science and technology.	Gila: Every accident or fault that we read about in the newspapers often causes the public to develop negative attitudes towards various developments in science or technology.  Sarah: The public makes almost no differentiation between developments in science or technology, and between science, values and technological applications, which may be discussed in terms of good or bad.  Aric: We don't know enough about the positive things for which science and technology are responsible. Whenever anything happens, science and technology are immediately blamed.	Danny: All in all I'm in favor of science and technology. Human life has been much improved. Even serious illness is better treated. All these are actually based on human curiosity, and the desire to know what the atom is made of and what matter is made of. Basic research drives applied research and applied research provides basic research with additional questions and problems.  Ron: How can one believe that once there was no electricity? It's a wonderful invention that everyone takes for granted.
Students' attitudes towards studying a science curriculum using a historical approach.	<b>Orit: I liked very much the chapters about the alchemists. I liked the magic in the work of the alchemists who worked according to the theory of Aristotle. I pitied them because they followed a theory that was a dead end and they did not understand it.</b>	<b>Alon: I loved the idea of moving back and forth, sometimes toward the alchemists and at other times toward contemporary scientists. I liked the idea that nowadays we can change base elements into gold, only it is expensive. I thought to myself that even we or some of us can become scientists. Everyone can make mistakes and the scientists are only human beings.</b>

*"Science – An Ever-Developing Entity"*. Both groups claimed that they did not choose to major in any of the scientific disciplines, since either they were bored by science studies in junior high school, or that they were scared of the formulas and calculations. Some mentioned the negative results of scientific discoveries, such as Chernobyl or Hiroshima, and wondered about the benefit of basic scientific research. "Why don't scientists concentrate on what is

really needed: developing medicine to fight severe illnesses, materials to fight pollution or developing better safety mechanisms for cars to decrease the number of accidents?" was a popular claim (see Table 1).

Based on these findings, we suggest that the historical approach may help to achieve a better understanding of the essence of scientific phenomena, scientific methodology, and overall scientific thinking (American Association for the Advancement of Science, 1989; Sparberg, 1996; Monk & Osborne, 1997). In addition, this approach, which integrates scientific development and a historical analysis of scientific events, may help to achieve a better understanding of the essence of science and the methods of scientists (Klopfer & Cooley, 1961; Hall, Lowe, McKavanagh, McKenzie, & Martin, 1983; Matthews, 1994; Duschl, 1993; Meyling, 1997; Lederman, Abd-El-Khalick, Bell & Schwartz, 2002).

Finally, the students should become familiar with various projects of scientists on a specific subject (Ihde, 1984), and the effect of various cultures on scientific development (Hayes & Perez, 1997).

## Conclusions and Implications

Based on the data analysis, we may conclude that for students who did not choose to major in any of the science disciplines, the combination of scientific subjects, the analysis of historical events, and issues taken from the spheres of the social sciences and humanities were more interesting and aroused more curiosity. Studying the concepts and their significance in various periods helped them to achieve a better understanding of the scientific endeavor. Many also remarked, regarding the variety of teaching methods, that the experiments that simulated ancient experiments, as well as films, articles, and projects that they prepared and presented to their classmates and teachers greatly contributed to the learning and comprehension of the material. The students evaluated the instruction strategies as enjoyable, increasing their interest in science in general, and the area of historical aspects in particular.

We suggest, that should be presented in a way that will be understood by the students, and provide an atmosphere of learning environment in which students will learn to understand phenomena and link between them without the complications of formulas (Ben-Zvi, 1999). We believe, that if students study a challenging curriculum, situated and encored within a certain context (a historical one in this case), their perceptions, beliefs, and attitudes towards science and science learning will be positive (Blumenfeld, Fishman, Krajcik, Marx & Soloway, 2000). Historical aspects should be integrated into the science curricula. These consist of scientific developments and historical analysis of scientific events, which are taught by introducing the students to events in development of science and the work of scientists, more specifically by (1) discussions consisting of the deliberations that arose during their work pertaining to phenomena, (2) conducting classroom debates, emphasizing how controversial some theories in science were at the time of their proposal (Niaz & Rodriguez, 2002), (3) conducting experiments that simulate experiments carried out by scientists in various periods, or (4) learning about the spirit of the times (Conant, 1957; Brush, 1974; Irwin, 1997).

## References

- American Association for the Advancement of Science. (1989). *Science for all Americans: A Project 2061 report on literacy goals in science, mathematics and technology*. Washington, DC: Oxford University Press.
- Arons, A. B. (1984). Education through science. *Journal of College Science Teaching*, 13, 210-220.
- Ben- Zvi, R. (1999). Non-science oriented students and the second law of thermodynamics. *International Journal of Science Education*, 21(12), 1251-1267.
- Blumenfeld, P. C., Fishman, B. J., Krajcik, J. S., Marx, R. W., & Soloway, E. (2000). Creating usable innovations in systemic reform: Scaling-up technology - embedded project-based science in urban schools. *Education Psychologist*, 35, 149-164.
- Brush, S. G. (1974). Should the history of science be rated? *Science*, 184, 1164-1172.
- Conant, J. B. (1957). *Harvard case histories in experimental sciences* (Vols. 1 & 2). Cambridge, MA: Harvard University Press.

- Duschl, R. A. (1993). Research on the history and philosophy of science. In: D. Gabel (Ed.), *Handbook of research on science teaching and learning* (pp. 443-465). New York: Macmillan.
- Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research*. Hawthorne, NY: Aldine.
- Hall, D., Lowe, L., McKavanagh, C., McKenzie, S., & Martin, H. (1983). *Teaching science, technology and society in junior high school*. Brisbane, Australia: Brisbane College of Advanced Education.
- Hayes, J. M., & Perez, P. L. (1997). Project inclusion: Native American plant dyes. *Chemical Heritage*, 15(1), 38-40.
- Ihde, A. J. (1984). *The development of modern chemistry*. New York: Dover.
- Irwin, J. (1996). A survey of the historical aspects of sciences in school textbooks. *School Science Review*, 78(282), 101-107.
- Irwin, J. (1997). Theories of burning: A case study using a historical perspective. *School Science Review*, 78(285), 31-37.
- Jungwirth, J. (1987). The intellectual skill of suspending judgement - do pupils possess it?. *Gifted Education International*, 6, 71-77.
- Klopfer, L. E., & Cooley, W. (1961). *Use of case histories in the development of student understanding of science and scientists*. Cambridge, MA: Harvard University Press.
- Lederman, N. G., Abd-El-Khalick, F., Bell, R. L., & Schwartz, R. S. (2002). Views of nature of science questionnaire: Toward valid and meaningful assessment of learners' conceptions of nature of science. *Journal of Research in Science Teaching*, 39, 497-521.
- Mamluk, R. (1995). *Science: An ever-developing entity*. Rehovot, Israel: Weizmann Institute of Science (in Hebrew).
- Mamluk, R., Ben-Zvi, R., Menis, J., & Penick, J. E. (2000). Can simple metals be transmuted into gold? Teaching science through a historical approach. *Science Education International*, 11(3), 33-37.
- Matthews, M. R. (1994). *Science teaching: The role of history and philosophy of science*. New York: Routledge.
- Meyling, H. (1997). How to change students' conceptions of the epistemology of science. *Science & Education*, 6, 397-416.
- Monk, M., & Osborne, J. (1997). Placing the history and philosophy of science on the curriculum: a model for the development of pedagogy. *Science Education*, 81, 405-424.
- Niaz, M., & Rodriguez, M. A. (2002). Improving learning by discussing controversies in the 20<sup>th</sup> century physics. *Physics Education*, 37(1), 59-63.
- Sparberg, E. B. (1996). Hindsight and the history of chemistry. *Journal of Chemical Education*, 73, 199-202.
- Tobin, K. (1995, April). *Issues of commensurability in the use of qualitative and quantitative measures*. Paper presented at the Annual Meeting of the National association for Research in Science Teaching, San Francisco, CA.



# PROMOTING SCIENTIFIC LITERACY BY INTEGRATING AUTHENTIC AND CONTROVERSIAL SOCIO-SCIENTIFIC DEBATES INTO SCIENCE LESSONS

Ingo Eilks and Ralf Marks  
University of Bremen

## Abstract

*This presentation discusses the objectives of chemistry education concerning its contribution to 'Allgemeinbildung', i.e. in its confrontation of "science through education" vs. "education through science". Using starting points like these, some ten years ago the socio-critical and problem-oriented approach was suggested by Eilks for chemistry teaching in Germany. In this paper its central assumptions and criteria for structuring lesson plans are presented as they have been refined by developing a whole series of lesson plans through Participatory Action Research in recent years. The derived theoretical framework suggests science teaching under thorough inclusion of socio-economical and ecological reflections by starting the lessons from relevant, authentic and controversial debates, which provoke and allow for open discussions and individual decision making processes. The presentation is illustrated by an example which deals with musk fragrances used in cosmetic products. From experience gained in applying different examples, the potential of this teaching approach is then reflected upon as a source for promoting the process-oriented skills of evaluation and communication as essential parts of a well-developed scientific literacy.*

## Introduction

Chemistry classes at the secondary level are unpopular among students in Germany (Gräber, 2002), just as they are in other countries (e.g. Osborne, 2003; Holbrook, 2005). Additionally, German chemistry teaching has quite often been characterised as ineffective in promoting higher-order cognitive skills, e.g. students' skills in communication or in evaluating socio-scientific issues (Gräber, 2002). One reason is believed to be the fact that most German chemistry lessons use an overly content-driven approach instead taking up applications and societal relevant issues (Gräber, 2002; Holbrook, 2005). Current practice in German chemistry teaching is not sufficiently oriented towards problem-solving and practical applications (Stanat *et al.*, 2002) and does not focus thoroughly enough on the interplay of science, technology and society with regard to local issues, public policy-making and global problems (Gräber, 2002; Eilks, 2000; Marks & Eilks, 2009). Such chemistry classes lack personal relevance for the students, which lead to both low levels of motivation and also a general lack of interest in chemistry as a discipline (Osborne, Driver, & Simon, 1998; Morell & Lederman, 1998; Osborne, 2007; Hofstein, Eilks, & Bybee, under review).

The described lack remains the case, despite science educators repeatedly indicating the need to make students competent in socio-scientific reasoning and to prepare young people to participate in socio-scientific controversies. Such changes must occur if teaching is to focus on the development of scientific literacy in its learners (e.g. Pedretti & Hodson, 1995; Driver, Leach, Millar, & Scott, 1996; Bybee, 1997; Eilks, 2000; Holbrook, 2003; Osborne, 2007; Marks & Eilks, 2009; Hofstein, Eilks, & Bybee, under review). A quote from Holbrook and Rannikmäe (2007) illustrates this:

*"... Science education should be regarded as 'education through science', rather than 'science through education'. [...] This encompasses an understanding of the nature of science [education], with links to achievement of goals in the personal*

*domain, stressing intellectual and communication skill development, as well as the promotion of character and positive attitudes, plus achievement of goals in the social education domain, stressing cooperative learning and socio-scientific decision-making. [...] the over-riding target for science teaching in school, as an aspect of relevant education, is seen in responsible citizenry, based on enhancing scientific and technological literacy.”*

The approach this paper is about totally agrees with this position and thus pleads for chemistry lessons to include societal issues and discussions involving science, technology and society (Eilks, 2002; Marks & Eilks, 2009, Hofstein, Eilks, & Bybee, under review).

However, the selection of such everyday-life contexts of chemistry and technology should not be arbitrary. Issues should be chosen which are authentic and truly relevant for students' lives. Numerous arguments support this idea. Many of these stem from viewing science education more thoroughly from the perspective of activity theory (van Aalsvoort, 2004 a and b; Roth & Lee, 2004) which demands science education to be oriented towards students' personal needs and interests in order to increase the relevance of science education in the eyes of the students (Fensham, 2004; Holbrook & Rannikmäe, 2007; Marks & Eilks, 2009). This must, however, be accomplished without neglecting the attainment of a basic understanding of relevant science concepts necessary for identifying and engaging socio-scientific discussions based on well-grounded knowledge (Lewis & Leach, 2006). A related justification also can be obtained from the German teaching tradition, which defines the main objective of schooling as achieving a high level of *Allgemeinbildung* (general education) (e.g. Hofstein, Eilks, & Bybee, under review). This concept encompasses the development of skills in 1) self-determination, 2) active engagement, and 3) solidarity within society (see e.g., Klafki, 2000). Also Roth and Lee (2004) and Elmose and Roth (2005) used the idea of *Allgemeinbildung* and characterised the focus as a readiness for both life and participation in a modern society. While all such societies are strongly based on science and technology, it is clear that such an approach focuses very strongly on a developed and multidimensional scientific literacy (Bybee, 1997).

Agreeing to the contrasting of ‘education through science’ instead of ‘science through education’ (Holbrook & Rannikmäe, 2007), such an approach to science teaching demands structures which promote communication and evaluation skills that can be applied within science, but also beyond. These skills are necessary to reflect the interplay of science and technology with society, ecology, economy, and with learners' own desires, needs and interests (e.g. Bybee, 1987; Solomon & Aikenhead, 1994; Gräber, 2002; Fensham, 2004; Aikenhead, 2007). Moreover, Bybee (1997) described such interactions as the core issue for well-developed, multidimensional scientific literacy:

*“The learner makes connections within the science disciplines, between science and technology, and between science and technology and larger social problems and aspirations.”*

Before, during and after Bybee's well-recognised contributions in the 1980s and 1990s (e.g. Bybee, 1987, 1997) there were extensive discussions of such aspects as: how to make science teaching more relevant to students, how to promote competency in evaluating socio-scientific issues as a central objective of science lessons, and how to teach students about the inter-relatedness of science, technology and society. Actual overviews of this STS-tradition are given in Sadler's review (2004) or in the critical discussion by Roberts (2007). Such STS-oriented chemistry lessons include a reflective overview of chemistry, its industrial applications and its ecological and socio-economic impacts. STS education is considered as necessary, if education is understood as a process of creating literate citizens who are able to play an active and responsible role in democratic decision-making processes about science and technology and their potential impacts (Millar, 1996; Holbrook & Rannikmäe, 2007; Hofstein, Eilks, & Bybee, under review). This approach may also improve students' interest in and attitudes towards science lessons (e.g. Osborne, Driver & Simon, 1998; Millar, 2006), aspects which are of great importance for learning achievement (Simpson, Koballa, Oliver, & Crawley, 1994).

## The Socio-critical and Problem-oriented Approach to Chemistry Teaching

From the above-mentioned framework Eilks (*e.g.* 2000, 2002) described a new conceptual approach to chemistry and science teaching in Germany about ten years ago titled “*A socio-critical and problem-oriented approach to chemistry teaching*”. The approach aims at promoting students’ motivation, bettering their attitudes towards chemistry and chemistry teaching and achieving a broad range of educational goals (*e.g.* Eilks, Marks, & Feierabend, 2008; Marks & Eilks, 2009). The main foci were:

5. to increase students’ interest in science and technology and to reveal the relevance of science in societal discussions and decision-making,
6. to make students aware of their own personal interest and motivate them to promote and protect their self-interest (either as consumers or within political decision-making processes); to provoke and develop decision-making processes within the individual,
7. to promote students’ skills in the critical use of information and increase their self-reflection on *why*, *when* and *how* science-related information is used by effected groups and/or for public purposes, and
8. to promote student-active science learning which is motivated using relevant, current and controversial socio-scientific issues.

<b>Concept of the socio-critical and problem-oriented approach to chemistry teaching</b>			
<b>Objectives</b>	<b>Criteria for selecting issues and approaches</b>	<b>Methods</b>	<b>Structure of the lesson plans</b>
Allgemeinbildung/ education through science	Authenticity	Authentic media	1. Textual approach and problem analysis
(Multidimensional) Scientific Literacy	Relevance	Student oriented chemistry learning and lab-work	2. Clarifying the chemistry background in a lab environment
Promotion of evaluation skills	Evaluation undetermined in a socio-scientific respect	Learner centred instruction and cooperative learning	3. Resuming the socio- scientific dimension
Promotion of communication skills	Allows for open discussion	Methods structuring controversial debating	4. Discussing and evaluating different points of view
Learning science	Deals with questions from chemistry and technology	Methods provoking the explication of individual opinions	5. Meta-reflection

**Figure 1. Framework of the socio-critical and problem-oriented approach to chemistry teaching**

Along various examples several key elements of the socio-critical and problem-oriented approach were refined and created a common structure for the lesson plans (*e.g.* Marks & Eilks, 2009): The lesson plans always start with authentic, current and controversial problems being debated within society. These topics must be present in different media sources, *e.g.*, newspaper articles, brochures from pressure groups, advertisements, reports on TV, etc., which are used to introduce the lesson plan and provoke a first round of questions. Only issues allowing authentic differences of opinion which have been expressed in public debate by stakeholders or pressure groups are chosen. Inappropriate issues are those which allow only one-sided solutions or those which would be viewed as unacceptable due to scientific, ethical, or sociological reasons by a majority of the class, teachers or parents. The teaching activities challenge students to make up their own minds and express their opinions in an open forum. This

method ensures that learners can express their personal points-of-view without judgement, censorship or condemnation as outsiders by the group or the teacher. Nevertheless, all lesson plans include and teach basic chemistry theory. They are built on a foundation of student lab-work and the use of open methods of learner-centred instruction. Discussion techniques are used to draw out different points-of-view, to recognise how contrary these can be, and to see how such opinions are presented, promoted and manipulated within society at large (see Figure 1).

In short, the teaching approach must start with societally-relevant, current, authentic and controversial issues from within society, having the potential to allow the learning of basic chemistry content knowledge, while simultaneously opening up discussions and promoting open decision-making processes. This is in line with Sadler (2004), who described the most fruitful settings for science education as:

*“... those which encourage personal connections between students and the issues discussed, explicitly address the value of justifying claims and expose the importance of attending to contradictory opinions.”*

## **An Example from the Classroom**

A highly-controversial topic which is currently being debated at various levels of society is the use of specific fragrances, namely synthetic musks, in cosmetic products (Eilks & Bester, 2003; Bester, 2007; Marks & Eilks, under review). The main problem causing the present dilemma is that synthetic musk fragrances are produced as “high volume chemicals” in volumes of over 2,000 tons a year in Western Europe (EU). They are used as perfumes in a wide range of cosmetic products. Synthetic musk fragrances are cheap to produce and are indispensable for the body care and detergent/soap industries, since they easily attach themselves to the surface of the skin. But these compounds are not unproblematic for the environment. Synthetic musk fragrances are funnelled into wastewater systems in great volumes via private homes and industrial concerns, thanks to widespread use of cleaners and body care products. A large amount of these substances pass through sewage treatment plants largely chemically unaltered, before they are discharged (largely intact) into streams, rivers and lakes. Furthermore, synthetic polycyclic musks are easily stored in the fatty tissues of aquatic organisms due to their lipophilic nature, especially in the tissues of “oily” fishes. This is problematic because both of the most important fragrances have shown hormone-activating effects and may lead to falling levels of fertility in male fish. This effect has not yet been documented in humans. But synthetic musks have already been detected stored in human tissue samples and, maybe even more problematically, in human breast milk. A second problem stems from the processing of the sludge produced by wastewater facilities, since this sludge is contaminated with synthetic musk fragrances, but used in agriculture and is therefore introduced directly into our personal environments. At present macrocyclic musk fragrances, which are allegedly more environmentally friendly, are being introduced into the market. However, there have not yet been sufficient analytical tests performed upon these substances to prove or disprove these claims. Until now there have been almost no legislative regulations concerning the use of synthetic musk fragrances. There is no way for consumers to discern whether the products they purchase contain synthetic musk fragrances (and which type) or not, because lists of detailed product ingredients are optional and normally not a legal requirement. However, consumer tests of different products can clarify this question for perspective buyers. For example, the German journal *Ökotest*, a magazine testing consumer products with respect to their health and environmental effects, used the presence of synthetic musk fragrances as a weed-out factor in its testing of shower gels. Products containing such substances cannot receive scores rating them ‘good’ or better (Ökotest, 2004).

The above described situation was used to develop a lesson plan for German 10th grade (age-range 15-16) chemistry lessons (Marks, Witte, & Eilks, 2007; Marks & Eilks, under review). The lesson plan consists of 8-10 forty-five minute classroom periods. The embedded basic chemistry knowledge about detergents and their function is part of the official governmental syllabus in Germany.

In the initial lesson various shower gels are given to the pupils. The products retain their price tags and include supermarket items, products from “dollar stores”, brand-name and generic articles, and shower products

without fragrances and/or preservatives. The students are challenged to select a product and are asked to list their reasoning on a slip of paper. The paper slips are then clustered on the blackboard into groupings containing similar arguments. In each testing in class (either with student teachers at the university, students in school, or teachers in in-service trainings), a vast majority of each group mentioned the smell of the product as the leading criterion for their choice. This is always followed by the image of the product and the appearance of the packaging. Good functionality as a detergent, skin care ingredients or other reasons (*e.g.* pH-neutrality/hypoallergenic) are only mentioned rarely. The students' criteria are compared to an authentic text from a consumer test magazine (Ökotest, 2004), leading to a discussion about the major components of shower gels (detergents, skin care ingredients, fragrances, dyestuffs and preserving agents). This is followed by questions about which of these substances are actually necessary for a shower gel to carry out the tasks to clean and care for the skin, which ones are added for other reasons, and which may be accounted for when evaluating a product. The text makes clear that especially the latter groups of substances (fragrances, dyestuffs and preserving agents) differentiate between the various products and are of importance for evaluating products concerning their healthy or environmental effects.

In the next face the students learn about the basic chemistry behind the function of a shower gel through a learning-at-stations setting while working in small groups of 3 to 4. The learners work for 2-3 classroom periods (each 45 min. length) to finish a total of eight learning stations. The stations are offered in the classroom and contain different activities, *e.g.* experiments, texts or modelling tasks. Students are allowed to divide the time at their disposal among the different stations using their own judgement and to decide the sequence of visiting the different stations. Of a total of eight stations, each three deal with detergents as a main ingredient of functional compounds in a shower gel and with fragrances as being important for the consumers' choices. Two further stations clarify "other" ingredients and include the making of a shower gel by the students themselves. Five of the eight stations include hands-on experiments, one uses graphic animation, one is text-based and one is model-based. For especially-talented or rapidly working groups, two extra stations with in-depth information on tenside-types and the synthesis of fragrances are offered.

In order to link newly-learned chemistry knowledge with the problems of using synthetic musks, an overview of how fragrances are extracted and then used by perfume makers is provided in a film. Also, the initial text from the consumer test magazine is revisited. In order to introduce controversy through different and/or partially contradictory views on the topic, the students are asked to produce a news report on the issue as if they were journalists working for a TV show. The students receive various news tickers as a source of information, much like journalists would take their information from news agencies' summaries. Within each of the various news tickers, a set of short messages is offered which discuss the issue from different perspectives, *e.g.* from companies, pressure groups, scientists, ... (Marks & Eilks, 2008a; Marks, Otten, & Eilks, under review). Two independent groups of 2-3 pupils are assigned to each perspective to ensure that all four perspectives are covered by two teams. The purpose here is to sensitize the students to the fact that information taken from the exact same sources can be presented differently by two different 'journalists' and also to show how varied the resulting news can be. The students should also learn about the role that a journalist's subject knowledge plays when writing a report on a scientific evaluation of a product. Pupils must also carefully evaluate and choose journalistic reporting "tricks" which are necessary to attract large audiences to the news, how much information can effectively be presented in one minute and how much less-important or background information is needed – and often is used by journalists – for reporting on a complex topic. Finally, the freshly-created news clips are presented to and evaluated by the entire class as to their comprehensibility, presentation and content information. A meta-discussion at the end of the lesson reveals the differences in the perspectives, including their relevance and connections to the interests of different shareholder groups in society, and reflects upon how complex such a simple question like "Which shower gel should I buy or use?" can become.

Similar lesson plans have been developed for a variety of issues (Eilks, Marks, & Feierabend, 2008; Marks & Eilks, 2009), all starting from authentic and controversial issues from within society, which allow for an open discussion. In every case, different fields are touched upon where societal decisions are identified for discussion.

Different units, for example, deal with the role of pressure groups in society, journalistic work, the practices of public relations figureheads and advertising experts, or decision-making at the parliamentary level. But all of the issues also reveal questions about an individual's decisions and when they are necessary for using very common products in everyday life. Table 1 gives an overview for some example units.

**Table 1. Potential issues for a socio-critical and problem-oriented approach to chemistry teaching**

Issue	Science content	Experiments	Societal controversy
Biodiesel (Eilks 2000, 2002)	e. g., fats, esterification, industrial synthesis, chemical equilibrium	e. g. synthesis of Biodiesel from rapeseed oil, comparing viscosity and burning behaviour	Public reception of reports on the ecological balance; the use of obviously contradictory interpretations of the results for a given product by different pressure groups and companies in the public debate
Light Crisps (Marks, Bertram, & Eilks, 2008; Eilks, Marks, & Feierabend, 2008)	e.g. fats and carbohydrates, energetics	e. g. measuring the fat and carbohydrate content of different sorts of food	Controversy about the potential of low-fat- vs. low-carb-diets; advertisements for 'light'-products in magazines and on TV
Alcopops (Marks, Siol, & Eilks, 2006; Marks & Eilks, 2008b)	e.g. alcohols, alcohols in the body, caffeine	e. g. quantitative analysis of drinks concerning alcohol and sugar content, qualitative analysis e. g. for caffeine	Prohibition and taxation of alcoholic drinks for young people ("Alcopops") in Germany; the reaction of producers by offering similar products unaffected by new "alcopop laws" and advertising them using the same methods used for the original Alcopops
Shower gels (Marks, Witte, & Eilks, 2007; Marks & Eilks, submitted)	e. g. soaps and detergents, fragrances	e. g. properties of detergents, fragrances and other ingredients	Artificial musk fragrances which are hormone-activating and possibly carcinogenic; their use in cosmetics and perfumes and evaluations of products by consumer tests
Hydrogen car (Eilks, Evlogimenos, Olympios, & Valanides, 2003)	e. g. electrochemical cells, fuel cells, hydrogen technology	e. g. electrolysis of water, building a fuel cell	Use of hydrogen as a fuel and the questions of where it comes from/ where the energy for the production of hydrogen comes from
Bio-Ethanol (Feierabend & Eilks, 2009 a and b)	e. g. alcohols, fermentation, distillation	e. g. fermentation, properties of alcohols, comparison of energy content for burning gasoline and alcohol	Competition between food vs. fuel production; the effects of switching to bio-fuels concerning food prices in developing countries; the effects of the bio-ethanol production on rain forests in Brazil; social standards in bio-ethanol production in some countries
Doping (not published yet)	e.g. screening, analytical test, GC, MS, IR	e.g. model experiment screening, analytical tests, model GC	Doping in sports and the difficulty in defining the boarder between functional food and illegal doping in professional sports and daily fitness.

---

## Experiences, Findings and Discussion

The development of the lesson plans presented here took place over about ten years in a Participatory Action Research (PAR) project (Eilks, & Ralle, 2002) consisting of a group of teachers from a variety of schools working on different questions of curriculum development and classroom research (Eilks, 2003, 2007). This approach was chosen to sustainably implement STS-oriented teaching in the classroom while simultaneously hindering teachers from automatically falling back into habitual teaching patterns when confronted by new strategies in an in-service course design only (Pedretti & Hodson, 1995; Rannikmäe, 2006).

In PAR projects in chemistry education, practising teachers and university researchers jointly develop lesson plans, teaching methods and materials. From a systematic analysis of research reports, personal experiences of the teachers, didactical and methodological analysis, or reflections about the chemistry content structure, first-draft lesson plans are negotiated within the action research group until all practitioners agree that the new lesson plan can potentially help to improve teaching practice. Through subsequent cycles of development, testing, evaluation and reflection/revision, the lesson plans are improved step-by-step. Accompanying the process of development, different kinds of evaluation data are collected as a baseline for better understanding the effects of the lesson plan and the implemented changes.

From different studies about the socio-critical and problem-oriented approach in chemistry teaching (*e. g.* Eilks, 2002; Marks, Bertram, & Eilks, 2008; Marks & Eilks, under review) a lot of information is available covering teachers' reflections in the action research group meetings, classroom observations, students' feedback questionnaires, and different studies based on group discussions. Some careful conclusions about successfully promoting scientific literacy can be drawn from the various studies.

Teachers and students consistently described the teaching situation as very motivating and intense. It was observed that the intense discussion of socio-scientific issues often didn't stop at the end of the classroom period and often stretched into the students' personal breaks between classes. Students repeatedly mentioned that, for the first time ever, they had perceived school chemistry as being relevant to them and that it was connected to their everyday lives as well as to other school subjects and disciplines. Changes in the attitudes and opinions among some of the students can be found, although analysing the discussions of students in class and the accompanying group discussions is not easy and is sometimes ambiguous (Albe, 2008). The intense discussions, especially due to their continuation after the lessons were over, indicate that the students accepted all the above-listed topics as interesting and relevant. In open-ended questionnaires, most students overwhelmingly characterised the specific examples as being good starting places from which to teach chemistry (*e.g.* Marks, Bertram, & Eilks, 2008; Marks & Eilks, under review). Therefore, the experiences with the different lesson plans support the idea that involving authentic and, especially, controversial debates on socio-scientific issues has the potential to promote students' interest in science education. This includes their skills in communication and evaluation and is not only restricted to communication and evaluation within chemistry as a scientific discipline, but also within a framework of understanding chemistry and technology as important parts of our modern world. Some quotes from students' reflection about the lessons may illustrate this:

*"I learned a lot about shower gels, soaps and their ingredients, which I normally never would have expected. Additionally, I learned that not all ingredients are good for the environment and that you have to look at everything from two perspectives, for example, in the case of musk fragrances ..."* (Issue 'Musk fragrances in shower gels')

*"I think that it is difficult to have an opinion to this question. On the one hand, there is the 'danger' for the environment when synthetic musk fragrances are used. We have to ask ourselves, whether it is more sensible to find a solution to the water purification side of the problem, or to continue research for other 'healthier' musk fragrances. On the other hand, natural musks still exist, whereby the problem is that the animals which produce it are threatened by extinction. We can only hope that enough money is dedicated to research efforts."* (Issue 'Musk fragrances in shower gels')

*"We have seen, [...] that all the products have advantages and disadvantages. Of course, in public the interest groups present only the products' advantages, because that's positive for themselves, too. They don't mention the disadvantages. So they are convenience-based ... we [the public relations experts] want to promote sales of the crisps and do not say any negative things about them."* (Issue 'Light crisps')

*We learned about "a critical re-thinking about issues where the answer originally appeared to be so easy."* (Issue 'Bio-Ethanol')

*"I learned a lot about the production, structure, use, advantages and disadvantages of Bio-diesel. Also, I consider it to be important that I learned about our environment and its protection. I especially learned about how companies sell environmentally friendly products and how naive we can be if there is the syllable 'bio' in it."* (Issue 'Bio-Diesel')

*"I have learned about the advantages and disadvantages of Bio-diesel, about interests of pressure groups and how to evaluate their opinions by considering their particular interests, and how to develop an opinion and make up my own mind."* (Issue 'Bio-Diesel')

From the theoretical side it seems that chemistry topics must include more than contexts (even if they stem from everyday-life) in order to motivate student science learning and stimulate pupils' interest and critical skill building. From our experience we would conclude that topics must be relevant, authentic, and controversial. Controversy in the eyes of the students apparently allows chemistry lessons to focus on the general objectives of education through science. The examples described here, including that of musk fragrances in shower gels and the evaluation of shower gels by consumers or consumer test magazines, seem to offer valuable assistance in this respect. But from the discussions we can also recognise that essential science content learning and understanding is necessary for students to participate in fruitful, substantial discussion. Within such topics, students should also have enough room to argue their own opinions. By bringing these aspects together the above examples give some slight indication that students view chemistry lessons differently after such teaching units.

In our view the socio-critical and problem-oriented approach to chemistry teaching seems promising in respect to promoting higher-order cognitive skills, i.e. in communication, reflection and evaluating controversial issues within the STS-framework. The students – at least a higher portion of them – seem to profess recognition of a higher relevance of chemistry education to their lives. Within the lessons and in the group discussions from the accompanying research, passages were recorded that support this conclusion. Students appeared to become more self-reflective and openly critical about the way both society and media deal with such debates. From the different studies we can reasonably assume that the approach described can potentially promote the essential skills of well-developed scientific literacy among at least some students when discussing and evaluating controversial issues taken from their everyday lives and society.

## References

- Aikenhead, G. S (2007). Humanistic perspectives in the science curricula. In S. K. Abell & N. G. Ledermann (eds.): *Handbook of Research in Science Education* (pp. 881-910). Mahwah: Lawrence Erlbaum.
- Albe, V. (2008). When scientific knowledge, daily life experience, epistemological and social considerations intersect: students' argumentation in group discussions on a socio-scientific issue. *Research in Science Education*, 38, 67–90.
- Bester, K. (2007). *Personal care compounds in the environment. Pathways, fate and methods for determination*. Weinheim: Wiley-VCH.
- Bybee, R. W. (1987). Science education and the science-technology-society (STS) theme. *Science Education*, 71, 667-683.
- Bybee, R. W. (1997). Toward an understanding of scientific literacy, In W. Gräber & C. Bolte (eds.): *Scientific literacy – an international symposium* (pp. 37-68). Kiel: IPN.
- Driver, R., Leach, J., Millar, R., & Scott, P. (1996). *Young people's image of science*. Buckingham: Open University Press.



- Eilks, I. (2000). Promoting scientific and technological literacy: teaching biodiesel. *Science Education International* 11(1), 16-21.
- Eilks, I. (2002). Teaching 'biodiesel': a sociocritical and problem-oriented approach to chemistry teaching, and students' first views on it. *Chemistry Education: Research Practice in Europe*, 3, 67-75.
- Eilks, I. (2003). Co-operative curriculum development in a project of Participatory Action Research within chemical education: teachers' reflections. *Science Education International*, 14(4), 41-49.
- Eilks, I. (2007). From technical to emancipatory Action Research – a six year case study on science teachers involved in a cooperative curriculum development project. Paper presented at the 6th ESERA-Conference, Malmo, Sweden.
- Eilks, I., & Bester, K. (2003). "Noch immer geht zu viel Müll den Bach runter" - Zur Behandlung von Mülltrennung und Abwasserklärung in der Jahrgangsstufe 7 ["Still too much waste runs down the river" – On the teaching about waste treatment and waste water clarification in grade 7]. *Praxis der Naturwissenschaften - Chemie in der Schule* 52 (8), 37-43.
- Eilks, I., Evlogimenos, S., Olympios, C., & Valanides, N. (2003). Ecologically friendly cars, without emissions. Should they be compulsory?. In J. Holbrook (ed.): A resource book for teachers in science subjects, UNESCO/ICASE 2003, <http://www.lmmt.org/lmtnytt/Fuel%20Cell2.pdf> (last access 01/10/2008).
- Eilks, I., Marks, R., & Feierabend, T. (2008). Science education research to prepare future citizens – Chemistry learning in a socio-critical and problem-oriented approach. In B. Ralle & I. Eilks (eds.): *Promoting successful science learning – The worth of science education research* (pp. 75-86). Aachen: Shaker 2008.
- Eilks, I., & Ralle, B. (2002). Participatory Action Research in chemical education. In B. Ralle and I. Eilks (eds.): *Research in chemical education - what does this mean?* (pp. 87-98). Aachen: Shaker.
- Elmose, S., & Roth, W.-M. (2005). Allgemeinbildung: Readiness for living in a risk society. *Journal of Curriculum Studies* 37, 11-34.
- Feierabend, T., & Eilks, I. (2009a). Bioethanol – Bewertungs- und Kommunikationskompetenz Schulen in einem gesellschaftskritisch-problemorientierten Chemieunterricht [Bio-ethanol – Promoting competencies in evaluation and communication within the socio-critical and problem-oriented approach to chemistry lessons]. *Der Mathematische und Naturwissenschaftliche Unterricht* 62(2), 92-97.
- Feierabend, T., & Eilks, I. (2009b). Learning chemistry and mimicking political decision-making processes - A Participatory Action Research study evaluating a lesson plan on the use of bioethanol as a fuel. Paper presented at the ESERA Conference, Istanbul.
- Fensham, P. (2004). Increasing the relevance of science and technology education for all students in the 21<sup>st</sup> century. *Science Education International*, 15, 7-27.
- Gräber, W. (2002). Chemistry education's contribution to Scientific Literacy – An example. In B. Ralle & I. Eilks (Eds.): *Research in chemical education – what does this mean?* (pp. 119-128). Aachen: Shaker.
- Hofstein, A., Eilks, I., & Bybee, R. (under review). Societal issues and their relevance for science education.
- Holbrook, J. (1998). Operationalising scientific and technological literacy – a new approach to science teaching. *Science Education International*, 9, 13-18.
- Holbrook, J. (2003). Increasing relevance of science education: the way forward. *Science Education International*, 14, 5-13.
- Holbrook, J. (2005). Making chemistry teaching relevant. *Chemical Education International*, 6 (1), retrieved August 01, 2009, from the World Wide Web at [http://old.iupac.org/publications/cei/vol6/06\\_Holbrook.pdf](http://old.iupac.org/publications/cei/vol6/06_Holbrook.pdf).
- Holbrook, J., & Rannikmäe, M. (2007). The nature of science education for enhancing scientific literacy. *International Journal of Science Education*, 29, 1347-1362.
- Klafki, W. (2000). The significance of classical theories of Bildung for a contemporary concept of Allgemeinbildung. In I. Westbury, S. Hopmann & K. Riquarts (Eds.): *Teaching as a reflective practice: the German Didaktik tradition*. Mahwah: Lawrence Erlbaum.
- Lewis, J., & Leach, J. (2006). Discussion of socio-scientific issues: the role of science knowledge, *International Journal of Science Education*, 28, 1267-1287.
- Marks, R., Bertram, S., & Eilks, I. (2008). Learning chemistry and beyond with a lesson plan on potato crisps, which follows a socio-critical and problem-oriented approach to chemistry lessons – a case study. *Chemistry Education: Research and Practice* 9, 267-276.
- Marks, R., & Eilks, I. (2008a). Nachrichtenspots erstellen über Chemie – Ein Weg Kommunikations- und Bewertungskompetenz zu schulen? [Writing news spots about chemistry – A way to teach communication and evaluation competencies?]. *Der Mathematische und Naturwissenschaftliche Unterricht* 61, 224-229.

- Marks, R., & Eilks, I. (2008b). Kommunikations- und Bewertungskompetenz entwickeln in einem gesellschaftskritisch-problemorientierten Chemieunterricht über Alcopops – Eine Reflektion aus einem Projekt Partizipativer Aktionsforschung [Developing communication and evaluation competencies in a socio-critical and problem-oriented approach to chemistry teaching on Alcopops – A reflection from a project of Participatory Action Research]. *Chimica etc. Didacticae* 34 (2008), Nr. 101, 48-77.
- Marks, R., & Eilks, I. (2009). Promoting scientific literacy using a socio-critical and problem-oriented approach to chemistry teaching: concept, examples, experiences. *International Journal of Science and Environmental Education*, 4 (2), 131-145.
- Marks, R., & Eilks, I. (under review). A case study on a chemistry lesson on shower gels following a socio-critical and problem-oriented approach: Teachers' and students' views.
- Marks, R., Otten, J., & Eilks, I. (under review). Writing news spots about chemistry – A way to promote students' competencies in communication and evaluation.
- Marks, R., Siol, A., & Eilks, I. (2006). Ein Schülerlabor zu Alcopops - eingebettet in einem gesellschaftskritisch-problemorientierten Chemieunterricht [A students' lab on Alcopops – embedded into the socio-critical and problem-oriented approach to chemistry lessons]. *Praxis der Naturwissenschaften – Chemie in der Schule* 55(2), 39-47.
- Marks, R., Witte, N., & Eilks, I. (2007). „Riecht gut, aber ...“ – Chemie und Bewerten Lernen am Beispiel des Duschgels [„Smells well, but...“ – Learning chemistry and to evaluate on the example of a shower gel]. *Praxis der Naturwissenschaften – Chemie in der Schule* 56(3), 11-15.
- Millar, R. (1996). Towards a science curriculum for public understanding. *School Science Review*, 77(280). 7-18.
- Millar, R. (2006). Twenty-first century science: insights from the design and implementation of a scientific literacy approach in school science. *International Journal of Science Education*, 28, 1499-1521.
- Morell, P. D., & Lederman, N. G. (1998). Students' attitudes toward school and classroom science: are they independent phenomena?. *School Science and Mathematics*, 98, 76-83.
- Ökotest (Hrsg.), (2004). Duschgele – Nicht ganz sauber [Shower-gels – not fully clean]. *ÖKO-TEST-Jahrbuch für 2004*.
- Osborne, J. F. (2003). Attitude towards science: a review of the literature and its implications. *International Journal of Science Education*, 25, 1049-1079.
- Osborne, J. F. (2007). Science education for the twenty first century. *Eurasia Journal of Mathematics, Science & Technology Education*, 3, 173-184.
- Osborne, J. F., Driver, R., & Simon, S. (1998). Attitudes to science: issues and concerns. *School Science Review*, 79(288). 27-33.
- Pedretti, E., & Hodson, D. (1995). From rhetoric to action: implementing STS education through action research. *Journal of Research Science Teaching*, 32, 463-485.
- Rannikmäe, M. (2006). Using socially derived teaching approaches in science classes – a longitudinal study on teachers learning in a research based curriculum innovation. In I. Eilks & B. Ralle (eds.): Towards research-based science teacher education (pp. 137-146). Aachen: Shaker.
- Roberts, D. A. (2007). Scientific literacy/science literacy. In S. K. Abell & N. G. Lederman (eds.): *Handbook of research in science education* (pp. 729-780). Mahwah: Lawrence Erlbaum.
- Roth, W.-M., & Lee, S. (2004). Science education as/for participation in the community. *Science Education*, 88, 263-291.
- Sadler, T. D. (2004). Informal reasoning regarding socioscientific issues: A critical review of research. *Journal of Research Science Teaching*, 41, 513-536.
- Simpson, R. D., Koballa, T. R., Oliver, J. S., & Crawley, F. E. (1994). Research on the affective dimension of science learning. In D. L. Gabel (ed.): *Handbook of research in science teaching and learning* (pp. 211-234). New York: MacMillan.
- Stanat, P., Artelt, C., Baumert, J., Klieme, E., Neubrand, M., Prenzel, M., Schiefele, U., Schneider, W., Schümer, G., Tillmann, K.-J., & Weiß, M. (2002). PISA 2000: Overview of the study. Berlin: MPI, [www.mpib-berlin.mpg.de/pisa/PISA-2000\\_Overview.pdf](http://www.mpib-berlin.mpg.de/pisa/PISA-2000_Overview.pdf) (last access 01/10/2008).
- Solomon, J., & Aikenhead, G. (eds.) (1994). *STS education: international perspectives on reform*. New York: Teachers College Press.
- Van Aalsvoort, J. (2004a). Logical positivism as a tool to analyse problem of chemistry's lack of relevance in secondary school chemistry education. *International Journal of Science Education*, 26, 1151-1168.
- Van Aalsvoort, J. (2004b). Activity theory as a tool to address the problem of chemistry's lack of relevance in secondary school chemistry education. *International Journal of Science Education*, 26, 1635-1651.

# ENHANCING PUPILS' ABILITIES TO PROPERLY JUDGE AND MAKE INFORMED DECISIONS IN THE FIELD OF RENEWABLE ENERGY SOURCES – BIOENERGY

Claus Bolte, Birgit Kirschenmann and Sabine Streller

Free University of Berlin, Germany

## Abstract

*Environmental problems like climate change, supposedly as a result of the usage of conventional energy supplies, are, according to Klafki (1995), one of the “epoch-making key-problems”. The world has only finite deposits of resources such as natural gas, oil and coal, however an increasing need for energy is a fact as well as a dilemma which has to be kept in mind if societies seriously try to solve these global problems and try to find guidelines for a future-compliant energy supply. Great chances to reduce these problems are attributed to the usage of renewable energy; especially to bioenergy, which is described as being an all-rounder. But, what is so special about these promising alternatives? How ecological, economic and developed are these alternatives? Which alternative is the “proper” one? And how can students form their own opinion if they have to make their own individual and reflected decisions? The Berlin “Chemistry in a Class of Its Own” project concerning the topic “Renewable Energy Sources – Bioenergy” tries to point out how upper high school students can and do form their own reflected opinions in this controversially discussed field.*

## Introduction

One of the central components of being educated in general and of being scientifically literate in particular is one's judgment competence and one's ability to make informed decisions. However, many people (adults as well as pupils) seem to not have these qualities at their disposal; science education does not seem to challenge them enough. This may be due to teachers not getting enough help devising lesson plans which cover topics that educate pupils in this aspect. Our unique project is designed to show whether evidence-based science lessons can be planned and carried out in order for pupils to become educated in the subject matter as well as in their ability to make informed decisions.

The “class of its own” project is an extracurricular educational programme designed to give pupils the opportunity to participate in courses which take place in the laboratories of the Department of Chemistry Education at Freie Universität Berlin (Bolte & Streller 2008, Bolte & Streller 2007, Streller & Bolte 2007, Kirschenmann & Bolte 2007a). In order to investigate the process of opinion making we offer a one-week course to upper high school pupils during their holiday (Kirschenmann & Bolte 2007b; 2006). The research accompanied by the project aims to answer – among others – the following questions:

- What knowledge do the pupils have about conventional and renewable energy sources in general and about bioenergy sources in particular before and after the project?
- What arguments do the pupils bring up when they are asked to form an opinion in this area and do they change their line of argumentation as a result of the course?

## Rationale

To develop our extracurricular educational programme, we used the “science in a class of its own” concept as the conceptual basis (Bolte & Streller 2008, Bolte & Streller 2007, Streller & Bolte 2007). Pupils in upper high school got the opportunity to deal with current issues and methods of chemistry in four (or five) day courses during their

holidays. In terms of designing the course it was important to find a balanced ratio of phases which are guided by theory and practical work as well as team work.

A main emphasis of the project “renewable energy sources – bioenergy” is to make young people aware of how proper judgment and informed decisions can be based on scientific insights and methods (Kirschenmann & Bolte 2007a; 2007b; 2006). Additionally, dealing with chemistry-related facts can (even) help to tackle developmental tasks of the adolescence – in the sense of learner developmental considerations (Havighurst 1972; Schenk 2005; Meyer 2006; Bertels & Bolte 2009). Especially with regard to the latter context, the topic of renewable energy opens up numerous questions and aspects for discussion with respect to the pupils’ interests (Gräber 1998, Bolte 2006; 2008), especially in the field of socio scientific issues and controversial discussed global problems (Bolte 2008) which seem to be relevant with respect to pupils viewpoints and their developmental tasks they have to solve in this period of the biography; e.g. the developmental task of finding a vocational orientation or forming ones own system of critical and reflected individual judgments (Schenk 2005; Bertels & Bolte 2009).

## Methods

To be able shed some light on the above questions – we mentioned above – we planned an intervention study. Using a pre-post-test-design, 76 upper high school pupils took part in our programme. The participants were questioned just before and just after the courses by means of different questionnaires which had been developed especially for this purpose. Four variable lay in the main focus of our research: students scientific knowledge, students attitudes towards science, students interest of learning science evaluated by means of the students assessments of the motivational learning environment (in the IDEAL-, REAL- and TODAY-version of the MoLE-Questionnaires; see Bolte (2006)) and students ability to make informed decisions.

After the pre-test was completed, the pupils took part in the four-day course, we call the “Science in a Class of Its Own“-course on the topic “Renewable Energy Sources – Bioenergy”. Numerous aspects on the topic of energy were examined in the Class of its own project, for example:

- Overview of the current questions regarding the need for energy and energy supply
- Revision and deepening of the technical terms from junior high school
- Provision of energy from conventional energy sources and renewable energy sources
- Working on the theoretical basics of the provision of energy from biomass
- Comparing selected scientific aspects of the provision of energy from bio-energy sources and from conventional energy sources
- Provision of energy from biomass and from conventional energy sources: What makes sense and what is possible?

In the project the students worked on the topics with different sources of information and for the most part by carrying out experiments themselves with the biogenic raw materials wood, biogas and biodiesel in order to explore their chemical and physical properties. In phases which were guided by theory and in phases of practical work the young people examine different questions:

- What is biodiesel and how is it produced? How similar are rape oil, biodiesel and diesel in their chemical and physical properties?
- What is biogas? How can biogas be produced? What distinguishes biogas from natural gas?
- How much energy do different solid fuels contain? Which components do the exhaust emissions contain when, e.g. wood pellets are burned?

Following our conceptual guidelines the groups of the course visited a biogas and biodiesel plant in the surroundings of Berlin in order to receive further important and up-to-date information. The experts on site provided an informative and instructive insight into the daily practice of the provision of energy from biomass for the participants.

In the “Science in a Class of Its Own” courses the students dealt with the possibilities but also with the limits of the provision of energy from biomass. The young people took a close look at their own individual moral concepts regarding the topic. Within the context of group work concerning systematic assessment (biodiesel vs. fuel) they had to find a common consensus. In role play with the topic of “Conventional and Alternative Provision of Energy” the students were asked to change their perspective and to work out different positions. As a conclusion the students presented their results in a playful way and took on the different roles with a lot of commitment in order to present their arguments as plausibly as possible.

Apart from our efforts to promote the scientific competences and the open-mindedness towards scientific questions of the students it was our aim to answer, among others, the questions mentioned in the objectives. Hence, at the end of the course the participants were asked again to answer the questions and tasks concerning the above mentioned variables.

Hence findings concerning our motivational and interest related research questions are already published (Bolte & Kirschenmann 2009), we will concentrate in this publication on our study concerning students’ abilities to make informed decisions. To be able to analyze the students’ abilities to make informed decisions we developed a questionnaire consisting two tasks. The first task, the so called “mayor task”, asks the pupils to put themselves in the position of a mayor who has to decide on an energy supply plant to be built in a residential area. In the first task the pupils have to give at least three arguments for and at least three against the seven different energy supply methods which were mentioned in a table; e.g. the biogenic energy sources: wood, biogas and biodiesel and the renewable energy sources: wind plants and solar cell plant, and the “conventional energy source: fossil energy sources (oil, coal, gas) and nuclear power. In the second task the participants are asked to form an order of priority of what they regard as their favoured energy supply.

In order to be able to make statements not only about the quantity but also about the quality of the arguments, a categorical system has been designed modelled according to Spranger (1921). All listed statements can be differentiated by means of this categorical system, allowing the following assignments: Arguments with a ...

- theoretical-technical,
- theoretical-natural-scientific,
- economical,
- aesthetic,
- social,
- political,
- religious and
- environmental

background.

Generally the data will be analyzed by means of descriptive statistics using SPSS statistic package.

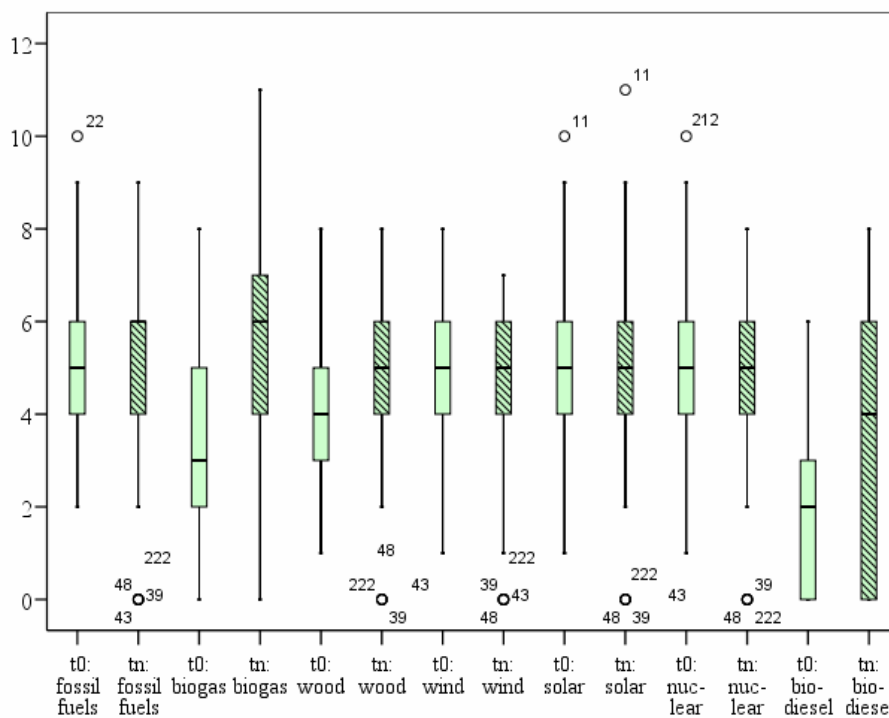
## Results

### Sample

The sample of this study consist 76 students from German upper high schools grade 10 to 13. The students took part in one of the four “Science in a Class of Its Own” courses, we had offered during the spring and summer holydays in 2006 and 2007. Only the data concerning our motivation and science interest related variables and research questions could be compared with the data source of a bigger control sample (N = 531; see Bolte & Kirschenmann 2009).

### Results from the “Major Task”

The results of the “mayor task” (see Figure 1) show that the pupils can list only few arguments for the biogenic energy sources in the pre-test. Before the course, they hardly mention any arguments for biogas (Median: 3), biodiesel (Median: 2) and wood (Median: 4). Apparently they have only little knowledge in this field at the beginning of the Class of Its Own course.



**Figure 1. The “mayor task” – Spread of the number of arguments per energy supply plant.**

The qualitative analysis of the students' arguments shows in the pre-test that they list relatively few theoretical-natural-scientific and theoretical-technical arguments in the area of bioenergy. Furthermore, the analyses in the field of biogas in the pre-test show that some of the participants used technically wrongly worded arguments as counter arguments when speaking of the ecology of biogas production (e.g. methane escapes → damaging to the ozone layer).

As expected in the post-test (see Figure 1), the students are able to mention clearly more arguments for wood (Median: 5), biogas (Median: 6) and biodiesel (Median: 4). In the post-test, no technically incorrect arguments stand out in the field of biogas anymore. This illustrates that the quality of their argumentation has increased scientifically. When talking about wood in the post-test, the students use fewer economical arguments in contrast to the pre-test. In this case we assume that the students' argumentative focus changed and economical arguments lost relevance in

favour of theoretical-natural-scientific or ecological arguments. Contrary to the pre-test, in which the participants list only counter arguments for biodiesel, they mention several pro arguments for this energy source in the post-test. Obviously, students are rather sceptical of biodiesel at the beginning of the course because they lack knowledge about it. By means of their newly acquired knowledge they can argue in a more sophisticated, factually more appropriate way and thus on a higher qualitative level after the course.

### Results from the “Ranking Task”

Concerning the second task of the questionnaire, the “ranking task”, students put the biogenic energy sources biodiesel and biogas in middle positions in the pre-test (see Figure 2). Wood is ranked in a lower position and with a wider spread with regard to its positioning.

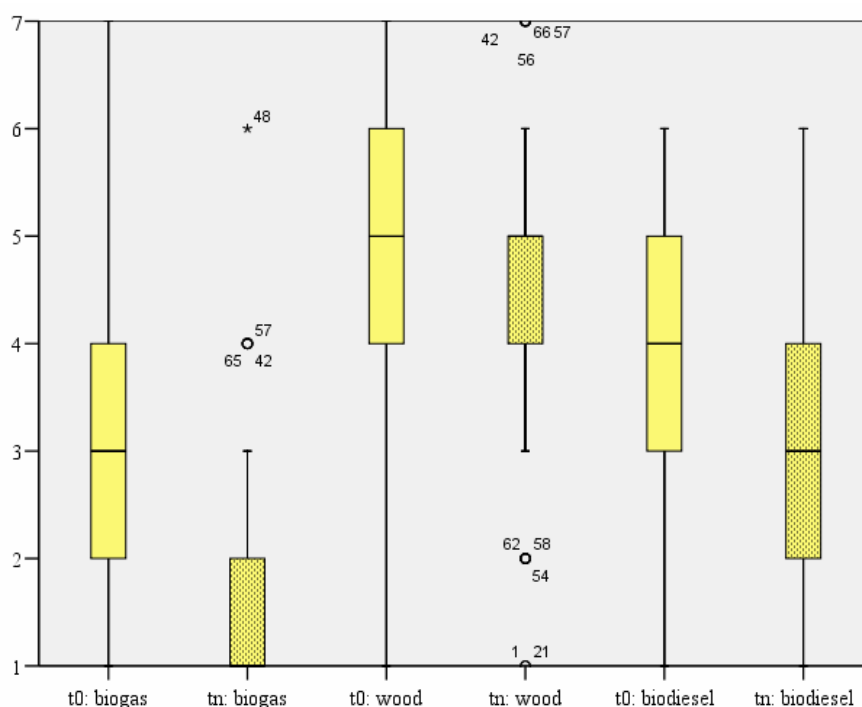


Figure 2. The “mayor task” – Spread of the number of arguments per energy supply plant.

In the post-test (see Figure 2), biogas and biodiesel are positioned higher and wood is ranked with a smaller spread. The results of the students’ ranking before and after the course indicate a change relating to the individual preferences of the students. These changes become clear in the order of priority of the biogenic energy sources and in the decrease of the statistical spread as opposed to the first ranking.

## Conclusions and Implications

Within the “Science in a Class of Its Own” project, the students dealt intensively with science-related issues and methods as well as with values, opinions and judgements about bioenergy and their (useful) applications. The results show that by means of courses like this students’ ability in proper judgement can be promoted. At the end of the course the students’ lines of argumentation are more sophisticated and based on more considerable knowledge. We are currently investigating how lasting the acquired competences are and in what way the programme can be adapted for science lessons in schools.

## Acknowledgements

This project was kindly funded by the *Fonds der Chemischen Industrie (FCI)*.

We would also like to thank Felix Hermerschmidt for his contribution and help with the translation.

## References

- Bolte, C. (2006). As good as it gets: The MoLE instrument for the evaluation of science instruction. *Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (NARST)*. San Francisco, USA.
- Bolte, C. (2008). A Conceptual Framework for the Enhancement of Popularity and Relevance of Science Education for Scientific Literacy, based on Stakeholders' Views by Means of a Curricular Delphi Study in Chemistry. *Science Education International*, 19, 331-350.
- Bolte, C., & Streller, S. (2007). Chemie (in) der Extra-Klasse: Bausteine des Lebens. In D. Hötticke (Ed.), *Naturwissenschaftlicher Unterricht im internationalen Vergleich. Zur Didaktik der Physik und Chemie. Probleme und Perspektiven* (pp. 598-600). Münster: Lit.
- Bolte, C., & Streller, S. (2008). "The building blocks of life – An introduction to biochemistry" – An extracurricular course to promote students' interests in learning chemistry. *Proc. XIII. International Organization for Science and Technology Education (IOSTE) Symposium: The Use of Science and Technology Education for Peace and Sustainable Development* (pp. 294-300). Kusadasi, Turkey.
- Bolte, C., & Kirschenmann, B., (2009). Enhancing Students' Interests in Learning Science by Creating Innovative Learning Environments – The Berlin-ParIS-Project "Bio-Energy Sources". *Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (NARST)*. Los Angeles, USA.
- Bertels, N., & Bolte, C. (2009). Developmental tasks, stereotypes and motivational learning environments in German Science Lessons *Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (NARST)*. Los Angeles, USA.
- Gräber, W. (1998). Schooling for life-long attention to chemistry issues: The role of interest and achievement. In L. Hoffmann, A. Krapp, K. A. Renninger & J. Baumert (Eds.), *Proc. Seeon-Conference on Interest and Gender*. Seeon, Germany: IPN.
- Havighurst, R. J. (1972). *Developmental tasks and education*. New York: D. MacKay.
- Kirschenmann, B., & Bolte, C. (2006). ParIS-Berlin: Bioenergien als Ausgangspunkt für sachgerechtes Urteilen. In A. Pitton (Ed.), *Lehrern und Lernen mit neuen Medien. Zur Didaktik der Physik und Chemie. Probleme und Perspektiven* (pp. 323-325). Münster: Lit.
- Kirschenmann, B., & Bolte, C. (2007a). Chemie (in) der Extra-Klasse zum Thema Bioenergie – Konzeption eines Bildungsangebots für Schüler/-innen der Sekundarstufe II. *Praxis der Naturwissenschaften/Chemie in der Schule*, 56(5), 25-30.
- Kirschenmann, B., & Bolte, C. (2007b). ParIS in Berlin: BILD Dir Deine Meinung... zum Thema Bioenergien. In D. Hötticke (Ed.), *Naturwissenschaftlicher Unterricht im internationalen Vergleich. Zur Didaktik der Physik und Chemie. Probleme und Perspektiven* (pp. 316-318). Münster: Lit.
- Klafki, W. (1995). *Neue Studien zur Bildungstheorie und Didaktik. Beiträge zur kritisch-konstruktiven Didaktik*. Weinheim: Beltz.
- Meyer, M. A. (2006). *Didactics, sense making, and educational experience*. Retrieved November 30, 2006, from University of Hamburg, Faculty of Education Web site: [http://www2.erzwiss.uni-hamburg.de/personal/meyermeinert/didactics\\_ecer.pdf](http://www2.erzwiss.uni-hamburg.de/personal/meyermeinert/didactics_ecer.pdf) (Date: 30.11.2006)
- Schenk, B. (Ed.). (2005). *Bausteine einer Bildungsgangtheorie*. Wiesbaden: VS Verlag.
- Spranger, E. (1921). *Lebensformen – geisteswissenschaftliche Psychologie und Ethik der Persönlichkeit*. Halle: Niemeyer.
- Streller, S., & Bolte, C. (2007). "Chemistry (in) the extra-class": An out-of-school course to enhance students' interest in chemistry. *Paper presented at the Conference of the European Science Education Research Association (ESERA)*. Malmö, Sweden.



# ENHANCING STUDENTS' CREATIVITY AND REASONING SKILLS

Miia Rannikmäe and Anne Laius

University of Tartu, Estonia

## Abstract

*This article explores the need for a paradigm shift in learning environment and the teaching approach in Estonian science classes. In particular, it focuses on the need for teaching to be student-centred, in which a socially derived learning approach enables students to improve their communication and cooperation skills and enhance their positive attitudes towards science learning. As the goal of science education is claimed to be scientific literacy, the teaching emphasises also students' creative and reasoning skills. The aim of this research was to evaluate the impact of science teachers' STL in-service courses and STL teaching on students' creativity and reasoning skills. The research group was formed from 12 chemistry and biology teachers in 8 Estonian schools and their 9th grade students. The results of this research showed that the 8-months STL in-service intervention improved the learning environment of science classes in the direction of the new paradigm as the opinions of students moved in the positive direction on all investigated scales of learning environment and the students' scientific creativity and reasoning skills increased significantly. The outcome of the research was expressed by means of a model based on factor-analysis and correlations between the 6 factors found.*

## Background and Rationale

The study relates to components of scientific literacy, such as problem solving and decision making which are connected to creative thinking and reasoning skills and can be fostered only in relevant and motivating school environments. The study shows that the learning environment needs to be student-centred, in which the socially derived learning environment enables students to improve their communication and cooperation skills and enhance their positive attitudes towards science learning. This change is seen as possible through in-service courses for teachers which introduce teachers to a socio-scientific approach to the teaching of science and requiring different techniques which foster students' different cognitive and affective skills.

This article focuses on the need for a paradigm shift in the learning environment and the teaching approach in Estonian science classes. The study is based on the belief that the enhancement of STL (scientific and technological literacy) is the major goal of science education, where STL is taken to mean developing the ability to utilise sound science knowledge *creatively* in everyday life by *solving problems, making decisions*, and hence improving the quality of life (Holbrook & Rannikmäe, 1997).

The problem solving and decision-making skills require students to develop the skills of reasoning. As argumentation refers to the verbal expression of reasoning, the reasoning skills can be measured through specially created socio-scientific situations with problems or dilemmas in them to argue (Sadler & Fowler, 2006).

Creativity, in the sense of creative thinking, is currently receiving increased attention in education; more and more school curricula now mention it, but the increased interest in creativity has occurred as if without reference to any value framework (Craft, 2006). The concept of creativity is hard to define as creativity may be found in any domain of human activity (Clegg, 2008). The importance of creativity for students, as future citizens, is an important goal advanced by most educators (Edwards & Blake, 2007; Kaufman, 2006). The problem however, is how to get teachers prepared to improve students' creativity in their everyday work in the classroom and to assist their own

development in this area. A supportive learning environment is crucial to students in many ways. Such an environment can be defined as a community with its own culture and values, providing a variety of learning methods and learning-places that support student learning (Ford *et al.*, 1996). The quality of the learning environment shapes the attitudes of both teachers and students and makes a difference to students' learning and higher-order skills, including creativity (Jankowska & Atlay, 2008).

## **Research Methods**

The main goal of this research was to investigate the effectiveness of STL in-service courses in changing the different aspects of the learning environment and increasing the students' creative and reasoning skills.

An in-service course, involving an 8-month intervention on STL teaching was developed for science teachers. This was intended to change the teacher-centred learning environment, which was shown to prevail in Estonian science classes. The research group was formed from 12 voluntary chemistry and biology teachers in 8 different Estonian schools, who were ready to participate in the STL in-service course in 2006 plus their students (N=224).

The in-service course included: (1) Introducing the STL philosophy of in-service courses and setting the scene (Wider goals of science education, meaning of scientific literacy, education through science, meaning of socio-scientific issues, importance relevance, using scenarios for motivation, strategies of student-centred teaching); (2) Interdisciplinary scientific knowledge through a series of lectures and seminars "The modern trends in molecular biology and biomedicine"; (3) Promoting the components of scientific literacy (The reasoning skills and scientific creativity); (4) Implementation in the classroom; (5) Collaborative discussion of implementation outcomes; (6) Promoting ownership towards creating and using the teachers' own teaching materials.

The effectiveness of the course was measured by: (1) Construction of STL teaching materials by integrative teacher teams (biology and chemistry teachers from one school) and also undertaking learning tasks for fostering student creative thinking and their reasoning skills. (2) A pre- and post-test to measure the dynamics of students' scientific creativity and socio-scientific reasoning skills (expressed by argumentation abilities) before and after the teaching of an 8-week STL teaching module. (3) Evaluation of the learning environment in science classes by means of a student survey before and after the intervention.

For fulfilling the aims of the research, the following instruments were used: (a) Students' scientific creativity test (Hu & Adey, 2002); (b) The test of students' argumentation skills; (c) Constructivist Learning Environment Survey (CLES) questionnaire (Instrument Package ..., 1997); (d) Biology test and (e) Chemistry test (For establishing levels the students' scientific knowledge before the intervention).

## **Results and Discussion**

The results of the Constructivist Learning Environment Survey revealed that the STL teaching intervention was effective as the students' opinions about the learning environment (Table 1) became more positive for all measured scales.

**Table 1. Changes of students' opinions about the learning environment**

Scale	Students' opinions Pre-test Mean*(SD) (N=224)	Students' opinions Post-test Mean*(SD) (N=224)	Difference in Means	t-test P
<b>Personal relevance</b>	3.34 (0.57)	3.68 (0.55)	0.34	0.01**
<b>Shared control</b>	2.52 (0.67)	2.68 (0.54)	0.16	0.03**
<b>Student negotiation</b>	2.99 (0.67)	3.31 (0.61)	0.32	0.02**
<b>Attitude</b>	2.84 (0.65s)	3.28 (0.64)	0.44	<0.001***

\* Likert-style responses ranging from “almost never” to “almost always” ranked from 1 to 5 respectively

\*\* Significant difference at the 0.05 level of confidence

\*\*\* Significant difference at the 0.01 level of confidence

According to the results of all students' pre- and post-tests, their argumentation skills (Table 2) and scientific creativity (Table 3) improved significantly during the time of the teacher 8-week STL learning intervention.

**Table 2. The change in students' argumentation skills**

Number of arguments			Quality of arguments			Diversity of arguments		
Pre-test AV (SD)	Post-test AV (SD)	t-test P	Pre-test AV (SD)	Post-test AV (SD)	t-test P	Pre-test AV (SD)	Post-test AV (SD)	t-test P
<b>1.98</b> (0.69)	<b>2.48</b> (0.91)	<0.001**	<b>3.77</b> (0.87)	<b>3.92</b> (0.91)	0.01**	1.74 (0.81)	1.83 (0.78)	0.07

\*\*Significant difference at the 0.01 level of confidence

Based on the outcomes from student responses to test items covering scientific creativity, reasoning, biology knowledge and chemistry knowledge and also outcomes from the learning environment questionnaire, factor-analysis revealed six factors that described 77.1 % of the sample. These factors were named as follows: (1) scientific creativity; (2) reasoning skills (argumentation); (3) biology knowledge; (4) chemistry knowledge; (5) learning environment based on attitude (AT) and student negotiation (SN); (6) learning environment based on personal relevance (PR) and shared control (SC). Expressed as a model based on significant correlations (figure 1), the relationships between the students' scientific creativity and reasoning skills and their dependence upon the learning environment and their biology and chemistry knowledge was illustrated. This model showed the fundamental influence of the learning environment on the students' scientific creativity and reasoning skills that were interlinked through different components. The importance of the learning environment was stressed by the model including the potential impact of a conducive learning environment on problem solving and decision making, interlinking them with both reasoning/argumentation skills and scientific creativity.

Table 3. The change in students' scientific creativity

Items	Pre-test	Post-test	Difference in means	t-test p
<b>I</b> (A task to cover science knowledge and thinking)	17.3	20.0	2.7	0.06
<b>II</b> (A task for measuring the degree of sensitivity to science problems)	19.4	23.0	3.6	0.04*
<b>III</b> (A task of scientific imagination)	10.8	14.2	3.4	0.01*
<b>IV</b> (A science problem-solving task)	4.6	5.8	1.2	0.09
<b>V</b> (Creative experimental ability task)	15.0	20.6	5.6	<0.001**

\*Significant difference at the 0.05 level of confidence

\*\*Significant difference at the 0.01 level of confidence

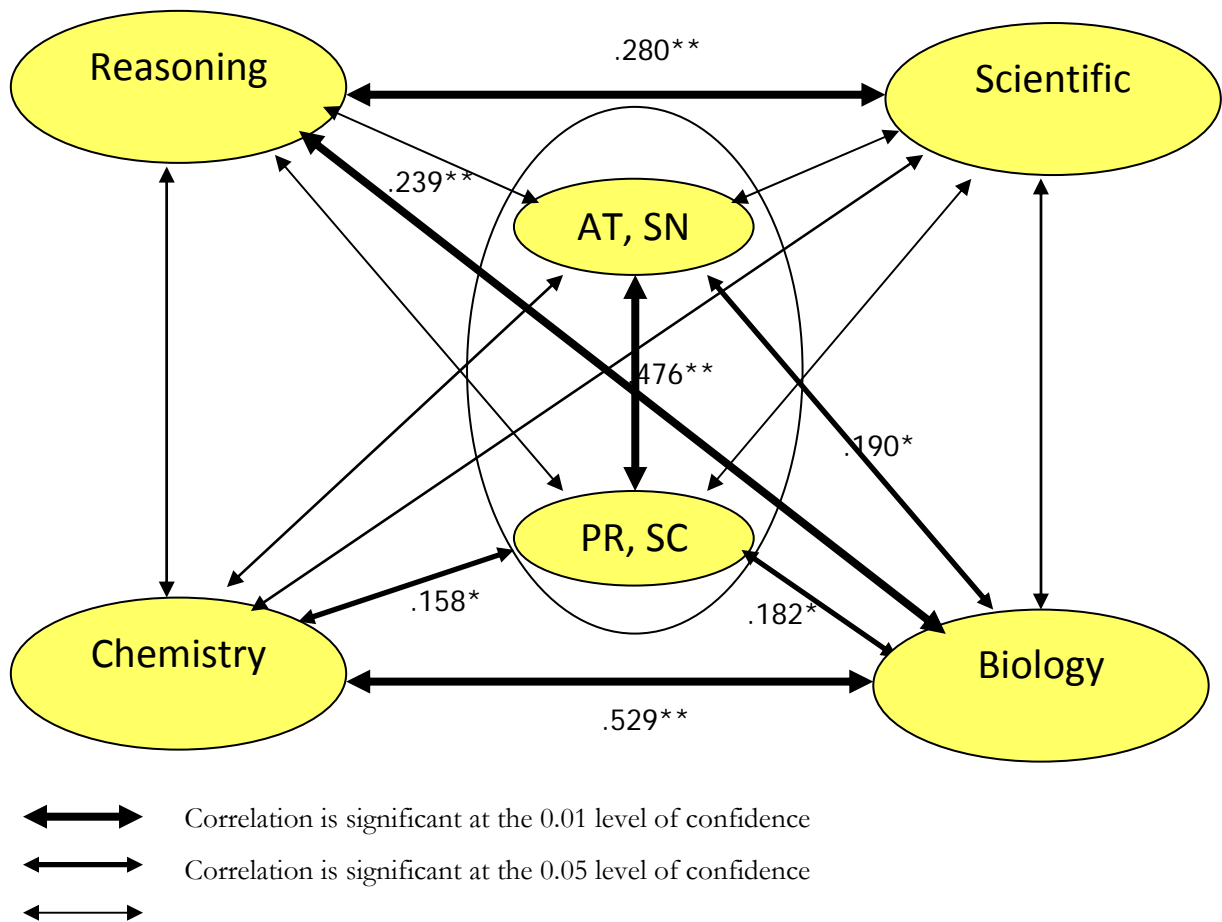


Figure 1. The interrelations between students' scientific creativity and reasoning skills, their scientific knowledge and the learning environment.

The results of the research showed that the use of a STL teaching approach was effective in changing the learning environment and both the teachers' and students' perceptions about science teaching and learning in Estonian science classes. The change in attitudes and the higher level of collaboration and communication in the classroom made it possible to improve students' higher order thinking skills, such as reasoning and scientific creativity. Thus, the paradigm shift towards a student-centred learning environment and the use of a socially derived teaching approach is crucial for improving the students' attitudes towards science learning and thereby to achieve the desired goals of an increased level of students' scientific literacy within its different components.

## References

- Clegg, P. (2008). Creativity and critical thinking in the globalised university. *Innovations in Education and Teaching International*, 45 (3), 219–226.
- Coffin, C. & O'Halloran, K. (2008). Researching argumentation in educational contexts: new directions, new methods. *International Journal of Research & Method in Education*, 31 (3), 219–227.
- Craft, A. (2006). Fostering creativity with wisdom. *Cambridge Journal of Education*, 36 (3), 337 – 350.
- Edwards, G. & Blake, A. (2007). Disciplining the practice of creative inquiry: the suppression of difference in teacher education. *International Journal of Research & Method in Education*, 30 (1), 33–55.
- Ford, P., Goodyear, P., Heseltine, R., Lewis, R., Darby, J., Graves, J., Sartorius, P., Harwood, D. & King, T. (1996). Managing change in higher education: a learning environment architecture. *Society for Research into Higher Education and Open University Press*, USA, 162 p.
- Holbrook, J. & Rannikmäe, M. (1997). Supplementary teaching materials — promoting scientific and technological literacy. ICASE, Tartu, Estonia, 6–32.
- Holvikivi, J. (2007). Logical reasoning ability in engineering students: A case study. *IEEE transactions on education*, 50(4), 367–372.
- Hu, W. & Adey, P. (2002). A scientific creativity test for secondary school students. *International Journal of Science Education*, 24 (4), 389–403.
- Instrument Package & User's Guide. (1997). Secondary science and mathematics teacher preparation programs: influences on new teachers and their students. A supplement to final report of the Salish I Research Project, 18–152.
- Jankowska, M. & Atlay, M. (2008). Use of creative space in enhancing students' engagement. *Innovations in Education and Teaching International*, 45 (3), 271–279.
- Kaufman, J. C. (2006). Self-reported differences in creativity by ethnicity and gender. *Applied Cognitive Psychology*, 20, 1065–1082.
- Sadler, T. & Fowler, R.S. (2006). A threshold model of content knowledge transfer for socioscientific argumentation. *Science Education*, 90, 986–1004.



## ASPECTS OF CRITICAL THINKING RELATED WITH SCIENTIFIC LITERACY

Alice Rodrigues  
University of Lisbon

Maurícia Oliveira  
University of Lisbon

### Abstract

*Scientific literacy and critical thinking are two areas of major importance in science education that are even aims of the science curricula at national and international level. Several authors argue that they are conceptually related. Nevertheless, there is a lack of empirical studies to prove it. Therefore, believing that teachers need empirical evidence that it deserves to promote critical thinking in order to achieve scientific literacy and yet, that it is useful to enlighten which critical thinking aspects influence pupils' scientific literacy and in what direction and extent this influence occurs, a research study was developed. A cross-national sample was defined following a stratified group model, considering as groups the NUTS II and the schools. The sample was constituted by 1156 pupils of the 9th grade (545 male and 611 female) pertaining to 21 schools from all 7 Portuguese NUTS II. The Cornell Critical Thinking Test (level X) and a pool of activities intended to assess scientific literacy were used as sources of data. The results point out that critical thinking is a predictor of a high level of scientific literacy. Also, the critical thinking aspects of deduction and induction have a significant and positive influence on pupils' scientific literacy. Some conclusions and implications regarding science curriculum and science teacher practices can be drawn.*

### Introduction

Nowadays it exists an international agreement concerning the importance to develop scientific literacy in science education. This is clearly stated in many curricula at international level, several of them inspired on National Science Education Standards (National Research Council, 1996).

Another major goal of today's school education is critical thinking that, according to several authors, is conceptually related with scientific literacy. In fact, the definitions of scientific literacy seem all to point out the importance of being a critical thinker in order to be scientific literate.

Nevertheless, there is a lack of empirical studies to prove that those two concepts are related. Therefore, believing that teachers need empirical evidence that it deserves to promote critical thinking in order to achieve scientific literacy and yet, that it is useful to enlighten which critical thinking aspects influence pupils' scientific literacy, a research study was developed.

The study hypothesis were: 1) the critical thinking level is not a predictor of pupils' performance in scientific literacy; 2) there are no significant statistic differences in the way that different critical thinking aspects influence pupils' scientific literacy.

## Rationale

Critical thinking and scientific literacy frequently appear related in research papers concerning those two areas of research. Since Dewey, who is thought by some authors “to have triggered the scientific literacy movement, or at least to have launched the initial efforts to assess in individuals something akin to what would later come to be known as scientific literacy” (Shamos, 1995, p. 80-81), several authors argue that critical thinking and scientific literacy are conceptually related, being critical thinking fundamental to scientific literacy. As Ten Dam and Volman (2004) affirm, “to be critical” seems to be part of our western culture” (p. 360). And, according to the same authors, schools must prepare students to participate in society as citizens, making choices and knowing why they make those choices, respecting the choices and opinions of others, communicating about these and thereby forming their own opinion, and making it known. Indeed the same behavior is expected from a scientifically literate person.

Nevertheless, to defend that critical thinking is fundamental to scientific literacy it is crucial that this two key-terms are first clearly defined. In the context of this study, it was decided to adopt the OECD (2007, p.12) definition of scientific literacy that was used in the PISA 2006 study. According to this source scientific literacy is the extent to which an individual:

- Possesses scientific knowledge and uses that knowledge to identify questions, acquire new knowledge, explain scientific phenomena and draw evidence-based conclusions about science-related issues.
- Understands the characteristic features of science as a form of human knowledge and enquiry.
- Shows awareness of how science and technology shape our material, intellectual and cultural environments.
- Engages in science-related issues and with the ideas of science, as a reflective citizen.

Regarding critical thinking, it was decided to adopt the Robert Ennis definition of the term that in broader terms states that, “critical thinking is a process, the goal of which is to make reasonable decisions about what to believe and what to do” (Ennis, 1996, p. xvii). According to the same author, critical thinking involves dispositions and areas of abilities, namely, elementary and advanced clarification; basic support; inference and, strategies and tactics.

Unfortunately, the terms “scientific literacy” and “critical thinking” are often used as slogans by many. For example, Bybee (1997) is one of the authors that claim that the term scientific literacy is misused. Also, with critical thinking we witness a similar phenomenon, although to a lesser extent. Indeed, these concepts come into the educational language without teachers understanding what they mean or what are the best teaching practices to pursue these goals or yet, what are their implications for teaching and learning science. For many, the terms “scientific literacy” and “critical thinking” just corresponds to the meaning they attach to them in terms of common sense. Indeed, it is believed that there is some misinformation on critical thinking and scientific literacy which leads to unsuccessful efforts in teaching.

According to a report published by UNESCO in 2001, teachers have not given much attention to higher order thinking skills, which naturally include critical thinking, because of:

- (a) Their belief that higher order thinking skills are part of a hierarchy skills and cannot be acquired until lower order skills have been mastered;
- (b) Their unwillingness to allow sufficient thinking time for students (p. 19).

As a matter of fact, research has been saying that science classes are still strongly teacher directed. The teaching and learning model used is mainly the transmissive model, which do not foster neither the critical thinking nor scientific literacy. Consequently, it is not odd that when pupils’ scientific literacy is assessed in studies, like PISA, in countries like Portugal when this kind of thinking and practices is still a reality; that the results come to show a sad scenario. In spite of the fact, that the Portuguese science curricula clearly states as it main goal to



promote scientific literacy, Portugal was classified statistically significantly below the OECD average in the league tables regarding scientific literacy in PISA study in 2000, 2003 and 2006.

Therefore, it urges to act at three different levels, the research level and the pre-service and in-service science teacher training to ensure that the knowledge and information regarding these two areas reach who really matters.

## Methods

The research follows an *ex post facto* design. A cross-national sample of 1156 pupils of the 9th grade (545 male and 611 female), that is, pupils who are concluding the compulsory school, with an average age of 14.7, pertaining to 60 classes from 21 different schools and from all seven NUTS II of the country (Nomenclature of Territorial Units for Statistics II), was constituted following a stratified group model.

Two main instruments were used to collect data, namely, the Cornell Critical Thinking Test - level X (Ennis and Millman, 1985) to assess pupils' critical thinking level and aspects and a set of science activities, specially validated for the study, to assess pupils' performance in scientific literacy. The data were personally collected by one of the researchers during classes with the presence of one of the pupils' teachers, in order to get pupils' full collaboration.

The set of science activities that were used to assess pupils' scientific literacy was the product that emerged from a validation study to the Portuguese reality of a pool of released science units selected and adapted from the OECD reports regarding the PISA 2000, 2003 and 2006 study. An exploratory followed by a confirmatory factor analyses performed to the scale used to assess pupils' scientific literacy reveal that the items fall in two dimensions or factors, namely, higher order thinking skills infused into scientific knowledge and attitudes toward science.

The data was analysed using the statistic software SPSS 16.0.

In order to first explore the data, a t-test was done to find out if there is a significant difference in the mean of the level of critical thinking for the groups' high and low performance in scientific literacy activities. The groups were previously created considering three equal percentiles. The middle group was neglected for effects of analysis. The effect size was calculated using the statistics eta squared.

Aiming to test the first hypothesis of the study a linear regression was performed for the variables pupils' critical thinking level and pupils' performance in scientific literacy considering this last variable as the dependent one.

A standard multiple regression was performed to test the second hypothesis. The pupils' performance in scientific literacy was considered the dependent variable and the aspects of critical thinking, the independent variables. Preliminary analyses were conducted to ensure no violation of the assumptions of normality, linearity, multicollinearity and homoscedasticity.

## Results

The results of the independent-samples t-test conducted reveal that there is a significant difference in the mean of the level of critical thinking for the group of low performance in scientific literacy activities ( $M = 16.390$ ,  $SD = 9.83$ ) and for the group of high performance in scientific literacy ( $M = 21.527$ ,  $SD = 10.98$ );  $t(591) = -5.85$   $p < 0.0005$  (two-tailed). The magnitude of the differences in the means (mean difference =  $-5.137$ , 95% CI:  $-6.86$  to  $-3.41$ ) is in the frontier between the small and the moderate (eta squared = 0.055).

Concerning the first hypothesis of the study, the results of the linear regression performed reveal that 3.5 % of the variance in pupils' performance in scientific literacy is explained by pupils' critical thinking level. In fact,  $R$  for regression was significantly different from zero, that is,  $F(1, 887) = 32.19$ ,  $p < 0.0005$ , with  $R^2$  at 0.035. The adjusted

$R^2$  value is 0.034, which indicates that 3.4 % of the variability in pupils' performance in scientific literacy is predicted by the critical thinking level. The unstandardized coefficient  $B$  is 0.104 ( $SE = 0.018$ ) and the standardized coefficient  $\beta$  is 0.187 with  $p < 0.0005$ .

Regarding the second hypothesis of the study the results of the evaluation of assumptions show that they were not violated. The results of the standard multiple regressions used to assess if critical thinking aspects (induction, deduction, observation, credibility and assumptions) are predictors of the pupils' performance in scientific literacy show that 4.3 % of the variability in pupils' performance in scientific literacy is predicted by the critical thinking aspects. In fact,  $R$  for regression was significantly different from zero,  $F(4, 884) = 10.02$ ,  $p < 0.0005$ , with  $R^2$  at 0.043. The adjusted  $R^2$  value is 0.039.

The results regarding each one of the critical thinking aspects show that deduction, followed by induction seem to play the more important role as indicated by the unstandardized regression coefficients. For deduction  $\beta = 0.204$  ( $p < 0.0005$ ) for induction  $\beta = 0.068$  ( $p = 0.05$ ).

## Conclusions and Implications

The results point out that critical thinking level is predictor of the pupils' performance in scientific literacy. The results of the independent samples t-test reinforced by the linear regression performed between pupils' critical thinking level and pupils' performance in scientific literacy come to confirm the theory and the authors' convictions.

In spite of the fact that only 3.5 % of the variance in pupils' performance in scientific literacy is explained by pupils' critical thinking level, it should be considered that scientific literacy is a very complex variable. In fact, a large amount of other variables, including reading literacy and mathematical literacy influence pupils' performance in scientific literacy. Therefore, if critical thinking is one of the variables that can contribute to improve pupils' scientific literacy, we think that the intended curricula and the implemented curriculum must appeal in an explicit and intentional way to critical thinking infused into science contents.

This relation between critical thinking and performance in scientific literacy activities comes to confirm the authors' idea that it does not make sense to enhance critical thinking and scientific literacy separately in science classes. They should be learned and taught intertwined thru strategies and activities specially designed to meet the purpose.

Finally, and since, according to the results, the critical thinking aspects of deduction and induction are the most important aspects of critical thinking responsible for a good performance in scientific literacy, the learning activities and teaching strategies to implement in science classes should focus especially these two critical thinking aspects.

## References

- Bybee, R. W. (1997). *Achieving scientific literacy: from purposes to practices*. Portsmouth, NH: Heinemann.
- Ennis, R. H. (1996). *Critical Thinking*. New Jersey: Prentice-Hall.
- Ennis, R. H. & Millman, J. (1985). *Cornell critical thinking test, level X*. Pacific Grove, CA: Midwest Publications.
- National Research Council (1996). *National Science Education Standards*. Washington DC: National Academy Press.
- OECD (2007). *PISA 2006: Science competencies for tomorrow's World – executive summary*. Paris: OECD Publications.
- Shamos, M. H. (1995). *The myth of scientific literacy*. New Brunswick: Rutgers University Press.
- Ten Dam, G. & Volman, M. (2004). Critical thinking as a citizenship competence: teaching strategies. *Learning and Instruction*, 14.
- UNESCO (2001). *The training of trainers manual for promoting scientific and technological literacy (STL) for all*. Bangkok, Thailand: UNESCO.

# SOCIOSCIENTIFIC ISSUES, ARGUMENTATION AND CONCEPTUAL UNDERSTANDING IN HIGH SCHOOL GENETICS

Vaile Dawson  
Curtin University

Grady Venville  
University of Western Australia

## Abstract

*The purpose of this research was to explore the impact of classroom argumentation about socio-scientific issues on high school students': 1. argumentation skills; 2. informal reasoning; and, 3, understanding of genetics. The research design was a multiple case study conducted in three schools. Each case study had a quasi-experiment embedded in the design with an intervention where the teachers embedded argumentation in the genetics course. Experimental classes in each case study implemented the intervention and comparison classes did not implement the intervention. Data collection included a pre-post-instruction survey, classroom observations, and teacher and student interviews. The results indicated that for all three cases the students who participated in the classroom argumentation improved on average significantly better than students who did not participate in classroom argumentation in argumentation skills, informal reasoning and, for two of the three case studies, improved significantly more in genetics understanding.*

## Introduction

It is essential that high school students have the opportunity to be involved in cutting edge debate about science topics that are of relevance and importance to them and the society in which they live (Driver, Newton & Osborne, 2000). They should be able to voice their well-informed opinions based on sound scientific understandings, demonstrate logical patterns of reasoning and support their arguments with scientific evidence (Sadler & Zeidler, 2005a; 2005b). Underpinning this rhetoric is the assumption that there is a reciprocal and positive relationship between the process of argumentation and student understanding of science (Sadler, & Fowler, 2006). It is assumed that student involvement in relevant, real-world argumentation is likely to contribute to understanding. In turn, it is assumed that an understanding of science is essential for students to develop quality arguments.

The term 'argumentation' is used to refer to a process of debate and structured discussion to reason about problems. Toulmin (1958) developed a model that can be used to teach students (and their teachers) the skills of argumentation and to analyze or evaluate students' argumentation about socioscientific issues. A review of research related to argumentation in science education (Sadler, 2004) revealed that the interaction between conceptual understanding and argumentation is by no means clear or straightforward. Some studies that were reviewed showed a positive relationship between reasoning and conceptual understanding while others did not. These studies, Sadler argued, provide confounding information with regard to questions about whether students in high school science classrooms can engage in meaningful argumentation about socioscientific issues, whether this process improves their understanding of the science content under consideration and, conversely, what degree of understanding is adequate for participation in the process of argumentation?

Socioscientific issues are scientific topics where individuals and groups within our society hold a range of conflicting (sometimes mutually exclusive) viewpoints. Decisions about these issues may have social, ethical, political and economic implications. Young people need to be informed, not only about the practical applications of science, but they need to be aware of the complexity of the issues so that they can become informed decision makers in the future. Examples of socioscientific issues that are likely to impact on the lives of young people now, and in the future, include climate change, sustainable development, food and energy resources, health care allocation and population control. On a personal level young people need to be able to make informed choices by evaluating the risks and benefits of using mobile phones, reproductive control and eating genetically modified foods.

## **Rationale**

The purpose of this research was to explore the interaction between high school students' argumentation skills and informal reasoning about a socioscientific issue and conceptual understanding of genetics. Genetics education was selected as the context in this study for three reasons. First, advances in the field of genetics have led to concerns about some applications in our society. Socioscientific issues related to genetics include the production and consumption of genetically modified (GM) foods, the development of 'designer babies' or 'saviour siblings' where pre-implantation genetic testing is used to select embryos free of particular genetic disorders, and genetic susceptibility testing for insurance and employment purposes. The second reason for focusing on the topic of genetics is technical. In Western Australia, where the research was conducted, genetics is mandated in our science curriculum documents and genetics is typically taught in year 10, the final year of compulsory science. Thus, it was anticipated that the findings would be relevant and of interest to many science teachers. Third, our discussions with science teachers have indicated that they are concerned about how to deal with the unavoidable issues that arise when teaching students about diagnosis, prevention and treatment of genetic diseases.

The findings presented in this paper form part of a larger research study conducted by the authors. The research questions addressed in this paper are:

1. How does an intervention based on argumentation impact on the structure of Year 10 students' argumentation and type of informal reasoning about a genetics socio-scientific issue?
2. How does an intervention based on argumentation impact on Year 10 students' understanding of genetics?

In the conclusion we discuss some of the methodological issues arising from this study and propose suggestions for those involved in similar classroom based research.

## **Methods**

The research method was a multiple case study (Stake, 2006) with mixed methods of data collection (Cresswell & Plano Clark, 2007). The study utilized both qualitative and quantitative data sources. The research was conducted as three case studies in three schools with four science teachers and their year 9 or 10 students (13-15 years old) who were studying genetics. Each of the four teachers participated in a professional learning session on argumentation, decision-making and socioscientific issues in genetics. These teachers then explicitly modeled and taught argumentation skills to their students over several lessons. The teachers introduced students to the parts of an argument including claims, data, warrants, backings, qualifiers and rebuttals. Working individually, the students then used writing frames about two socioscientific issues. The writing frames contained prompt questions designed to scaffold the structure of an argument. Students also participated in whole class discussions and small group work to develop and justify decisions about socioscientific issues related to genetically modified foods and cystic fibrosis (Dawson and Venville, 2008).

## Sample

Details of the school type, teachers' backgrounds and experience, professional learning, classroom intervention, genetics topics and data sources for each of the three cases are summarised in Table 1.

## Data sources and analysis

A quasi-experimental design with a pre- and posttest was used to examine the effect of teaching argumentation on students' argumentation skills, informal reasoning type and understanding of genetics. The students in the experimental group were taught genetics and argumentation by teachers who participated in the professional learning while the comparison group were taught the same genetics topic by teachers from the same schools who had not participated in the professional learning and did not teach argumentation.

Argumentation and informal reasoning skills were measured before and after studying genetics by analysing students' written responses to a socioscientific issue on designer babies (research question 1). Students were presented with a scenario where it was possible to create a disease free designer baby for a cost of \$10000 (see Appendix A). Students were asked whether the procedure should be allowed and were offered choices of 'yes', 'no' or 'I don't know.' They were then asked to write as many reasons as possible to justify their decision.

The students' written responses were analysed using two methods. To determine the complexity of the argument used by each student, a classification scheme based on Toulmin's argumentation pattern (TAP) was used (Dawson & Venville, 2009). Students' written arguments were assigned a level or score from 0 to 4 depending on the presence of claims (decision only), data (evidence to support claim), warrants (relating data to claim), backings (assumptions to support data/warrant) and qualifiers (conditions under which claims or data are true). Level 1 arguments consisted of a claim only; level 2 arguments comprised a claim, data and/or warrant; level 3 arguments included a claim, data, warrant, backing or qualifier; and Level 4 arguments included a claim, data, warrant, backing and qualifier. No response was scored as a 0.

In order to determine the type of informal reasoning used by the students, a method previously used by Sadler & Zeidler (2005a) and Dawson and Venville (2009) was used. Students' responses were classified as rational (logical, using correct scientific language, evaluating risk), emotive (care, empathy, concern for others) or intuitive (gut response, personal). The responses were scored as rational (a score of 3), emotive (a score of 2) or intuitive (a score of 1). All student responses for argumentation and informal reasoning were coded blind by two researchers. Pre- and posttest scores for all students were entered into an SPSS database and analysed statistically. Differences in pre- and posttest scores for argumentation and informal reasoning were analysed statistically using a Wilcoxon Signed Rank Test while differences between the experimental and the comparison groups were analysed using a Mann-Whitney U Test.

The conceptual understanding part of the survey was made up of 18 multiple choice items and three short answer items that probed students' understanding of genetics concepts (research question 2). The maximum score for the test was 52. The short answer items probed students' understanding of the relationships between genetics concepts such as DNA, genes and chromosomes as well as their ability to understand the principles of inheritance. Differences between the pre and post scores for the experimental and comparison groups were analysed using a repeated measures ANOVA.

**Table 1** Brief description of case studies

	<b>CASE STUDY 1</b>	<b>CASE STUDY 2</b>	<b>CASE STUDY 3</b>
<b>School Description</b>	•Co-educational catholic independent	•Co-educational catholic independent	•Co-educational wholly government funded
<b>Experimental group Teacher/s</b>	•Male biology teacher (19 years experience)	•Female biology teacher (7 years experience )	•Female biology teacher (7 years experience) •Female, non-biology major teacher (15 years experience)
<b>Comparison group teachers</b>	<ul style="list-style-type: none"> <li>• Male biology teacher (7 years experience)</li> <li>• Male biology teacher (5 years experience)</li> </ul>	<ul style="list-style-type: none"> <li>• Male biology teacher (8 years experience)</li> </ul>	Female biology teacher (1 year experience)
<b>Intervention group</b>	Year 10 n=46	Year 9 n= 23	Year 10 n= 58
<b>Comparison group</b>	Year 10 n=46	Year 9 n=50	Year 10 n=21
<b>Professional learning</b>	Brief (90 minute) professional learning on socioscientific issues, argumentation, decision-making	Two days on genetic diseases, socioscientific issues, argumentation, decision-making	Two days on genetic diseases, socioscientific issues, argumentation, decision-making
<b>Classroom Intervention</b>	<ul style="list-style-type: none"> <li>•2 x 50 minute lessons including small group and whole class argumentation</li> <li>•Writing frames</li> </ul>	<ul style="list-style-type: none"> <li>•3 x 50 minute lessons including small group and whole class argumentation</li> <li>•Writing frames</li> </ul>	<ul style="list-style-type: none"> <li>•2 x 50 minute lessons including small group and whole class argumentation</li> <li>•Writing frames</li> </ul>
<b>Genetics topic</b>	40 lessons, cells, inheritance, genetics, genetic diseases	24 lessons, cells, reproduction, genetic variation, inheritance, ethical issues	28 lessons, reproduction, inheritance, genetic variation, natural selection, ethical issues
<b>Data sources</b>	<ul style="list-style-type: none"> <li>•Pre/post survey</li> <li>•Classroom observation</li> <li>•Post student interviews</li> <li>•Post teacher interviews</li> <li>•Writing frames</li> <li>•Teacher's plans</li> </ul>	<ul style="list-style-type: none"> <li>•Pre/post survey</li> <li>•Classroom observation</li> <li>•Post student interviews</li> <li>•Post teacher interviews</li> <li>•Writing frames</li> <li>•Teacher's plans</li> </ul>	<ul style="list-style-type: none"> <li>•Pre/post survey</li> <li>Writing frames</li> <li>•Teachers' plans</li> </ul>

## Results

### Argumentation Quality

In each of the three cases, the quality of argumentation for the experimental group and the comparison group were compared pre and post-instruction. Overall, it was found that the incidence of Level 1 (claim only) and Level 2 (claim, data and/or warrants) arguments were the most common in both experimental and comparison groups before instruction. The experimental groups, however, showed greater increases in Level 3 and Level 4 arguments compared with the comparison groups who only showed a very small or no increase in Level 3 and Level 4 argument.

A Wilcoxon Signed Rank Test showed that the improvement in argumentation in all three experimental groups from pre-instruction to post instruction was significant. (case study 1,  $p < .001$ , case study 2,  $p < .05$ , case study 3 ( $p < .05$ ). There was no significant improvement in the comparison groups in case study 1 and 3 but there was a slight improvement in case study 2 ( $p < .05$ ). A Mann-Whitney U Test showed post unit scores for the experimental groups in case study 1 and 3 were significantly better than for the comparison groups (case study 1,  $p < .01$ , case study 3,  $p < .01$ ). A result was not possible for case study 2 because the experimental and comparison samples were not equivalent.

The following example from a student in the experimental group in case study 2 illustrates the improvement in argumentation from pre to post instruction.

*Student 74 Pre – I don't know. I think it should be allowed to take out genetic diseases but not to make your baby different looking (Level 1, claim only)*

*Student 74 Post – I don't know (claim) because in some ways it is right in being able to take out genes for genetic disorders because it will save the parents and child a lot of pain (data). I think you shouldn't be able to change things such as sex, intelligence, height and hair colour (qualifier) because it shouldn't be the parent's decision and is interfering with nature (data). If everyone had designer babies then a lot of people's hair colour, height etc would be the same and not unique to a person and special (backing). (Level 4)*

### Informal Reasoning Type

In each of the three cases, patterns of informal reasoning for the experimental groups and the comparison groups were compared pre and post-instruction. It was found that the incidence of rational informal reasoning increased post-instruction in all three experimental groups. A Wilcoxon Signed Rank Test showed the improvement in the experimental groups from pre-instruction to post instruction was significant in all three cases (case study 1,  $p < .01$ , case study 2,  $p < .05$ , and case study 3,  $p < .05$ ). There was no significant improvement in informal reasoning in the three comparison groups.

A Mann-Whitney U Test showed post unit scores for the experimental groups in case study 1 and 3 were significantly better than for the comparison groups (case study 1,  $p < .05$ , case study 3,  $p < .001$ ). A result was not possible for case study 2 because the experimental and comparison samples were not equivalent.

The following two examples from the experimental group in case study 2 illustrate the change in informal reasoning from pre to post instruction.

*Student 68 Pre – No. because it is not right to play God. (intuitive)*

*Student 68 Post – No. There may be serious errors if the baby doesn't develop properly and ends up with a disorder and it is not right to play God and you shouldn't do this because it has not been tested and they aren't 100% sure it will be disease free. (rational/intuitive)*

*Student 66 Pre – No. I think the baby should be naturally born because the average parent would want their son/ daughter to look like them. (emotive)*

*Student 66 Post – Yes. This discovery (sic) could be the cure for cancer and diseases. Only the rich would be able to afford this designer babies project (sic). Scientists need to do a lot of research to analyse (sic) the risks involved. (rational)*

### Conceptual Understanding

A repeated measures ANOVA indicated that the students' mean genetics scores in all three experimental groups and comparison groups from case study 1 and 2 did improve significantly over time, ( $p < .001$ ), which would be expected because the students were studying genetics during the period between the pre-unit and post-unit surveys. It is of concern that the comparison group in case study 3 did not improve despite the students studying the same genetics topic as the experimental group. The repeated measures ANOVA indicated that the gain in the experimental groups' mean scores was significantly more than the gain in the comparison groups' mean scores for case study 1 ( $p < .05$ ) and case study 3 ( $p < .001$ ). There was no significant difference between the experimental and

comparison group in case study 2. It is worth noting, however, that the students in the experimental group in case study 2 were very social and talkative. The mean scores and standard deviation before and after studying genetics for the experimental and comparison groups in each of the three cases are summarized in Table 2 below.

**Table 2 Descriptive statistics for the pre-instruction and post instruction genetics knowledge scores for the comparison and experimental groups.**

Group treatment	Time	Case study 1		Case study 2		Case study 3	
		Mean (of 52)	SD	Mean	SD	Mean	SD
Comparison	Pre-instruction	10.70	4.34	8.55	3.56	7.81	3.52
	Post-instruction	17.74	8.98	17.92	8.82	8.81	5.61
Experimental	Pre-instruction	12.52	5.76	7.15	2.60	7.91	3.69
	Post-instruction	22.50	7.99	15.60	7.17	16.48	6.22

## Conclusions and Implications

The results of this research demonstrate that, in all three case studies, an intervention that included teacher professional development on argumentation, socioscientific issues and decision-making followed by explicit instruction on argumentation in students' genetics classes resulted in students significantly improving their quality of argumentation and using a rational type of informal reasoning about a genetics socioscientific issue. These findings are significant as they indicate that a targeted professional development session and a brief classroom intervention can improve students' argumentation skills and change their informal reasoning type from intuitive and emotive to rational. In two of the three cases the students who were taught argumentation skills improved their genetics knowledge significantly more than the comparison group. This finding indicates that development of argumentation skills may promote conceptual understanding.

There are several methodological issues and questions related to this research study which should be considered. These issues are:

1. Different teachers taught the experimental and comparison groups in each case study.
2. Students were not randomly assigned to groups.
3. The intervention was similar but different across cases.
4. The intervention was modest.
5. Students' argumentation skills and informal reasoning were determined through written responses.
6. Is change in argumentation sustained and/or transferable to different contexts?

The methodological issues arising out of this study are largely due to the nature of school structures. As researchers working in schools we are ethically obliged to cause minimal disruption to both teachers and students.



In Western Australia, where the study was conducted, students attend high school in years 8 to 12 (about 12-17 years of age). High school science teachers usually specialize in biology, chemistry or physics in their university studies and will teach in their specialty area in years 11 and 12. In years 8 to 10 science teachers typically teach all science topics (biology, chemistry, physics and earth science) and remain with the same students over a whole school year. The four teachers who participated in the professional learning and taught argumentation skills to their students were biology specialists who had volunteered to participate after being approached by the researchers. In this study, we made every effort to ensure that the experimental and comparison groups were comparable. In each case, both groups attended the same school, studied the same genetics topic for the same length of time in the same year, and were taught by biology specialists.

However, it is still possible that differences in the experimental and comparison groups in regard to genetics understanding are due, in part, to the expertise of the teachers. We endeavoured to reduce the effect of this variable by selecting comparison group teachers who were biology specialists. We could not control for years of experience. To address this issue, in 2009, we identified two schools where year 10 students changed teachers each term so that they were all taught genetics by the same biology specialist. We have recently completed a further three case studies with three teachers from these schools using a similar quasi-experimental design where both the experimental group and the comparison groups were taught genetics by the same teacher. In each case, the teacher taught a genetics topic to the comparison group and then participated in a brief professional development session on argumentation, socioscientific issues and decision-making. The teachers then taught the same genetics topic, with the addition of the argumentation lessons, to the experimental group. At the time of writing, data analysis is underway.

An alternative explanation for improved genetics understanding in the experimental groups of case study 1 and 3 is that the students in this group were more academically able than students in the comparison groups. The structure of schools is such that it is not possible to randomly assign students and teachers to experimental or comparison groups. While the mean genetics understanding scores for each group before studying genetics indicates that there were no significant differences, we can not exclude this possibility.

In each of the three case studies reported here, the four teachers participated in similar professional learning experiences of varying lengths and then designed and implemented their argumentation lessons using the writing frames and lesson plans that were supplied by the researchers. Each of the teachers differed in the approach taken. It is not possible to determine how this variation affected students' argumentation skills.

The argumentation intervention was brief and it is possible that a more sustained intervention may have produced more conclusive results. In the three case studies, the argumentation lessons with the experimental group were conducted over 2-3 lessons during a genetics topic of 24-40 lessons. During that time the comparison group continued to study their genetics content. At the end of the topic, both groups completed formal school examinations on genetics content. We did not want to risk disadvantaging the experimental group by prolonging the intervention because they needed to complete the same amount of genetics content.

In this study, students' argumentation quality and informal reasoning type were determined through an individual written response to a genetics socioscientific issue about a designer baby. It is not known whether students' written responses are indicative of their ability to construct a verbal argument either within their science classes or in other contexts.

Finally, a desired outcome of developing students' argumentation skills is that students will use these skills when evaluating and justifying decisions about socioscientific issues they encounter later in life. Thus, any improvement in argumentation skills or change in informal reasoning type would need to be both sustained and transferable to new contexts. In late 2009, we will be re-testing students nine months after an argumentation intervention to determine students' argumentation skills and reasoning type using a different genetics socioscientific issue and an environmental socioscientific issue.

## References

- Cresswell, J. W. & Plano Clark, V. L. (2007). *Designing and conducting mixed methods research*. Thousand Oaks, CA: Sage.
- Dawson, V.M., & Venville, G. (2009). High school students' informal reasoning and argumentation about biotechnology: An indicator of scientific literacy? *International Journal of Science Education*, 31(11), 1421-1445.
- Dawson, V.M. & Venville, G. (2008). Teaching strategies for developing students' argumentation skills about socioscientific issues in high school genetics. *Research in Science Education*. [Online]
- Driver, R. Newton, P. & Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science Education*, 84(3), 287-312.
- Osborne, J., Erduran, S., & Simon, S. (2004b). Enhancing the quality of argumentation in school science. *Journal of Research in Science Teaching*, 41(10), 994-1020.
- Sadler, T. D., & Fowler, S. R. (2006). A threshold model of content knowledge transfer for socioscientific argumentation. *Science Education*, 90, (6), 986-1004.
- Sadler, T.D. & Zeidler, D.L. (2005a). Patterns of informal reasoning in the context of socioscientific decision-making. *Journal of Research in Science Teaching*, 42(1), 112-138.
- Sadler, T.D. & Zeidler, D.L. (2005b). The significance of content knowledge for informal reasoning regarding socioscientific issues: Applying genetics knowledge to genetic engineering issues. *Science Education*, 89(1), 71-93.
- Sadler, T.D. (2004). Informal reasoning regarding socioscientific issues: A critical review of research. *Journal of Research in Science Teaching*, 41(5), 513-536.
- Simon, S., Erduran, S. & Osborne, J. (2006). Learning to teach argumentation: Research and development in the science classroom. *International Journal of Science Education*, 28,(2-3), 235-260.
- Stake, R. E. (2006). *Multiple case study analysis*. New York: The Guilford Press.
- Toulmin, S. (1958). *The uses of argument*. Cambridge, England: Cambridge University Press.

## Appendix A

A Sydney IVF clinic has recently been offering to produce 'designer babies' for parents. For just \$10,000 the clinic will check and, if necessary, change the parent's genes in order to produce the baby of their choice. Once selected, the baby develops normally inside the mother. The choice at the moment is limited to sex, intelligence, height and hair colour but a spokesperson said that several other features would soon be available. All 'designer babies' are guaranteed free from identifiable genetic diseases.

*Do you think this use of gene technology should be allowed?*

Write as many reasons as you can to support your answer.

**PART 3**  
**ENVIRONMENTAL EDUCATION**



# SCHOOL GOES TO THE FARM: CONCEPTUALISATION OF RURAL-BASED SUSTAINABILITY EDUCATION

Helmi Risku-Norja and Elli Korpela  
MTT – AgriFood Research Finland

## Abstract

*'School Goes to the Farm' activities are aimed at promoting socio-cultural sustainability and education for sustainable development (EfSD) by improving knowledge among children and youth about the relationship between nature and culture and about the role of rural areas in the society. This is done by developing local co-operation between schools, farms and the regional nature centres. The experiences show that the local school-farm co-operation is an interesting possibility both for the schools and for the farms. Rural-based EfSD excellently meets the needs of contextual, comprehensive and experiential learning. Farms can be exploited as a learning environment in several of the school subjects, and the activity is especially well suited for concretising the goals of the cross-curricular themes. The way the pupils learn in the farm cannot be substituted with learning from books or in the classroom. Complying with the goals of the cross-boundary approach of the national curriculum for basic education it is also easily justified with educational arguments. This article captures the background and set-up of a pilot project. The premise of is discussed on the basis of teachers' and pupils' experiences, and a conceptual model of the contextual approach of rural-based EfSD is presented.*

## Introduction

The schools should provide the pupils with basic knowledge and skills in various school subjects, and at the same time they have to keep pace with the information flow. With the knowledge increasing at an accelerating tempo, this alone is already a mighty challenge. In addition, schools are exposed to new educational demands. This is because modern life also requires dialogue between school and society, and information needs to be considered in relation to the social reality the school is part of.

The overriding challenge is to address current social, cultural, economic and environmental problems that are evident at scales ranging from local to global. The concept "Sustainable Development" (SD) has been introduced to integrate the issues concerning environment, society, culture and economy. SD can be defined as environmental, economic and social well-being for today and tomorrow, it is a worldwide process aimed at securing the prerequisites of good life for the present and coming generations, and in decision-making and activities endeavouring equally to account for the environment, people and economy (WCED, 1987).

Changing the present way of life and adopting more sustainable life styles requires improved understanding of the concept sustainable development. Both the Johannesburg Summit (UN, 2006) and the Millennium approach (Millennium Ecosystem Assessment, 2008) emphasize the role of active citizenship and public awareness in responding to the quest of ecosystem and human health, prosperity and participation. Stemming from this the school is confronted with a new task of coaching the pupils towards active citizenship. The pupils should have attitudes, skills and knowledge to make informed decisions that comply with the aims of sustainable development, and they should also be capable of acting upon these decisions.

The UN has dedicated the on-going decade, 2005-2014, for Education for Sustainable Development (EfSD). The motion stresses the crucial role of education in promoting SD, and emphasises the profound need to integrate the principles, values and practices of SD into education and learning at all educational levels (UNESCO, 2002). EfSD addresses the ecological, economical, social, cultural and ethical principles and values underpinning SD. EfSD is, therefore, interdisciplinary and value-driven aimed at conceptual and behavioral change.

Traditionally, the focus of environmental education is on ecosystem functioning and nature protection (Palmer, 1998; OECD & CERI, 2006). However, “environment” may also be understood broadly comprising both the physical environment and the socio-cultural relations, and in that case environmental education is often regarded as synonymous to EfSD (Hesselink, van Kempen, & Wals, 2000; OECD & CERI, 2006; Wals, 2001). To avoid possible confusion, EfSD is used here as an overall concept covering all dimensions of SD, and it is distinct from environmental education *sensu stricto*.

There is vast amount literature dealing with the theory, methods and outcome of environmental education. Important milestones were the works of Hines et al. (1986/87), Hungerford and Volk (1990), Palmer (1998) and Fransson & Gärling (1999). Theoretical approach has been further developed by e.g. Bamberg & Möser (2007) and by Hansla, Gamble, Juliosson, & Gärling (2008), and various methods have been used such as experiential learning, outdoor education and situational learning (Braund & Reiss, 2004; Chawla, 1999; Palmberg & Kuru, 2000). The initiatives dealing with practical implementation of environmental education are voluminous and rapidly growing (OECD & CERI, 2006; Dyttrtová, Jeronen, & Pavelková, 2007).

While environmental education has been intensively studied, EfSD has not, and there is clearly a need for contextual conceptualisation and for practices in implementing EfSD. This article describes the realization of a pilot project, and introduces rural-based sustainability education as an example of the contextual approach to EfSD. The experiences from the project and the premise of the approach to contribute to EfSD are discussed by referring to transformative learning theory (Illeris, 2004; Mezirow, 2000).

## **Rationale**

Consciousness and responsibility of environmental, socio-cultural and economic topics develop in close contact with the surrounding society (von Glasersfeld, 2003). SD is the value basis of the Finnish national core curriculum for basic education, the NCCBE. The curriculum also stresses the links between the school and the world outside the school by encouraging the use of alternative learning environments and by integrating the teaching through broad cross-curricular thematic entities<sup>1</sup> (NCCBE, 2004). Using a cross-curricular approach the pupils are made to consider from different points of view the matters and events tangential to their own lives. The aim is to help the analysis of the multi-faceted and controversial phenomena of the present day world and, thus, to contribute to their objective and critical evaluation. This requires that the pupils process information through critical thinking, and then proactively modify their own behavior. The approach, thus, supports the growing into active citizenship by highlighting the interaction between human activity and the phenomena of the world.

With the cross-curricular approach, the school is exposed to a new educational demand. The approach is a welcome innovation, but at the same time it requires a lot from the teachers, who have been given only a very general idea of what it means, but no concrete tools how to proceed and apply it in teaching. Similarly the concept SD has been introduced only on rather general and abstract terms, and without practical context the meaning may remain obscure. There seems to be, therefore, a need for concretising EfSD with an approach that can be linked to today's actual educational and societal challenges.

---

<sup>1</sup> “Responsibility for the environment, health and sustainable future”, Active citizenship and entrepreneurship”, Communication and media skills”, Growing as human being”, “Traffic and safety”, “Cultural identity and internationality”, “Man and technology”

The challenges stem from the alienation of people from the basic facts and praxis of life and living. In the modern, technology based service and information society personal experiences are increasingly based on virtual reality and on the services of the commercial adventure production. Technical devices often replace even personal contacts in human relationships. With the increasingly globalised food system people in general, children and the young especially are losing their ties to rural areas and rural culture, and to agriculture. The route of food from field to fork and back to field is blurred, as are the associated processes and impacts. The balanced interaction between man and nature in general is obscure. At the same time the appreciation of farming and food production is eroding. This is at least partly because in the present day world the status is based mainly on the economic performance, and agriculture with approximately one per cent share of the gross national product (Statistics Finland, 2003) is not particularly highly valued.

Inspired by own experiences on farm camp schools (ECO LEARN, 2006) as well as by the Norwegian example on using farms as pedagogical resource (Krogh, Verstad, Nergard, Jolly, & Parow, 2003; Parow & Jolly, 2003) we developed an action model of rural-based EfSD (Risku-Norja & Yli-Viikari, 2008; Risku-Norja, Vieraankivi, & Korpela, 2008) as a response to these challenges. The action model aims at bringing up aware, responsible and conscious citizens. This is done by increasing understanding of the relationship between man and nature and by promoting adaptation of sustainable life styles. Another aim is to develop teaching by focusing on an integrated approach and to expand the learning environments outside the classroom. The focus is on local co-operation between schools and farms, and the overarching aim is to promote socio-cultural sustainability through interaction between school and local society, and to improve appreciation of rural areas and agriculture.

#### Research task

The aim of the pilot study was to contribute to EfSD by developing a contextual approach through farm-school co-operation. The practical applicability of the approach is evaluated by considering its suitability to the schools' curricula and to schools' everyday life, pupils' attitudes towards farming and countryside, the impact of the pupils' experiences and experiential learning on the farm on pupils' knowledge, learning and on their attitudes towards farms and countryside. Teachers' and farmers' attitudes towards and opinions about farm-school co-operation as well as development needs to improve the suitability of such co-operation to the school's curriculum and to the farm's normal work were also considered. Based on the experiences a conceptual model of learning is outlined. The compliance of the approach with the principles of EfSD is considered within the framework of conceptual and behavioural change as discussed e.g. by Hewson et al. (1990), Hungerford and Volk (1990), Duit (1999), Caravita (2001), and Winne (2005) and of the transformative learning theory (Illeris, 2004; Mezirow, 2000).

## Methods

The pilot project involved nine groups of pupils and their teachers from eight lower grade schools (grades four to six), where pupils' age ranges were respectively from 10 to 13 years. All together 204 pupils took part to the project. Farms which took part to the project were local, from the same village than visiting schools, except for one city school which visited a state owned nature centre and traditional farm in the neighboring village. Local farms were family farms and close enough for school groups to travel there by bicycle, skiing or by using public transport.

Programs were accomplished through mutual planning between the teacher and the farmer. Prior to the classes' first visit to the farm, the teacher and farmer(s) sat down together to draw the overall theme, schedule and principles of the visits. They thought through the highlights as well as possible risks and difficulties of the individual visits. The roles of teacher and farmer were clear: in this co-operation the farm provided the framework for the outside classroom learning and the teacher had responsibility for pedagogical functionality and discipline. The main idea was to try to give pupils a realistic and picture of the farm's everyday life and works, and pupils were encouraged to take part to real farm work. It was up to the teacher how deep in action and hands-on work he/she wanted pupils to participate in the farm.

Many areas of farming were represented in the project. Overall themes varied from plant production to horse, pig and sheep farming, to forestry as well as dairy and honey production. Most of the groups had more than one theme during their two to four farm visits. School groups went to the farm usually on mornings and, depending on the theme and amount of activities that were planned for the day, stayed there for a full day (5 hours) or half day (3 hours). All farm visits included packed lunches prepared by the school which pupils had outdoors.

The applicability of the co-operation between school and the farm, its suitability to the schools' curricula, the program's benefits to the parties involved and the further development needs were all studied by using qualitative research methods. The reason for using qualitative methods was the subject of the research itself. When measuring attitudes and feelings as well as developing a new, inexperienced pattern it is important to let the research material to speak for itself. It is not rational to test hypothesis or theories but examine the material elaborately and in a detailed way (Hirsjärvi, Remes, & Sajavaara 1997).

Participating teachers had the most important role in gathering the research data. They kept a diary about the farm visits in view of the program's compliance with the school's curriculum and its success in general. The teachers were asked to describe their expectations and feelings before the farm visits. They were also asked to list possible risks and threats in advance. After a farm day the teachers answered the activation questions. In addition they were asked to evaluate the meaning of the day for pupils and to evaluate the visit in general. After the program, teachers took part in the group interview. The aim was to compile experiences and ideas about the farm-school co-operation for further improvement. The group interview was seen as a necessary platform to allow brainstorm type generation of ideas and critics. Free expression was encouraged.

During the farm visits, in addition to the teacher and the farmer, there were one or two people from the research team to help with the practicalities and to observe the activities, the practical arrangements and the behavior and responses of the pupils in a new learning environment as well as the farmer's first impressions and experiences. The farmers were also interviewed after the program.

## **Results**

### Suitability to schools' curriculum and to schools' everyday life

It was easy for teachers to address the suitability of the farm visit to the school's curriculum. In particular, cross-curricular themes, many of them otherwise difficult to teach in the classroom, were present in the farm programs. This kind of theme is for example 'Growing as a human being' which was present in many activities such as working together, helping other people without getting any material reward, taking care of the animals and having collective responsibility for performance of the tasks. Experiences in the farm also concretized directly themes such as 'Responsibility for the environment, health and sustainable future' and 'Active citizenship and entrepreneurship' with an example from real life. In most of the farms pupils also got to know something about their local cultural heritage and identity as well as the new technology used in farms.

Of the specific subjects environmental knowledge and natural history as well as geography and biology were directly linked to the visits. In addition, the farm program could be exploited as subtexts in most subjects, e.g. outdoor work and cycling or cross-country skiing to the farm as sports, learning diaries strengthen pupils' ability to express themselves in written form and many kinds of examples with practical applicability for the different calculations to be used in mathematics. One class group made a video about their co-operation one school had an art exhibition inspired by the forest visits. Also, other teachers pointed out the possibility to use experiences in a farm later by means of arts or even media education. In their diaries, teachers mentioned some examples of the farm activities that directly met the curriculum: farm and forest animals, forestry, species recognition, different living environments like meadows and shore. Pupils also got to know their immediate surroundings, its nature and place of employment, the life span of local products as well as everyman's rights and responsibilities.



Taking part in the program fitted well in the schools' everyday life. In the lower grade schools, the class teacher teaches most of the subjects to the pupils and can, therefore, fairly freely adjust the schedule to the farm visits. Yet teachers pointed out that organization and practical arrangements of the program took some time as there were several things to agree beforehand. Organization required meeting(s) with the farmer, informing the parents and other teachers about the visit, agreeing with the kitchen about the packed lunch for the pupils and planning the transport to the farm. In most of the cases the farm was close enough for pupils to travel there by bike or by using skis during the winter. Transport was also easy to organize if the farm was located on a public transport route. In cases where other type of transport was necessary, access to the farm required extra money for the chartered bus or extra arrangements to transport pupils in smaller cars. However, all the participating teachers felt that taking part to the program was worth the trouble as the farm and its surroundings offered the pupils a new learning environment which was considered as realistic and genuine and which brought a welcome change to the normal school routines both for the pupils and the teacher.

### Pupils' attitudes toward the farming and farm visits

Overall attitudes of pupils seemed to get more positive towards the farm after visiting it. Especially the visits which included working with animals were only of a positive nature to most of the pupils. Also having the lunch out in farm surroundings or forest after physical work was rewarding and an unforgettable experience especially in those cases where lunch was cooked by the open fire during the winter. Teachers thought that it was good for pupils to see, what a farm actually was and what was happening there. It was good for them to realize that farmers have to also work for their living and that they won't just get free money from the EU. In some aspects like the smell of the animal shelters and the boy's thoughts about the horses being only a girlish thing, the attitudes clearly became more positive after the farm visit. According to the teachers, however, few visits are too short a time to make far-reaching conclusions.

Teachers agreed that the youngest pupils, the 4<sup>th</sup> graders (10-11 years in age), were the best age group when it came to judging the attitudes. They were least reserved towards the visits beforehand. The 4<sup>th</sup> graders were also eagerly waiting for the visits and were involved in all the activities without questioning them. They were willing to gather information about animals before and after the farm visit and keen to work with the farm issues in school after the visit. For most 5<sup>th</sup> graders the farm visit was more interesting than they expected beforehand. Generally they were complaining a bit at first when they had to work in stables, forest or in a pig house, but then they did not want to quit working or leave the farm when the day was ending. 6<sup>th</sup> graders were the most critical towards the farm and working in a farm beforehand and some of them were complaining even in the farm. They would have wanted more free time in the farm and just 'hang around' in its surroundings. However, according to their teacher this negative attitude was more related to adopting an older pupil's "role" as also 6<sup>th</sup> graders were working happily in the farm when the time came to work.

### Learning

The intention of the school-farm co-operation was for pupils to learn about farming and foresting by doing with their own hands in real surroundings. In this way they learned, not only encouraged by active participation but also had a better recollection of their learning because of the memorable experiences in a farm. Gathering personal experiences by doing and seeing things made it easier for pupils to absorb and understand the relevant information at a later stage. Therefore, certain significance of the activities in the farm was the creation of frames of references for later learning.

According to the teachers, even if few visits in a farm were quite a short period of time to observe an actual learning process, they mentioned some things which pupils obviously had acquired; the pupils learned about different types of practical farm and forest work by taking part, and they also learned to work as a group with their classmates and to listen and work with people they had not met before. Visiting the same place several times taught

pupils about perseverance, routines, continuity and patience. This is an important aspect in today's "supermarket society" where pupils are used to throwaway consumption where they just pick new items when they get bored with previous ones. Another valuable lesson for pupils was to learn to respect life itself. For example, being in peace with and taking care of newborn lambs was a deeply emotional experience. Working with animals in general was a rewarding environment for learning empathy towards other living creatures.

#### Teachers' general attitudes and thoughts about the program

Farm-school co-operation program surpassed the teachers' expectations. They thought it was a 'smashing' foundation and were willing to develop the program even further together with their pupils and the farmer. Teachers felt that co-operation with farmers was easy and that pupils' enthusiasm and joy at the farm was very rewarding. It was also a relief to see that initial fears of the children making their own way to the farm among other traffic and being at the farm as such a big group were abated as everything went according to plan. Teachers were happy that the farm programs mostly involved hands-on activities with real work and therefore transformed into a real and positive picture of farms to the pupils.

However, no matter how interesting it was, taking part in this kind of program which was not 'ready baggage' required a lot of extra work and energy from the teacher. Active participation in other projects at the same time was out of the question. Given that this was a pilot project and pupils' visits at the farm were part of the research, reporting about the co-operation was sometimes time consuming for the teachers. They also mentioned that at times, the timetable at the farm or the forest became a bit too hectic.

Teachers had a few important development ideas for future programs as well. They found it important to create continuum and regularity to the program. It would be easier for teachers to start and carry on the program if they would know beforehand that it is coming and that a relationship with a farm would exist already when starting. Having the co-operation with the farm in the schools' curriculum and plan of action would also make allocation of the resources for the program easier. Teachers also pointed out the importance of meeting other participating teachers before and during the program for support and for sharing of ideas.

#### Farm entrepreneurs' opinions about the program

Participating farms were quite easy to find as most of the teachers had had some type of contact with the farmers before, for example, in the case of a farmer's child attending the local school. Farmers were willing to be involved with the program and they found it important to provide pupils with relevant and correct information, counterbalancing prejudices and to contribute to a positive attitude toward farming. They wanted children to understand from where food comes from and how it is produced, to be aware about food safety issues and to learn to appreciate domestic food production. Due to the fact that organizing the program for pupils required quite a lot of time and effort, farmers also expected pupils to be prepared properly. They expected children to have suitable clothing for the current weather and the farm work and that the teacher had control of the behavior of the group.

Generally farmers were happily surprised about pupils' enthusiasm toward the farm work and visits. They thought that even if it required lot of organization and time, visits also brought a nice change to the farms' everyday life. Nearly all the farmers who took part in the program recommended co-operation with schools to the other farmers in their acquaintance. In the pilot project, farm entrepreneurs received a small compensation which was funded from the project budget. However, the money was not the main reason to participate. Farmers saw the co-operation as an appropriate way to improve their public relationships. Co-operation was seen especially suitable for small scale farms, whereas a slight risk of animal diseases was mentioned as a possible threat in bigger animal farms.

Farmers thought that it was important that they could agree with the teacher precisely upon the activities in the farm and that they had mutual understanding on what work needed to be completed. If the farmers had to patch up pupils' achievement or the work that was agreed upon was not done, the eagerness to welcome school groups

decreased rapidly. Mutual feedback already in the farm should be aimed at to avoid the situation that something is bothering on or the other party afterwards.

## Conclusions and Implications

The leading principles of the project were locality, continuity and active participation. Locality means that the focus is in treasuring and improving community-based cohesion, and the co-operation is between schools and farms located nearby. Continuity refers not only to temporally enduring co-operation but also to continuity across the disciplinary borders of the school subjects in order to help pupils understand the intermingling of the ecological, economic and socio-cultural aspects of sustainability. The principle of active participation stresses social interaction, learning by doing and practical application of what is learned.

Local approach increases interaction between the school and the local community. It improves children's knowledge about their home district, which is important for identity formation (e.g. Chawla, 2004). It also increases the commitment of both the farmers and the teachers. Enduring co-operation allows long term planning so that the activities build up a coherent continuum, and are at the same time reasonable in view of both the school's and the farmer's needs.

Outdoor education is known to be an effective way of learning (Amos & Reiss, 2006; Braund & Reiss, 2004; Chawla, 1999; McRae, 1990; Neill, 1997). Pupils' knowledge builds, as its best, from concrete experiences and as a result of values and emotions attached to that. The more senses that are activated in the learning process, the easier these are brought back later. Outdoor education enables pupils to anchor theoretical concepts in the memory and give the concept a concrete and deeper meaning (Palmberg & Kuru, 2000) and it is also in line with the recommendations of the Finnish NCCBE of using alternative learning environments (NCCB 2004).

The goal of SD and the integrated issues it deals with implicitly mean that the EfSD is interdisciplinary and transformative. Active participation exploits pupils' experiences, emotions and senses in teaching, it stresses learning by doing and practical application of what is learned. Experiential learning together with other pupils allows the pupils to use their varying abilities and skills and to learn through own and shared experiences. With practical examples and positive experiences in concrete situations even the difficult matters become understandable. When education is tied to the local environment and to local community, the significance of what is learned is obvious and the pupils have the possibility to apply what they have learned in practice. Education is situational and contextual, and it is spiced with emotions, personal experiences and collective activity. Personal experiences on the farm provide pupils with a solid foundation making it easier to receive and assimilate new knowledge and information.

### Conceptual learning model

The school-farm co-operation allows the combining of comprehensive and contextual learning. In this instance, *comprehensive learning* means that knowledge, activity, emotions, values and all senses are involved in learning. In addition to concepts and knowledge, the focal role of personal experiences, emotions and social interaction for learning is acknowledged. *Contextual learning*, on the other hand, means that the new things are learned by deepening and expanding the existing knowledge, so that the pupils are interested in the things to be learned and understand the links to the previous knowledge meaning that they are able to apply what they have learned in practical situations (Cantell & Koskinen, 2004).

The learning environment on the farm comprises both physical and social levels, the farm and the surrounding nature, the people, their activity and the impacts on the local and societal level. Personal experiences on the farm are obtained through physical activity and emotional involvement by using all different senses, by seeing, smelling, hearing, feeling and tasting. New experiences arouse pupil's interest, which is the key for the hunger to know more. New knowledge has to be reconciled with the existing knowledge and evaluated against it. This initiates active knowledge processing. Interest, new knowledge, activated senses and emotions and critical

evaluation all shape and modify values and attitudes. This process creates the basis for conceptual and behavioural change, which take expression in practical life situations both in personal choices and decisions, and in participation in civic activity.

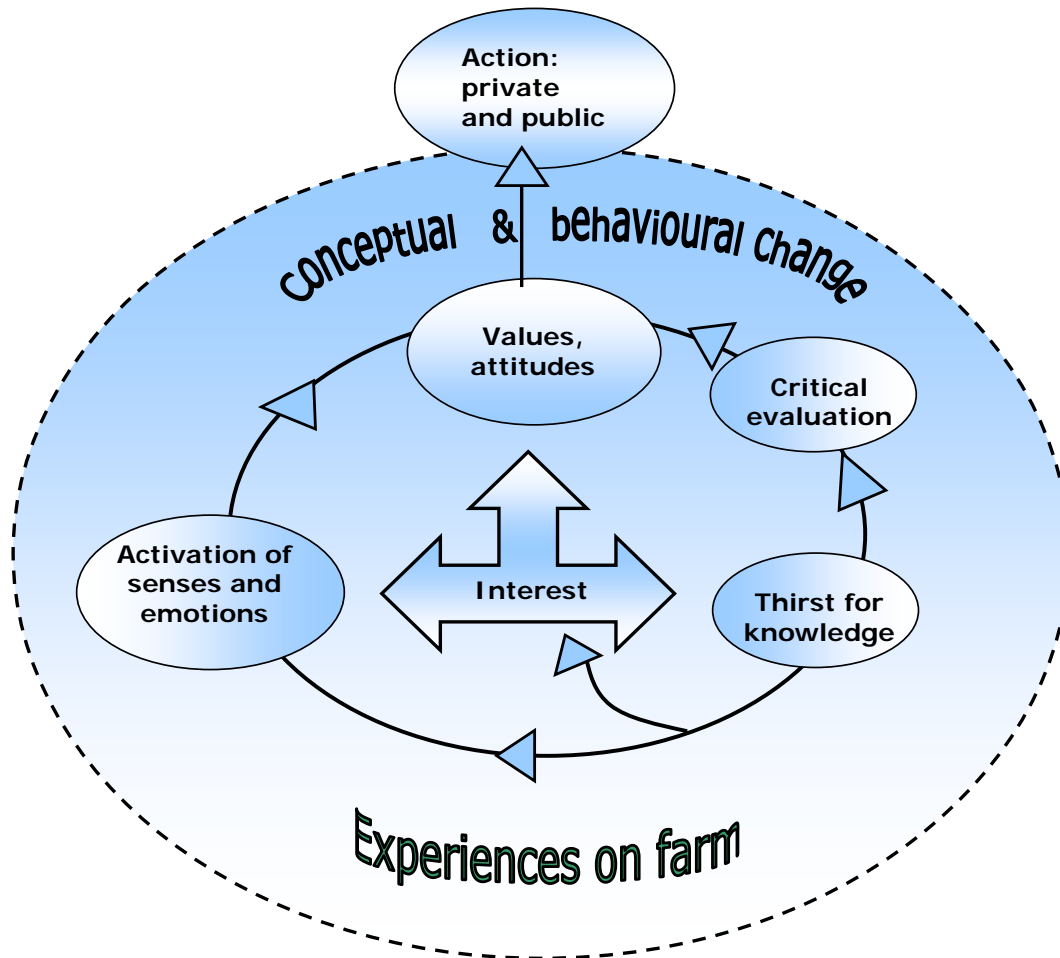


Figure 1. Conceptual model of rural-based sustainability education.

The key elements of rural-based EfSD are contextuality, interdisciplinarity and whole school approach (Morgan & Sonnino, 2008) expanded so as to involve also the actors of the local community. Providing basic knowledge and skills in the teachers' own subject is not enough, but school education needs to be slotted into the social reality and the teachers need to co-operate with each other and with the non-educational professionals of the school as well as with the actors of the local community. So far, it has been up to the teacher's professional skills, probably also to coincidence, how pupils' experiences on the farm can be utilised to support pupils' learning. EfSD requires a reorientation in teaching methods and it is, therefore, a true challenge for pre-service and in service teacher education.

## References

- Amos, R., & Reiss, M. (2006). What contribution can residential field courses make to the education of 11–14 year-olds? *School Science Review*, (87), 1-0.
- Bamberg, S., & Möser, G. (2007). Twenty years after Hines, Hungerford, and Tomera: A new meta-analysis of psycho-social determinants of pro-environmental behaviour. *Journal of Environmental Psychology*, (27), 14-26.
- Braund, M., & Reiss, M. (2004). *Learning science outside the classroom*. London: RoutledgeFalmer.
- Cantell, H., & Koskinen, S. (2004). Ympäristökasvatuksen tavoitteita ja sisältöjä. In H. Cantell (Ed.), *Ympäristökasvatuksen käsikirja* (pp. 60-79). Jyväskylä: PS-kustannus. [in Finnish]

- Caravita, S. (2001). A re-framed conceptual change theory? *Learning and Instruction*, (11), 421-429.
- Chawla, L. (1999). Life paths into effective environmental action. *The Journal of Environmental Education*, 31(1), 15-26.
- Chawla, L. (2004). Identity and the natural environment. In S. Clayton, & S. Opatow (Eds.), *The psychological significance of nature* (pp. 406-408). Cambridge, MA: MIT Press.
- Duit, R. (1999). Conceptual change approaches in science education. In W. In W. Schnotz, S. Vosniadou & M. Carretero (Eds.), *New Perspectives on Conceptual Change* (pp. 263-282). Oxford: Pergamon.
- ECO LEARN. (2006). Maalle oppimaan! Retrieved August 10., 2009, from <http://www.agronet.fi/leirikoulu/>
- Dytrtová, R., Jeronen, E. & Pavelková, J., (2007). Environmental Management for Education and Edification. Brno: TRIBUN EU., IV(1).
- Fransson, N., & Gärling, T. (1999). Environmental concern: conceptual definitions, measurement methods, and research findings. 19, 369–382. *Journal of Environmental Psychology*, (19), 369-382.
- Hansla, A., Gamble, A., Juliosson, A., & Gärling, T. (2008). The relationships between awareness of consequences, environmental concern, and value orientations. *Journal of Environmental Psychology; Journal of Environmental Psychology*, 28(1), 1-9.
- Hesselink, F., van Kempen, P. P., & Wals, A. E. J. (2000). *ESDebate: International on-line debate on education for sustainable development*. IUCN, Gland.
- Hewson, P. W., Beeth, M. E., & Thorley, N. R. (1990). Teaching for conceptual change. In K. G. Tobin, & B. J. Fraser (Eds.), *International Handbook of Science Education* (pp. 199-218). Dordrecht, Netherlands: Kluwer Academic Publishers.
- Hines, J. M., Hungerford, H. R., & Tomera, A. N. (1986/87). Analysis and synthesis of research on environmental behavior: A meta-analysis. *Journal of Environmental Education*, (18), 1-8.
- Hirsjärvi, S., Remes, P. & Sajavaara, P. 1997. Tutki ja kirjoita (Research and write), in Finnish. Helsinki, Finland: Kirjayhtymä.
- Hungerford, H. R., & Volk, T. L. (1990). Changing learner behaviour through environmental education. *The Journal of Environmental Education*, 21(3), 8-21.
- Illeris, K. (2004). Transformative learning in the perspective of a comprehensive learning theory. *Journal of Transformative Education*, 2(2), 79-89.
- Krogh, E., Verstad, B., Nergard, T., Jolly, L., & Parow, K. (2003). The Farm as a Pedagogical Resource. An evaluation of the co-operation between agriculture and primary school in the county of Nord-Trøndelag, Norway. *XXth Congress of the European Society for Rural Sociology*, Sligo, Ireland.
- McRae, K. (1990). Integrated outdoor education. In K. McRae (Ed.), *Outdoor and environmental education – diverse purposes and practices*, (pp. 75-91) The MacMillan Company of Australia Pty Ltd.
- Mezirow, J. (Ed.). (2000). *Learning as transformation: Critical perspectives on a theory in progress*. San Francisco: Jossey Bass Higher and Adult Education Series.
- Millennium Ecosystem Assessment, Ecosystems and Human Well-being, Synthesis (2005). Retrieved January 08., 2008 from <http://www.millenniumassessment.org/documents/document.356.aspx.pdf>
- Morgan, K., & Sonnino, R. (2008). *The School Food Revolution. Public Food and the Challenge of Sustainable Development*. London: Earthscan.
- NCCBE (2004). *National Core Curriculum for Basic Education*. Helsinki: National Board of Education. [in Finnish]
- Neill, J. T. (1997). Outdoor Education in the Schools: What can it achieve? *AMAPs SA Paper, 10th National Outdoor Education Conference*, Sydney, Australia.
- OECD, & CERI. (2006). Environment and School Initiatives – 20 years of innovation and action research in Environmental education and Education for Sustainable Development. Retrieved 10 November, 2006, from <http://www.ensi.org/>
- Palmberg, I., & Kuru, J. (2000). Outdoor activities as a basis for environmental responsibility. *Journal of Environmental Education*, 31(4), 32-36.
- Palmer, J. A. (1998). *Environmental education of the 21st century: Theory, practice, progress and promise*. London: Routledge.
- Parow, K., & Jolly, L. (2003). *Living School -The farm as a pedagogical resource*. Retrieved November 8, 2006, from <http://www.gspr.no/venstre.asp?id=197>

- Risku-Norja, H., Vieraankivi, M., & Korpela, E. (2008). Farms as learning environment - experiences from school-farm co-operation. Paper presented at the *annual meeting of the Scientific Agricultural Society of Finland 2008*. [http://www.smts.fi/mpol2008/index\\_tiedostot/Posterit/ps061.pdf](http://www.smts.fi/mpol2008/index_tiedostot/Posterit/ps061.pdf)
- Risku-Norja, H. & Yli-Viikari, A. (2008). School goes to the farm - action model for rural-based sustainability education. *Innovation Systems and Rural Development : Proceedings from 10th Annual Conference, Nordic-Scottish University for Rural and Regional Development*. Brandbjerg, Denmark. (27/2008) 90-100.
- Statistics Finland. (2003). *Statistical yearbook of Finland 1984-2002*. Helsinki: Statistics Finland.
- UN (2006). *Johannesburg Summit 2002*. Retrieved September 15, 2009, from [http://www.un.org/jsummit/html/basic\\_info/basicinfo.html](http://www.un.org/jsummit/html/basic_info/basicinfo.html)
- UNESCO (2002). *UN Decade of Education for Sustainable Development (2005-2014)*., Retrieved August 10, 2009, from [http://portal.unesco.org/education/en/ev.php-URL\\_ID=23279&URL\\_DO=DO\\_TOPIC&URL\\_SECTION=201.html](http://portal.unesco.org/education/en/ev.php-URL_ID=23279&URL_DO=DO_TOPIC&URL_SECTION=201.html)
- von Glasersfeld, Ernst (2003). An Exposition of Constructivism: Why Some Like it Radical. <http://www.oikos.org/constructivism.htm>
- Wals, A. (2001). Education for sustainable development: critique, promise and guide post. Karlskrona, Sweden.
- WCED. (1987). *Our common future*. Oxford: Oxford University Press.
- Winne, M. (2005). Education for change. *Journal of Agricultural and Environmental Ethics*, (18), 305-310.

# UNIVERSITY STUDENTS' MORAL REASONING PATTERNS TOWARD ENVIRONMENTAL MORAL DILEMMAS

Busra Tuncay  
Giresun University

Ozgul Yilmaz-Tuzun  
Middle East Technical University

## Abstract

*This study examined moral reasoning patterns of university students about four environmental moral dilemmas in enhancement of impacts of the described environmental damages on environment itself or on humans. Study's sample constituted 85 undergraduate students (55 female and 30 male) with a mean age of 22.83 years. Three categories were used (i.e., ecocentric, anthropocentric, and non-environmental) for participants responses regarding their considerations about the dilemmas. Content analysis was carried out on the responses and then frequencies of each reasoning category were computed. Descriptive analyses revealed importance of familiarity to the environmental issues for providing responses. Low number of moral concerns was obtained for the old growth dilemma due to unfamiliarity. It was also seen that participants exhibited more ecocentric moral considerations than anthropocentric and non-environmental reasoning. According mixed ANOVAs, for the garbage dilemma, participants specified fewer number of moral concerns when impact on environment was provided. Moreover, including information about impact on environment resulted in an increase in ecocentric and a decrease in non-environmental moral reasoning patterns.*

## Introduction

It has long been known that most of the environmental problems we face today are mainly caused by human activities (United Nation the World Commission on Environment and Development [WCED], 1987; United Nations of Environment Program [UN-UNEP], 1992). Bearing this fact in mind, as also stated by Yeung (2002), a change in people's behaviors is needed in order to provide solutions to many environmental problems. Nevertheless, it is seen that efforts to change people's environmentally destructive behaviors permanently have not been successfully attained yet. In this respect, environmental education may play an important role. However, what is going to be addressed during environmental education is a critical question.

In the literature, there are studies demonstrating that scientific knowledge based environmental education has not been fully successful to attain its goal of fostering concerns among individuals and in turn leading to behavior shifts in accordance with the concerns by accumulating knowledge (Finger, 1994). One of the reasons for the unconvincing results of the studies searching for a linkage between scientific knowledge and environmental attitudes may be insufficiency of this approach to affect deeply held values of individuals, so that individuals alter their behaviors toward environment and become citizens who exhibit more environmentally friendly behaviors (Fien and Slater, 1981; Gigliotti, 1990).

At this point, the need for more affective approaches in environmental education has arisen since it is believed that our actions and opinions about environmental issues are guided by our emotional responses and values rather than our scientific knowledge on those issues Guveritz (2000). According to Kortenkamp and Moore (2001), how we deal with environmental problems largely depends on our perceptions about our relationship with nature.

Correspondingly, there is a great deal of research in the area of the relationship between humans and the rest of the nature, which aim to measure attitudes and opinions of people about the environment. Nevertheless, while investigating individuals' attitudes toward environment, the reasons of these attitudes should also be studied since pro-environmental attitudes may result from a variety of motivations, which have different implications for behavior (Karpiak, 2008). As proposed by Axelrod (1994) it is likely that people develop hierarchies in their reasoning patterns, which guide their decisions regarding environmental issues.

Supported by the literature, this study is based on the assumption that the possible gap between people's environmental knowledge and environmental attitudes (DeChano, 2006) may be due to their not handling environmental problems as moral issues, which is related to their environmental concern. Moral reasoning is related to views about whether and why conservation and sustainability are important (Karpiak, 2008). The idea that people care about environmental quality because a degraded environment possesses a threat to the well-being of people is categorized as anthropocentric moral reasoning (Fransson & Garling, 1999). On the contrary, reasoning that includes the idea that nature merits moral consideration owing to its intrinsic value, value aside from its usefulness to humans is an ecocentric moral reasoning. In addition, similar to Kortenkamp and Moore (2001), in the present study as a third category non-environmental moral reasoning was used for people's responses referring social contracts, guilt or truthfulness presented in the dilemmas.

## **Rationale**

In this study, examining moral reasoning patterns (anthropocentric, ecocentric, and non-environmental concern) of university students toward the given environmental moral dilemmas in enhancement of impacts of the described environmental damages on environment itself or humans is aimed. Based on Schwartz' (1997) norm-activation theory, it is hypothesized that effect of information enhancement about the consequences of environmental damage on humans and environment itself will be influential in participants reasoning patterns.

A very recent study of Karpiak (2008) provides us an empirical connection between moral reasoning patterns and environmentally friendly behaviors and thus implies the importance of moral reasoning toward environmental issues, since these patterns guide thoughts of people. Moreover, this research is particularly important because a few research has been done to determine students' environmental moral reasoning patterns in nonwestern countries. In this sense, the study has significance in that it gives implications for the possible effect of culture on people's environmental moral reasoning and researchers believe that in order to preserve nature around the world it is necessary to conduct research in these countries as well as western countries.

## **Methods**

### **Sample**

A convenience sample of 85 undergraduate students (55 female and 30 male) with a mean age of 22.83 years participated in this study. All of the students took an elective environmental education course offered in the university where the study took place. The participants enrolled in various faculties (faculty of arts and sciences, faculty of economic and administrative sciences, faculty of engineering and faculty of education). They were volunteers and no extra credit was given for their participation.

### **Instrument**

In research examining issues of fairness and justice, and decision making dilemmas are widely used since they are convenient for empirical examination of these constructs (Axelrod, 1994). Correspondingly, in the present study four different environmental moral dilemmas about four specific environmental issues (Overgrazing a common, building a landfill for garbage, logging an area of old growth forest, and cutting firewood in a protected forest) were



used to examine participants' environmental moral reasoning patterns. The dilemmas were originally developed by Axelrod (1994) and Beringer, (1994) and later modified by Kortenkamp and Moore (2001).

Within the dilemmas, whether additional information on how the environmental damage would affect the environment itself and humans were given or not were manipulated in a 2 x 2 factorial design. Dilemma topic was a within-subjects factor and information enhancement was manipulated between subjects. The order of the dilemmas, which were randomly assigned to the participants, was counterbalanced with a Latin squares design.

In the study, the dilemmas were modified in a way that the names of main characters and the places where the dilemmas took place were changed according to participants' native language and culture. These adaptations seem to be important to be able to understand participants' actual moral reasoning when considering their personal decisions about environmental issues they may encounter in their daily life (Kortenkamp & Moore, 2001). The language of the original dilemmas was not changed because the participants have necessary capacity and ability to respond the dilemmas in English since education language of the university is English.

#### Data Collection and Analyses

For data collection, participants of the study were asked to decide on whether the main characters of each dilemma should support or perform an environmentally damaging action or not, together with their underlying reasons for their decisions. Each participant explained his/her considerations about the dilemmas in writing.

In order to analyze the data content analysis was carried out on the responses and then frequencies of each reasoning category were computed. Based on the calculated frequencies, descriptive and inferential statistics were conducted by using the Statistical Package for Social Sciences (SPSS) version 15.0 for Windows.

## Results

#### Descriptive Analyses

When frequencies for anthropocentric ( $f=115$ ), ecocentric ( $f=278$ ), and non-environmental ( $f=197$ ) moral reasoning were computed across each dilemma, it was seen that ecocentric reasoning was provided with the most frequency. More detailed information about participants' responses for each dilemma topic is tabulated in Table 1.

In addition it was seen that highest non-response percentage was obtained for the old growth dilemma topic (25.9%). Likewise, content analysis revealed that some of the participants have prevalent misconceptions about old growth forests. For instance, two of the participants stated that since old growth forests are old, trees in those forests are dead. On the contrary, nearly all of the participants (95.3%) perceived at least one moral concern for gathering firewood dilemma. These two analyses revealed that participants had the most difficulty in revealing their knowledge and moral reasoning about old growth forest dilemma, which is unfamiliar to the participants since less than 12% of the total forest is covered by old growth forest in this country.

#### Inferential Analyses

To determine possible differences among participants' responses based on different dilemmas, 2 (Impact on Environment Information) x 2 (Impact on Humans Information) x 4 (Dilemma Topic) mixed ANOVAs were run with frequency of total number of moral concerns and use of each moral consideration category as dependent variables. When total number of moral concerns was taken as dependent variable, the test resulted in significant main effect for 'Impact on Environment Information', Wilks's Lambda =.884,  $F(4, 79)=2.581$ ,  $p=.043$ . On the garbage dilemma, participants specified fewer concerns when impact on environment was provided.

In addition, when use of each moral consideration category was taken as the dependent variable, no significant main effect for ‘Impact on Humans Information’ was found but the test was significant for the main effect of ‘Impact on Environment Information’, Wilks’s Lambda=.814,  $F(3, 81) = .160$ ,  $p=.001$ . Univariate follow-up revealed significant differences on ecocentric moral reasoning,  $F(1, 85) = 5.808$ ,  $p=.018$ ,  $MSE=25.686$ , and non-environmental moral reasoning,  $F(1, 85) = 6.674$ ,  $p=.012$ ,  $MSE=23.550$ . Participants of the study expressed higher ecocentric and lower non-environmental concerns in the presence of information about the impacts of the actions on environment.

**Table 1. Frequencies and Percentages of Number of Responses for each Dilemma**

Dilemma Topics	# of responses	Frequency (f)	Percentage (%)
Grazing	0	15	17,6
	1	32	37,6
	2	16	18,8
	3	17	20,0
	4	3	3,5
	5	1	1,2
	6	1	1,2
Garbage	0	12	14,1
	1	31	36,5
	2	17	20,0
	3	20	23,5
	4	5	5,9
Old Growth	0	22	25,9
	1	33	38,8
	2	14	16,5
	3	9	10,6
	4	4	4,7
	5	2	2,4
Gathering Firewood	0	4	4,7
	1	27	31,8
	2	24	28,2
	3	14	16,5
	4	14	16,5
	5	2	2,4

## Conclusions and Implications

As hypothesized at the beginning of study, analyses supported the importance of familiarity to the environmental issues for perceiving moral aspects of them and exhibiting moral concerns. Low number of moral concerns was obtained for the old growth dilemma, which may be due to rarity of old growth forests (less than 12%) in the country. Similarly, presence of information about impacts on environment was influential in participants’ reasoning. Although statistically significant main effect was not found for ‘Impact on Humans Information’, information enhancement about impacts of the specified actions on environment led to a significant increase in participants’ ecocentric moral reasoning and a decrease in their non-environmental moral reasoning.

Moreover, for the garbage dilemma it was seen that when participants were provided with impacts on environment they revealed fewer number of moral concerns in general, maybe due to their thinking of the issue from a narrower perspective. Giving impacts of environmentally damaging action on environment itself may have lead the participants focus on only environmental aspect of the moral dilemma and neglect other moral aspects.

The reason for obtained difference in results of the present study, regarding moral reasoning patterns of university students, from some other ones such as Kortenkamp and Moore's (2001) study may be the effect of culture on moral reasoning. The participants of Kortenkamp and Moore (2001) used significantly more non-environmental moral reasoning than ecocentric and anthropocentric moral reasoning. On the contrary, in this study it was seen that participants exhibited more ecocentric moral considerations about the given dilemmas than the two other moral reasoning categories. However, the found differences may also be a result of the sample's characteristics since the present study was conducted with university students who had taken elective environmental course most probably owing to their interest in environmental issues and problems.

The findings of the research are important in that it contributes to our understanding of university students' environmental moral reasoning patterns in relation to the origins and development of the human relationship with nature. The researchers of the study believe that a likely connection between moral reasoning patterns and environmentally friendly behaviors (Karpiak, 2008) implies the importance of further research on environmental moral reasoning with more diverse samples for an effective environmental education.

## References

- Axelrod, L.J. (1994). Balancing personal needs with environmental preservation. *Journal of Social Issues*, 50, 85-104.
- Beringer, A. (1994). The moral ideals of care and respect. In *European University Studies: Series 20, Philosophy* (Vol.425, pp. 10-260). Berlin: Frankfurt am Main.
- DeChano, L. M. (2006). A multi-country examination of the relationship between environmental knowledge and attitudes. *International Research in Geographical and Environmental Education*, 33(1), 15-27.
- Fien, John and Slater, Francis (1981). Four strategies for values education in geography. *Geographical Education*, 4, 39-52.
- Finger, M. (1994). From knowledge to action? Exploring the relationships between environmental experiences, learning and behaviour. *Journal of Social Issues*, 50, 141-160.
- Franson, N., & Garling T. (1999). Environmental concern: conceptual definitions, measurement methods, and research findings. *Journal of Environmental Psychology*, 19, 369-382.
- Gigliotti, L.M. (1990). Environmental education: what went wrong? What can be done? *Journal of Environmental Education*, 22(1), 9-12.
- Gurevitz, R. (2000). Affective approaches to environmental education: going beyond the imagined worlds of childhood? *Ethics, Place and Environment*, 3(3), 253-268.
- Karpiak, C.P. & Baril, G.L. (2008). Moral reasoning and concern for the environment. *Journal of Environmental Psychology*, 21, 203-208.
- Kortenkamp, K. V. & Moore, C. F. (2001). Ecocentrism and anthropocentrism: moral reasoning about ecological commons dilemmas. *Journal of Environmental Psychology*, 21, 261-272.
- Schwartz, S. H. (1977). Normative influences on altruism. *Advances in Experimental Social Psychology*, 10, 221-279.
- Stern, P., & Dietz, T. (1994). The value basis of environmental concern. *Journal of Social Issues*, 50, 65-84.
- Stern, P. C., Dietz, T., Kalof, L., & Guagnano, G. A. (1995). Values, beliefs, and pro-environmental action: Attitude formation toward emergent attitude objects. *Journal of Applied Social Psychology*, 26, 1611-1636.
- UNEP. 1992. *World Atlas of Desertification*. London: Edward Arnold.
- WCED (1987). *Our common future*. Oxford: Oxford University Press.
- Yeung, S. P. (2002). Teaching approaches and the development of responsible environmental behaviour: the case of Hong Kong. *Ethics, Place and Environment*, 5(3), 239-269.



# HOW DO PRE-SERVICE TEACHERS IN ISRAEL PERCEIVE THE CONCEPT 'ENVIRONMENT'

Bella Yavetz  
Kibbutzim College of Education

Daphne Goldman  
Beit Berl Academic College

Sara Pe'er  
Oranim Academic College of Education

## Abstract

*The environment should be understood in context to interactions between social, economic and political forces that organize people within their surroundings. Students enter learning processes with personal sets of beliefs, values, ideas and understandings regarding human-nature relationship, resulting from previous experiences, that influence their learning experience. This study investigated, with an open-ended questionnaire, perceptions of 465 pre-service teachers regarding the concept 'environment' and its relevance to subject-area they will teach. This investigation is part of a longitudinal research characterizing development of environment literacy (EL) of students in three academic teacher colleges in Israel. Analysis of students' responses reveal various categories: holistic; romantic; biophysical versus social; human-nature relationship on a scale ranging from humans-separate-from-nature through humans-as-part-of-the-environment to interdependence between human and natural environments; value-of-nature on a scale ranging from anthropocentric to ecocentric approaches; environmental quality; environmental protection reflecting different eco-philosophical approaches. The majority of students from all disciplines feel environmental topics are relevant to their teaching-area. Environmentally-affiliated majors perceive this relevance mainly via subject-matter while non-environmentally-affiliated majors perceive this link via their future ethical responsibilities as educators. Understanding students' eco-philosophy enriches the emerging picture of graduates' EL and provides valuable information contributing to better integration of EE component in teacher-training programs.*

## Introduction

The environment is not only an ecological entity separate from people but a cultural, social and political construct. The environment should be understood in context to the interactions between social, economic and political forces that organize people within their surroundings. Similarly, environmental problems are defined according to their effects on the individual, society and natural systems, as these are conceptualized by people (Wals, 1992; Robertson, 1994).

Environmental education, as education for the environment, is education for social and environmental change. It, therefore, requires understanding the way different people perceive their world and view their personal situation in the world- i.e., successful environmental education is contextual. (Wals, 1992; McKeown-Ice & Dendinger, 2000). Each student enters the learning process with a personal set of beliefs, values, ideas, perceptions and understandings regarding the human-nature relationship, stemming from his previous experiences, that influence their learning experience (Ausubel, 1968 in Novak & Gowin, 1984).

This study investigated perceptions of pre-service teachers (towards the end of their studies) regarding the concept 'environment' and how it is related to the subject area they will teach. This investigation is part of a longitudinal research characterizing the development of environment literacy of students in three academic teacher colleges in Israel (Goldman, Yavetz & Pe'er, 2006; Pe'er, Goldman & Yavetz, 2007; Yavetz, Goldman & Pe'er, 2009).

## **Rationale**

Understanding how learners conceptualize the environment, human-environment relationships and environmental issues may provide valuable information and contribute to more effective environmental education (Robertson, 1994). This is all the more important with respect to teacher students, in view of their future role as environmental educators. Along these lines, understanding the eco-philosophical perceptions of teacher students may contribute to more effective integration of environmental education within teacher education programs.

## **Methods**

### Participants:

The study was conducted with 465 students in three teacher-training colleges in Israel (Kibbutzim College of Education, Oranim Academic College and Beit Berl Academic College). The three colleges in which the study was conducted are the largest in Israel and are situated in different regions of the country. Hence, the study covered a heterogeneous population steered towards the teaching profession. The programs in these colleges extend four years and students graduate with a Bachelor in Education degree (B.Ed.) and a teaching certificate. The structure of the academic programs in these colleges is basically similar. The program is comprised of three components: 1) disciplinary studies in one or two major fields, 2) education and pedagogy studies and 3) including internship, the latter two designed according to the students' educational training track (pre-school, elementary school, secondary school, special education, informal education).

### Instrumentation:

The research addressed two questions: 1) "When you hear the word 'environment', you think about:"; 2) "In your opinion, how do environmental topics relate to the teaching subject you chose to major in? Explain." These questions comprise one section of a larger questionnaire investigating components of students' environmental literacy. The questionnaire was developed by Goldman et al. (2008).

The questionnaire was conducted 3rd year students during the last month of the 2006 academic year.

### Background Data:

Students' average age was 28.2 years. The majority (84%) were females. Based on academic major, students were classified into two groups: those that studied environmentally-affiliated fields (EAF- environmental science, agriculture, geography, life sciences and Land-of-Israel studies), and those that studied non-environmentally-affiliated fields (NEAF -social studies, history, literature, mathematics, arts, physical education, etc.). Only 26.5% of the students majored in EAF.

### Data analysis:

The aim of the text analysis was to achieve conceptualization of the students' understandings of the environment and of the relationship between environmental topics and their teaching areas. Content analysis was conducted on written answers in two stages. While reading answers, words or sections of content were labeled with descriptive words. These were grouped into categories which were titled. The categories that emerged were grouped or organized into higher order categories/themes that correspond to models, scales and ideas from ecophilosophical literature.

---

## Results

### Students understanding of the concept 'environment'

Analysis of students' responses reveals a number of categories reflecting different aspects concerning of ways they perceived the environment, such as:

Holistic approach - Conceptualization of the environment as something holistic - all encompassing. The examples demonstrate different levels of detail and complexity of students' answers.

"Everything around us"

"The place I live in - the world - cosmos"

"all living organisms, plants and all the un-living around me... the environment is comprised of everything, even a building is part of the environment"

Romantic approach - A prevalent category associating of the environment with nature:

"Natural wild environment"

"Green, nature, bird-chirps, hikes, flowing rivers, pure water, fun, serenity",

"Pastoral environment - green grass, blue skies, bird chirps and butterflies, no noise or pollution"

Egoistic view -Students commonly perceive the environment with themselves as the center:

"Everything outside my body";

"Everything around me that helps me to live"

Interacting dimensions of environmental Issues (based on the model described by O'Donoghue and Russo, 2004) -

a) Biophysical- Perception of the environment in terms of living components and life support systems:

"Plants, air, water, animals"

"Area around me that includes: animals, plants, weather conditions"

"Gardens, forests, streams, open space"

b) Social – Perception of the environment in terms of aspects of human society:

"Area we live in from various aspects: population, norms and values, nature"

"Society, nature, man, relations between people"

"Culture, society"

c) Biophysical - Social Interactions: A more complex understanding of environment as interrelatedness between the biophysical and social dimensions:

"Nature, animals, people, interaction between components and mutual affects"

"Where I live, my town, state, world, plants, oceans, animals & people, and connections between them"

d) Economic dimension- Jobs, economic forces (1 answer only):

"Nature reserves cost money"

e) Political-Power, policy & decisions (two answers only):

"Political corruption"

"Enforce laws...no one to turn to"

Human-nature relationship - This is a value-based perception on a hierarchy ranging from humans-separate-from-nature through humans-as-part-of-the-environment to interdependence between human and natural environments.

a) Humans separate from nature:

"Trees, green, stream, without people"

"every natural area where mans' impact" isn't evident"

"Natural environment without damage"

b) Humans as part of the environment:

“Nature, trees, animals and people”

“Natural things and artificial things man created”

“All nature and urban areas people live in”

c) Interdependence between human and natural environments:

“Interaction between man and nature”

“Nature, animals, man, interactions between components and their mutual effects”

“All that exists. Nature, animals, people, interactions between all the components and their effects upon each other”

Value-of-nature - This is another value based conception on a continuum ranging from anthropocentric to ecocentric approaches.

a) Anthropocentric approach:

“Natural environment has use - it protects us and provides our many needs”

“All that provides a basis for my life”

“We need to protect the environment because it is important for managing healthy and productive life”

b) Ecocentric approach:

“Relating to earth worldly and not egoistically”

“How to live without damaging our partners in nature”

“Awareness of nature’s needs”

Environmental quality -A very common conceptualization identifies the environment either in terms of:

a) Man’s negative impact:

"pollution"; "refineries"; "dirty beaches, air & water pollution, cleanliness, trash, smoke"

b) Environmental protection, reflecting different eco-philosophical approaches-

1. Nature-conservation: "protecting animals"; "nature reserves"

2. Environmental stewardship: “I, as a citizen, can protect the environment by not dirtying it”

3. Wise-use: "We should protect the environment because it is necessary for healthy and effective lifestyles"; "..the environment. is for people, so we should protect it well .."; "the environment should be protected so our children and grandchildren can benefit from it".

Students' perception of the relations between environmental subjects and their area of teaching:

The majority of students (95%), both from environmentally-related and non-environmentally-related disciplines, feel that environmental topics are very relevant to their area of teaching. This relevance is perceived in two major ways: on educational premises and via subject-matter (sciences as well as social studies).

Via education - Various rationalizations (categories):

a) Environment and concern for environment is an educational value (Education for values)

"Our role as educators is to instill values related to the environment"

"I believe values of responsibility for your actions- not to treat the world as a trash barrel- can be transferred through education"

b) Universal value:

“Environment is connected to all aspects of life. Its validity is independent on place, language, knowledge.”

“Environmental topics relate to each person be him a teacher or not, moreover if he’s a teacher.”

c) Mission as educators - responsibility to educate for the environment:

"Teachers should know that environmental education isn't always provided at home, therefore we, as teachers of future generations, need to teach these subjects"



d) As teachers they should serve as role models:

"First of all, as an educator I need to provide a role model for my pupils"

Via subject-matter - Students provided various rationalizations for the affiliations between environmental issues and their area of teaching:

a) Their teaching area is viewed as framework for integrating environmental content:

"In all subjects of English- poetry, grammar, speech, etc.- I can teach about environment, I think I will do this"

b) Teaching area is viewed as a tool for promoting environmental values:

"Informal education provides an opportunity to convey the environmental message"

c) Environmental topics are viewed as a means for achieving educational goals of their teaching area:

"In special education we can integrate things from nature and environment to develop our target population in different aspects such as motor skills, etc"

"Informal education uses the environment as a method"

d) Some sought direct relation of subject matter:

"The laws of physics relate to our lives and what occurs in the environment and describe environmental processes"

Students who studied environmentally-related fields perceive this relevance mainly via subject-matter and their perceptions reflect the ecological emphasis of these disciplines and absence of social-science perspectives crucial for understanding environmental issues:

"Environment and ecology are parts of the subject Biology so the effects of different factors on components of the ecosystem are taught"

The majority of students who studied non-environmentally affiliated fields perceive the link between environment and their teaching area at an educational level.

## Conclusions and Implications

Analysis of the teacher students' texts concerning their understanding and conceptualization of the environment reveals categories that have been described in the literature, for example: dimensions of the environment and environmental issues (O'Donoghue & Russo, 2004), human-environment interrelationship, value of non-human nature (Robertson, 1993)

Similar to the study conducted by Van Petegem, Blicq and Ogonvalle, (2007) with preservice teachers in Zimbabwe, our results indicate that the students focus mainly on biophysical and social aspects, and their responses are almost devoid of reference to the cultural, political and economical aspects of the environment. Most of the students' responses about the environment are of descriptive nature and don't explain the environment with inclusion of references to processes. This has also been described by Shepardson (2005) and Desjean-Perrotta, Moseley & Cantu (2008) Furthermore, the majority of students, especially those who majored in non-environmentally-related disciplines, don't perceive the environment as a system of inter-relationships between all the components.

Responses of students who studied environmentally related fields reflect the biophysical and ecological emphasis of these disciplines and absence of social-science perspectives crucial for understanding environmental issues. This may reflect the mechanistic approach of the current environmentally- related programs which emphasize imparting of objective knowledge. This issue has been raised by others (Van Petegem et al., 2007).

A preliminary step in EE is moving learners to a position where they acknowledge the importance of environmental issues. That the majority of students, regardless of their major, see relevance of environment to their future function as teachers is encouraging and provides a basis to work upon with regards to directions for integrating EE within the framework of teacher training programs.

Eliciting teacher students' perceptions of the environment and their perceptions how this relates to their future role as educators enriches and deepens the emerging picture concerning the environmental literacy of graduates of teacher education colleges. These graduates, in the future, will be responsible for leading environmental education in the educational system.

## References

- Desjean-Perrotta, B., Moseley, C., & Cantu, L.E. (2008). Preservice teachers' perceptions of the environment: Does ethnicity or dominant residential experience matter? *Journal of Environmental Education*, 39(2), 21–31.
- Goldman, D., Yavetz, B. & Pe'er, S. (2006). Environmental literacy in teacher training in Israel: environmental behavior of new students. *Journal of Environmental Education* 38(1), 3-22.
- Goldman, D., Yavetz, B. and Pe'er, S. (2008). Environmental literacy in teacher training: a comparison between students at the onset and end of their studies. Report to Mofet Institute [in Hebrew].
- McKeown-Ice, R. & Deding, R. (2000). Socio-political-cultural foundations of environmental education. *Journal of Environmental Education*, 31(4), 37-45.
- Novak, J. D., & Gowin, D. B. (1984). *Learning how to learn*: Cambridge: Cambridge University Press.
- O'Donoghue R. & Russo, V. (2004). Emerging patterns of abstraction in environmental education: a review of materials, methods and professional development perspectives. *Environmental Education Research* 10(3), 331-351.
- Pe'er, S., Goldman, D. & Yavetz, B. (2007). Environmental literacy in teacher training: Environmental attitudes and knowledge of beginner students and their relationship to environmental behavior. *Journal of Environmental Education* 39(1), 45-59.
- Robertson, A. (1993). Eliciting students understanding: Necessary steps in environmental education. *Australian Journal of Environmental Education* 9, 95-114.
- Robertson, A. (1994). Toward constructivist research in environmental education. *Journal of Environmental Education* 25(2), 21-31.
- Shepardson, D. P. (2005). Students Ideas: What is an Environment? *Journal of Environmental Education* 36(4), 49-58.
- Van Petegem, P. V., Blicke, A. & Van Ogenvalle, J. V. (2007). Conceptions and awareness concerning environmental education: a Zimbabwean case study in 3 secondary teacher education college. *Environmental Education Research* 13(3), 287–306.
- Wals, A. (1992). Young adolescents' perceptions of environmental issues: Implications for environmental education in urban settings. *Australian Journal of Environmental Education*, 8(1), 45-58.
- Yavetz, B., Goldman, D. & Pe'er, S. (2009). Environmental literacy of preservice teachers in Israel: A comparison between students at the onset and end of their studies. *Environmental Education Research* 15(4), 393-415.

# EVALUATING THE DEVELOPMENT OF ENVIRONMENTAL LITERACY IN PRESERVICE TEACHERS

Daphne Goldman  
Beit Berl Academic College

Bella Yavetz  
Kibbutzim College of Education

Sara Pe'er  
Oranim Academic College of Education

## Abstract

*Sufficient preparation of preservice teachers in environmental education (EE) is a prerequisite for their future ability to implement effective EE. The recent increase in EE within educational system in Israel has highlighted a shortage of environmental educators. This longitudinal study compared, in a pretest-posttest design, development of environmental literacy (EL) during studies between teacher students who majored in environmentally-affiliated fields (EAF) and those who majored in non-environmentally-affiliated fields (NEAF). Students' EL and viewpoint regarding impact of college studies on EL variables and environmental-worldview were studied using a questionnaire. If studies have impact, the difference between two groups should increase during studies. Contrary to expected, results indicate that for the overall mean of environmental behavior, attitudes and knowledge, the difference between groups did not change. EAF-students acknowledged significantly greater contribution of studies to their EL as compared to other students and attributed significantly greater contribution of components of academic experience to development of environmental worldview. Most of the programs categorized as environmentally-affiliated do not include all necessary components of EE. They emphasize imparting objective knowledge with focus on biophysical and ecological aspects. Findings may provide starting points for decision makers and program developers on effective directions for disseminating EE in teacher-education programs.*

## Introduction

Although environmental studies are not mandatory in the national educational curriculum (K-12) in Israel, environmental subject matter has been integrated since the 1970s (Veisenstern 2004). In recent years, increasing public awareness and concern about the state of the environment has been paralleled by an increase in government commitment to expand environmental education (EE) in the public educational system, reflected by a growing number of schools that integrate EE into the school curriculum (Goldman Shwartz, Peled, Dunetz, Chen, Gavrieli & Grossman, 2003; Veisenstern 2004; Ministry of Environmental Protection, 2009). In 2004 the general director of the Ministry of Education published guidelines for implementing sustainable development principles as a part of EE in the educational system (Ministry of Education, Culture and Sport 2004). Most recently, in 2007, the Ministry of Education called for schools to dedicate 30 hours of EE in each year of elementary school (Ministry of Education 2007).

The recent increase in environmental education (EE) within the educational system in Israel has highlighted a shortage of teachers adequately trained to implement effective EE (Goldman, 2004). Teachers are the key to effective EE in the classroom. It follows that teacher education institutions hold the key to equipping teachers to effectively address EE (McKeown and Hopkins 2002). In Israel, the government commitment to expand EE in the school system has not extended to teacher education and no guidelines have yet been outlined that address EE in teacher preparation. Furthermore, to date, there is a paucity of EE research addressing questions pertinent to preparation of teachers.

Studies investigating the impacts of preservice teacher programs on components of students' environmental literacy (EL) are limited (Markku and Riitta 2000; Moseley, Reinke & Bookout 2002; Ozden 2008). This longitudinal study investigated the influence of whole undergraduate teacher education programs conducted in academic colleges in Israel on components of students' environmental literacy. Since environmentally-related disciplines, especially science, are usually seen as the most suitable framework for inclusion of EE (Van Petegem, Blicke & Van Ongevalle, 2007), the aim of this study was to compare development of EL between student teachers participating in training programs that differ in their environmental component.

## **Rationale**

The rationale for this study is based on the following premises: Education is a crucial element in achieving sustainable development (Archie & McCrea, 1998; Orr, 1992; UNCED, 1992; UNESCO-UNEP, 1976; UNESCO-UNEP, 1978; Since society perceives the formal education system as holding major responsibility for environmental education, teachers play a key role towards achieving sustainable societies (McKeown & Hopkins, 2002); This implies the necessity of adequate preparation of student teachers in the realm of EE.

There is empirical evidence indicating that insufficient teacher preparation is one of the major factors hindering the implementation of effective EE in schools (Cutter & Smith, 2001; Knapp, 2000; McKeown-Ice, 2000; UNESCO, 1997). To the time this study was initiated, no comprehensive study had been conducted in Israel focusing on characterizing the EL of students in teacher-training programs. Findings may provide starting points for decision makers and for program developers on effective directions for disseminating EE within the structural framework of current programs.

## **Methods**

### **Participants**

The study was conducted in a pretest and posttest design with 214 students in three large teacher education colleges in Israel (Beit Berl Academic College, Kibbutzim College of Education, Oranim Academic College). The three colleges in which the study was conducted are among the largest in Israel and are situated in different regions of the country. Hence, the study covered a heterogeneous population steered towards the teaching profession. The structure of the academic programs in these colleges is similar and is comprised of three components: disciplinary studies in one or two major fields, education and pedagogy studies and practical experience - the two latter designed according to the students' educational training track.

### **Instrumentation**

The questionnaire was developed and validated by the authors (Goldman, Yavetz & Pe'er, 2006; Pe'er, Goldman & Yavetz, 2007; Yavetz, Goldman & Pe'er, 2009). It consisted of 6 sections: 1-4 were administered to both pretest and posttest groups; 5 & 6 were administered to posttest group.

Section 1- Self-reported environmental behavior: Respondents were asked to state to what extent they carry out 21 environmentally related activities, using a Likert-type scale with five possible responses (1-never, 2-very seldom, 3-sometimes, 4-often, 5-almost always).

Section 2- Environmental attitudes: This section included 23 statements to which the students were asked to state their extent of agreement using a 5-point, Likert-type scale with 5 possible responses (1-strongly disagree, 2-disagree, 3-have no opinion, 4-agree, 5-definitely agree).

Section 3- Environmental and ecological knowledge: This section included 23 multiple-choice questions pertaining to ecological and environmental knowledge. Since this research was designed as a longitudinal study, the knowledge inventory was constructed so as to characterize the knowledge level of high school graduates at the onset of their college studies and the influence of students' college education on their knowledge. Hence, the questions were constructed in two groups- basic and advanced- according to the level of knowledge evaluated. The content of the questions dealt with four themes: fundamental ecological principles and processes, global environmental issues, local environmental issues, environmental actions strategies.

Section 4- Background variables: Questions about students' age, gender, type of hometown, ethnic background, parents' level of education, as well as their disciplinary major.

Section 5- Attitudes regarding impact of studies on self-perceived EL: This section included 3 items (rated on a 5-point likert scale from 1-no contribution at all 5-very strong contribution) evaluating students' attitudes regarding the contribution of college studies to their self-perceived environmental behavior, attitudes, knowledge.

Section 6- Attitudes regarding factors contributing to development of environmental worldview: This section included 6 items (rated on a 5-point likert scale from 1-no contribution to 5-very strong contribution). Evaluating students' attitudes regarding influence of various factors (disciplinary studies, educational studies, internship, on-campus events and activities, events not related to their academic studies, personal maturation) to the development of a personal environmental worldview.

The pretest questionnaire was conducted with beginner students during the first month of 2003 academic year and the posttest questionnaire was conducted with the same group of students during the last month of 2006 academic year (advanced students).

#### Background Data

Students' age at onset of studies was  $24 \pm 2.5$ . The majority (86.6%) were females. Based on academic major, students were classified into two groups: those studying environmentally-affiliated fields (EAF- environmental studies & agriculture, geography, science, biology and chemistry, and Land-of-Israel studies), and those that studied non-environmentally-affiliated fields (NEAF -social studies, history, literature, mathematics, arts, physical education, etc.). Only 29% of the students majored in EAF, 71% majored in NEAF. Distribution of these background data was similar in the three colleges investigated.

#### Methods of data analysis

SPSS 14 was used for data analysis. T-test was used to examine differences between EL-variables at beginning and towards end of studies, and differences between EAF and NEAF students' attitudes regarding influence of studies on EL. Repeated measure MANOVA was used to examine major effects of disciplinary major and time factor, and interaction between these, on EL-variables.

## Results

### Self-reported behavior

The difference in overall behavior between EAF and NEAF-students did not change during studies. Regarding behavioral categories, EAF- students reported significantly greater participation in *nature-related leisure activities* and *environmental activism* both at the beginning and towards end of studies. Difference between EAF and NEAF-increased significantly after three years of college as compared to these groups at onset of studies for *recycling efforts* and *citizenship action* (Table 1).

**Table 1. Interaction between changes in students' environmental behavior after three years of studies and their disciplinary major (scores range from 1-never to 5- almost always)**

Environmental behavior category		EAF Mean $\pm$ SD (n=62)	NEAF Mean $\pm$ SD (n=146)	t	p	F (1, 206)	Sig.
Resource-conserving actions with personal financial benefit	Pre-test	4.40 $\pm$ 0.74	4.37 $\pm$ 0.65	0.283	.778	0.244	.622
	Post-test	4.39 $\pm$ 0.69	4.30 $\pm$ 0.72	0.748	.455		
Environmentally- responsible consumerism	Pre-test	3.98 $\pm$ 0.91	3.86 $\pm$ 0.91	0.972	.332	0.983	.323
	Post-test	4.13 $\pm$ 0.76	4.13 $\pm$ 0.70	-0.080	.937		
Nature-related leisure activities	Pre-test	3.79 $\pm$ 0.71	3.53 $\pm$ 0.71	2.432	.016	0.670	.414
	Post-test	3.92 $\pm$ 0.70	3.56 $\pm$ 0.66	3.433	.001		
Recycling efforts	Pre-test	2.57 $\pm$ 1.14	2.82 $\pm$ 1.07	-1.450	.149	3.896	.050
	Post-test	3.12 $\pm$ 1.13	3.09 $\pm$ 1.09	0.263	.792		
Citizenship action	Pre-test	2.41 $\pm$ 0.76	2.28 $\pm$ 0.67	1.202	.231	6.016	.015
	Post-test	2.73 $\pm$ 0.82	2.36 $\pm$ 0.68	3.487	.001		
Environmental activism	Pre-test	1.68 $\pm$ 1.10	1.39 $\pm$ 0.65	2.449	.015	0.015	.903
	Post-test	1.84 $\pm$ 1.06	1.53 $\pm$ 0.80	2.243	.026		
Overall mean of behavior items	Pre-test	3.25 $\pm$ 0.47	3.14 $\pm$ 0.49	1.398	.164	1.724	.191
	Post-test	3.44 $\pm$ 0.52	3.25 $\pm$ 0.47	2.683	.008		

### Attitudes

EAF- students acknowledged significantly greater importance of *environmental education* both at beginning and towards end of studies. Only for *value-of- nature* did the difference between EAF and NEAF-students significantly change during studies, reflecting a decrease in EAF-students' scores (Table 2).

**Table 2. Interaction between changes in students' environmental attitudes after three years of studies and their disciplinary major (score range: 1-strongly disagree to 5-definitely agree)**

Environmental attitude category		EAF	NEAF	t	p	F (1,207)	Sig.
		Mean $\pm$ SD (n=62)	Mean $\pm$ SD (n=149)				
Importance of EE in educational system	Pre-test	4.27 $\pm$ 0.44	4.06 $\pm$ 0.56	2.566	.011	0.180	.672
	Post-test	4.42 $\pm$ 0.45	4.23 $\pm$ 0.53	2.369	.019		
Locus of Control	Pre-test	4.07 $\pm$ 0.48	4.14 $\pm$ 0.44	-1.141	.255	0.046	.831
	Post-test	4.10 $\pm$ 0.49	4.20 $\pm$ 0.45	-1.285	.200		
Environmental legislation and law enforcement	Pre-test	3.85 $\pm$ 0.60	3.98 $\pm$ 0.60	-1.439	.152	1.568	.212
	Post-test	4.11 $\pm$ 0.56	4.11 $\pm$ 0.66	-0.020	.984		
Value of natural environment	Pre-test	3.77 $\pm$ 0.77	3.88 $\pm$ 0.58	-1.132	.259	6.922	.009
	Post-test	3.65 $\pm$ 0.88	3.99 $\pm$ 0.59	-3.316	.001		
Priorities for national resource-management policy	Pre-test	3.60 $\pm$ 0.69	3.50 $\pm$ 0.72	0.894	.373	0.534	.466
	Post-test	3.94 $\pm$ 0.67	3.76 $\pm$ 0.74	1.579	.116		
Overall mean of the attitude items	Pre-test	3.94 $\pm$ 0.37	3.94 $\pm$ 0.39	-0.138	.891	0.054	.817

### Knowledge

Results indicate that the difference between the two groups of students changed significantly during studies only for basic level environmental knowledge (Table 3).

**Table 3. Interaction between changes in students' environmental knowledge after three years of studies and their disciplinary major. Maximum score is 100.**

Level of Question		EAF	NEAF	t	p	F (1,209)	Sig.
		Mean $\pm$ SD (n=62)	Mean $\pm$ SD (n=149)				
Basic	Pre-test	43.19 $\pm$ 21.49	49.44 $\pm$ 22.24	-1.878	.062	5.436	.021
	Post-test	52.69 $\pm$ 23.80	49.22 $\pm$ 24.92	1.000	.319		
Advanced	Pre-test	35.60 $\pm$ 18.31	31.45 $\pm$ 18.66	1.480	.140	0.046	.831
	Post-test	40.44 $\pm$ 20.65	35.57 $\pm$ 20.30	1.580	.116		
Overall mean of knowledge	Pre-test	38.57 $\pm$ 17.11	38.49 $\pm$ 17.84	0.030	.976	1.983	.161
	Post-test	45.23 $\pm$ 18.40	40.81 $\pm$ 20.09	1.493	.137		

Attitudes regarding impact of studies on self-perceived EL

EAF-students acknowledged significantly greater contribution of studies to their self-perceived environmental behavior, attitudes and knowledge as compared to NEAF-students (Table 4).

**Table 4. Influence of disciplinary major on students' perceptions regarding contribution of studies to environment knowledge, attitudes and behavior (scores range from 1-no contribution at all, to 5-very strong)**

Environmental literacy component	EAF	NEAF	t	p
	Mean $\pm$ SD (n=61)	Mean $\pm$ SD (n=144)		
Behavior	3.55 $\pm$ 1.15	2.51 $\pm$ 1.12	5.982	.000
Attitudes	3.40 $\pm$ 1.02	2.37 $\pm$ 1.04	6.490	.000
Knowledge	3.77 $\pm$ 0.93	2.57 $\pm$ 1.03	7.669	.000

Attitudes on factors contributing to development of environmental worldview

We also investigated students' perceptions regarding influence of various factors (formal and non-formal components of studies as well as factors unrelated to studies) during their academic experience on development of their environmental worldview. Environment-related majors acknowledged significantly greater importance of all the factors investigated and identified disciplinary studies as most significant influential factor in comparison to other students who identified personal maturation (Table 5).

**Table 5: Influence of disciplinary major on students' perceptions regarding influence of factors during academic experience to development of personal environmental worldview (scores range from 1-no contribution at all, to 5-very strong)**

Factor	EAF	NEAF	t	p
	Mean $\pm$ SD (n=61)	Mean $\pm$ SD (n=144)		
Disciplinary studies	4.30 $\pm$ 1.14	2.13 $\pm$ 1.35	10.410	.000
Education and teaching studies	3.03 $\pm$ 1.21	2.23 $\pm$ 1.24	4.260	.000
Practical experience	3.11 $\pm$ 1.36	2.42 $\pm$ 1.40	3.270	.001
On campus events and activities	2.63 $\pm$ 1.21	2.17 $\pm$ 1.28	2.385	.018
Events not directly connected to studies	3.16 $\pm$ 1.27	2.62 $\pm$ 1.36	2.579	.011
Processes of personal maturation	3.77 $\pm$ 1.17	3.13 $\pm$ 1.40	2.189	.030



---

## Conclusions and Implications

The main question this study investigated was: did students who majored in environmentally-affiliated disciplines (environmental studies & agriculture, geography, science, biology and chemistry, and Land-of-Israel studies) develop a higher level of EL as compared to other students? It would be expected that if academic studies have significant impact, differences between these two groups of students would increase as a result of studies. Contrary to expected, results indicate that for the overall mean of EL-variables, differences between the two groups did not change during their studies. In spite of the significant change that developed during studies in the difference between the two groups for *recycling efforts* and *citizenship action*, involvement of environmentally-affiliated students' in these behavioral categories towards the end of their studies still reflects only limited responsible environmental behavior. Both groups of students demonstrated overall pro-environmental attitudes both as beginner and advanced students. As expected, environmentally-affiliated students acknowledge significantly greater importance of *environmental education*. Unexpected, was the decrease in environmentally-supportive attitudes for *value of the natural environment* after studying EAF-disciplines (table 2). This category contained items based on the NEP-scale, which specifically evaluate fundamental values towards non-human components of nature (Dunlap, Van Liere, Mertig & Jones., 2000). The limited ecological-environmental knowledge these students demonstrated towards the end of their studies (Table 3) may suggest that they still lack the sufficient knowledge foundation necessary for developing a more ecological worldview and less anthropocentric orientation. This situation has been reported for preservice teachers (Desjean-Perrotta, Moseley & Cantu, 2008). The low environmental knowledge base found in this study has also been reported for other preservice students (Stir, 2006).

Although environmentally-affiliated majors attributed significantly greater contribution of studies to their environmental knowledge, attitudes and behavior, a gap exists between these views and the actual impact studies had on these EL-variables. Such a discrepancy has been reported by others (Moody & Hartel, 2007).

In summary, the EL of graduates of environmentally-affiliated programs is discouraging and insufficient for effective environmental educators. This is especially crucial in view of initiatives of Ministry of Education and Ministry of Environmental Protection to advance EE in the public school system. Inclusion of environmental subjects in teacher training programs is currently conducted mainly via the disciplinary component. Most of the programs categorized in this study as environmentally-affiliated emphasize imparting objective disciplinary knowledge with focus on biophysical aspects (for example: environmental science, ecology). In view of this, results of this study support that ecology education is not synonymous with environmental education. Programs limited to the study of concepts from natural sciences are insufficient in enabling students to fully comprehend and analyze the complex environmental-social issues of our world and daily life necessary for addressing sustainability education in the school system (McKeown-Ice & Deding, 2000) and for developing more responsible environmental behavior so that teachers can serve as role models for their students.

Findings of this study may provide starting points in two aspects:

- a) Bringing EE into policy of teacher education institutions- For decision makers, the findings provide empirical evidence to ground the imperative for policy change.
- b) For program developers and academic staff- Findings suggest effective directions for disseminating EE within structural framework of existing programs. These include reorienting environmentally related programs to EE by broadening their scope to include socio-economic-political dimensions crucial for addressing sustainability issues, introducing an EE component into all programs (disciplinary, pedagogue), adapting this to each department, realizing the potential of campus activities as an avenue for active involvement of students in sustainability projects and development of environmental leadership.

## References

- Archie, M. and McCrea, E. (1998). Environmental education in the United States: Definition and Direction. In M. Archie (Ed.), *Environmental education in the United States- past, present, and future. Collected Papers of the 1996 National Environmental Education Summit* (pp. 1-8). North American Association for Environmental Education.
- Cutter, A. and Smith, R. (2001). Gauging primary school teachers' Environmental Literacy: An issue of priority. *Asia Pacific Education Review* 2(2), 45-60.
- Desjean-Perrotta, B., Moseley, C. & Cantu, L.E. (2008). Pre-service teachers' perceptions of the environment: does ethnicity or dominant residential experience matter? *Journal of Environmental Education* 39(2), 21 – 31.
- Dunlap, R.E., Van Liere, K.D., Mertig, A.G. & Jones, R.E. (2000). Measuring endorsement of the New Ecological Paradigm: A revised NEP scale. *Journal of Social Issues* 56(3), 425–442.
- Goldman, D. 2004. Training teachers for environmental education in Israel - the situation. In: T. Tal, (Ed.), *National Priorities in the Field of Environmental Quality- Environmental Education* (pp. 92-7). Technion- Israel Institute of Technology, Samuel Neaman Institute for Advanced Studies in Science and Technology [In Hebrew].
- Goldman, D., Shwartz, E., Peled, O., Dunetz, D., Chen, S., Gavrieli, A. & Grossman, S. (2003). *Policy Regarding Environmental Education in Israel: The position of Environmental Education and Towards a New Vision- Position Paper*. Israel: National Council for Environmental Quality (In Hebrew).
- Goldman, D., Yavetz, B. & Pe'er, S. (2006). Environmental literacy in teacher training in Israel: Environmental behavior of new students. *Journal of Environmental Education* 38(1), 3–22.
- Knapp, D. (2000). The Thessaloniki Declaration: A wake-up call for environmental education? *Journal of Environmental Education* 31(3), 32-39.
- Markku, K. and Riitta, W. (2000). An environmental education program for teacher trainers in Finland. *Journal of Environmental Education* 31(2), 31–37.
- McKeown-Ice, R. (2000). Environmental Education in the United States: A survey of preservice teacher education programs. *Journal of Environmental Education* 32(1), 4-11.
- McKeown-Ice, R. & Dedinger, R. (2000). Socio-political-cultural foundations of environmental education. *Journal of Environmental Education* 31(4), 37-45.
- McKeown, R., & Hopkins, C. (2002). Weaving sustainability into pre-service teacher education programs. In W. F. Filho (Ed), *Teaching Sustainability at Universities - Towards curriculum greening*, (pp. 251-274). Frankfurt: Peter Lang.
- Ministry for Environmental Protection (2009). *The Green School* [In Hebrew]. Retrieved on 18.05.2009 at: <http://www.sviva.gov.il/bin/en.jsp?enPage=BlankPage&enDisplay=view&enDispWhat=Zone&enDispWho=greenschools&enZone=greenschools>
- Ministry of Education, Culture and Sport (2004). General Director's release: Implementing Education for Sustainable Development in the Educational System [In Hebrew]. Jerusalem.
- Ministry of Education. 2007. General Director: Environmental education – A Main Challenge in the Educational System in Israel, Action Program to Promote Environmental Education [In Hebrew]. Jerusalem.
- Moody G.L. and Hartel, G.H. (2007). Evaluating an environmental literacy requirement chosen as a method to produce environmentally literate university students. *Journal of Sustainability in Higher Education* 8(3), 355 – 370.
- Moseley, C., Reinke, K., & Bookout, V. (2002). The effect of teaching outdoor environmental education on pre-service teachers' attitudes toward self-efficacy and outcome expectancy. *Journal of Environmental Education* 34(1), 9–15.
- Orr, D.W. (1992). *Ecological literacy: Education and the transition to a postmodern world*. Albany, NY: State University of New York Press.
- Özden, M. (2008). Environmental awareness and attitudes of student teachers: An empirical research. *International Research in Geographic and Environmental Education* 17(1), 40–85.

- Pe'er, S., Goldman, D. & Yavetz, B. (2007). Environmental literacy in teacher training: Environmental attitudes, knowledge and behavior of beginning students. *Journal of Environmental Education* 39(1), 45–59.
- Stir, J. (2006). Restructuring teacher education for sustainability: Student involvement through a “strengths model.” *Journal of Cleaner Production* 14(9–11), 830–836.
- UNCED (1992). *Agenda 21: Programme action for sustainable development*. NY: United Nations.
- UNESCO (1997). *Educating for a sustainable future: A transdisciplinary vision for concerted action*. UNESCO Publication No. EPD-97/Conf.401/CLD.1). Paris: UNESCO.
- UNESCO-UNEP (1976). The Belgrade Charter. *Connect* 1(1), 1-9.
- UNESCO-UNEP (1978). The Tbilisi Declaration. *Connect* 3(1), 1-8.
- Van Petegem, P., Blicke, A. & Van Ongevalle, J. (2007) . Conceptions and awareness concerning environmental education: a Zimbabwean case-study in three secondary teacher education colleges. *Environmental Education Research* 13( 3), 287–306.
- Weisenstern, I. 2004. The subject 'Environmental Science' in the educational system. In: T. Tal [Ed.], *National Priorities in the Field of Environmental Quality- Environmental Education* (pp.20-3). Technion, Israel Institute of Technology, Samuel Neaman Institute for Advanced Studies in Science and Technology [In Hebrew].
- Yavetz, B., Goldman, D. & Pe'er, S. (2009). Environmental literacy of preservice teachers in Israel: A comparison between students at the onset and end of their studies. *Environmental Education Research* 15(4), 393-415.



# SOCIAL-PSYCHOLOGICAL FACTORS AND PERSONAL DETERMINANTS OF STUDENTS THAT INFLUENCE EFFECTIVITY OF ENVIRONMENTAL EDUCATION

Daniel Kuracina

Comenius University in Bratislava, Slovakia

Lenka Ondrusova

Comenius University in Bratislava, Slovakia

## Abstract

*It is often spoken about the necessity of environmental education over the last years. Feelings, emotions, belief, and knowledge are equally important for formation of environmental attitudes. Environmental education should also deal with impartial social-psychological factors that affect against the propaganda based on knowledge. The most important are personal predispositions like altruism, selfishness, responsibility, and good-will to cooperate. This study deals with attitudes to environmental realities and also tries to determine existence of relationship between environmental opinions and gender stereotypes, climate of the class and creativity. We were interested in comparing particular Slovak regions. Environmental attitudes are formed mostly by the influence of environmental education. Very important is also environment of students outside the school for example their family, community, media etc. Gender determinants, gender stereotypes, altruism, good social ties are also dependent variable in relationship with environmental attitudes. Creativity, on the other hand, seems to be independent variable.*

## Introduction

The contribution was supported by the Cultural and Educational Grant Agency, Science Grant Agency of the Ministry of Education of the Slovak Republic – Projects KEGA 3/3032/05 and VEGA 1/0858/08.

Imaginings of relationship between man and nature as well as the value of nature itself create the ground for protection of nature, setting for effective communication between conservationists and community, and also create theoretical basis for environmental and further education. J. A. POOLEY – M. O'CONNOR (2000) dealt with study of information resources and their impact on environmental attitudes. They came to the conclusion that in formation of environmental attitudes are equally important feelings, emotions, belief, and knowledge. The reason, that was given, is influence of experiences and practice on attitudes. Determination of environmental behavior determinants helps to improve programs for environmental education. D. MESSICK (1986) draws attention to so called social dilemma. On one hand there is considerable attention devoted to environmental problems worldwide, on the other hand there is passivity and unconcern and problems are not solved in real life. Environmental education should also deal with impartial social-psychological factors that affect against the propaganda based on knowledge. The most important are personal predispositions like altruism, selfishness, responsibility, and good-will to cooperate. Necessity is also rising of environmental sensitivity. M. FINGER (1994) suggests creating of new conception of environmental education that can explain mentioned social dilemma. This conception should devise education activities and identify factors, which can influence the environmental behavior. Here M. FINGER (1994) offers his option of new conception. It is based on environmental education that is allowed to each of us in social and cultural context. When we think about person and his (her) own world, we speak about environment in which

every man creates his own opinion and sense of being. Environmental attitudes and behavior are based on our experiences and our view of life and world. R. DUNLAP - K. VAN LIERE (1978) created standardized questionnaire NEP, which is aimed at detection of change of attitudes (social environmentalism). Results in some European countries shows that knowledge of people moves towards environmentally friendly attitudes. Traditional culture of society can also have enormous influence on environmentally friendly behavior (SCHULTZ, 2001) - individualism versus collectivism. Modern way of life however slowly wipes away the differences. Every new element is often very quickly assimilated. Interesting is comparison of our testing results with those of other authors. There were no differences between sexes of participants in results yet. Gender determinants however are important in incorporating of person into the hierarchy of society that forms attitudes toward environment.

## **Rationale**

We were interested in comparing particular Slovak regions. Big differences are mostly in economic trend of regions (technical, agricultural). Are there differences among the particular regions? It is often said that students in countryside and small villages are closer to the nature what means that they have more positive environmental attitudes. Other important question was difference between sexes or difference between classical and modern approach toward gender stereotypes. Is environment influenced by upbringing with or without gender stereotypes? Do we improve our empathy and sensibility? Young man who is prosperous in social sphere has positive ties with community. Is there relationship between climate of school, climate of class (students feel good among his classmates and there are positive social ties) and environmental attitudes? And what about creativity, and environmental education? Is creative person more empathic toward environment?

## **Methods**

Research in general was realized in years 2005, 2006 and 2007 and we used questionnaire assigned for 5th to 9th grade of primary schools. Diagnostic and evaluation of social-psychological factors and personal determinants that forms environmental attitudes of pupils was done in 18 cities in Slovakia (approx. 3000 participants). The main aim was detection of differences in particular Slovak regions. We did quantitative analysis – polarising techniques (multidimensional questionnaire, NEP questionnaire). We had available choice. We tried to choose schools with accurate properties for our research. The main research was preceded by pilot research. Questionnaire consists of Likert-type scales indicating attitude. Items are divided into four sections: 1)Section I – Gender, 2) Section II – Climate of class and school, social support, 3) Section III - Protection and production of environment – NEP, 4)Section IV – Creativity - Breskin creativity test.

This article deals only with 8th and 9th grade students, because this group of young people are at the same level from the psychological point of view and we mostly paid attention upon section I and section II. We think that in these two sections the most important are dependent variables: gender determinants, gender stereotypes, altruism, and good social ties.

---

NEP questionnaire

1. If a human does something against nature, it ends up with a disaster.	1 2 3 4 5
2. Balance in nature is very fragile and easily disturbed.	1 2 3 4 5
3. Balance in nature is strong enough to resist human influence and modern technologies.	1 2 3 4 5
4. People seriously damage environment“. This statement received the most positive rating.	1 2 3 4 5
5. So called „ecological crisis“is often exaggerated.	1 2 3 4 5
6. If mankind keeps treating nature the same way as now, big ecological catastrophe will come soon.	1 2 3 4 5
7. Human wit and ingenuity ensure that the Earth will become untreatable.	1 2 3 4 5
8. Despite of knowledge and modern inventions, mankind is still controlled by laws of nature.	1 2 3 4 5
9. People will learn how the laws of nature work to regulate the nature.	1 2 3 4 5
10. The Earth is as a space ship with limited area and resources.	1 2 3 4 5
11. We are getting near to maximum amount of people that Earth can earn living.	1 2 3 4 5
12. The Earth has many natural resources if we learn to use them more effectively.	1 2 3 4 5
13. Plants and animals have equal living rights as human.	1 2 3 4 5
14. People have right to change nature according to their needs.	1 2 3 4 5
15. People were predetermined to rule the nature.	1 2 3 4 5
16. Laws and standards that prevent the environmental pollution became very strict in last periods of time.	1 2 3 4 5
17. Laws and norms preventing pollution of environment should be much stricter.	1 2 3 4 5
18. It is necessary to measure pollution more strictly in order to keep nature clean.	1 2 3 4 5
19. Ecological and environmental policy is very onerous for the industry.	1 2 3 4 5
20. I would sign petition for more strict laws protecting nature.	1 2 3 4 5
21. I would participate in protest against firms/corporations which harm the nature...	1 2 3 4 5
22. I would participate in the protest against current state of environment. current state of Environment is not good.	1 2 3 4 5
23. I plan to attend actions that are organized by the protectionist groups.	1 2 3 4 5
24. If I learn about some protectionist action or I read about it in newspapers, I will inform my parents and friends.	1 2 3 4 5
25. I plan to write a letter to related offices in future in order to rise my contribution to projects and organizations for nature protection	1 2 3 4 5

## Results

Total average value of all attitudes to environmental realities of all respondents, both boys and girls, is 2.39. The outcome is that the attitude of 8th and 9th grade pupils toward some environmental realities was generally positive. Results of our research show these items as positive:

Item E1: „If a human does something against nature, it ends up with a catastrophe“.

Item E2: „Balance in nature is very fragile and easily disturbed“.

Item E3: „Balance in nature is strong enough to resist human influence and modern technologies“.

Item E4: „People seriously damage environment“. This statement received the most positive rating.

item E6: „ If mankind keeps treating nature the same way as now, big ecological catastrophe will come soon“.

Item E8: „Despite of knowledge and modern inventions, mankind is still controlled by laws of nature“.

Item E10: „The Earth is as a space ship with limited area and resources“.

Item E12: „The Earth has many natural resources if we learn to use them more effectively“.

Item E13: „Plants and animals have equal living rights as human“.

Item E14: „People have right to change nature according to their needs“.

Item E15: „People were predetermined to rule the nature“.

Item E17: „Laws and norms preventing pollution of environment should be much stricter“.

Item E18: „It is necessary to measure pollution more strictly in order to keep nature clean“.

Item E20: „|I would sign petition for more strict laws protecting nature. “

Item E21: „I would participate in protest against firms/corporations which harm the nature“.

Item E22: „ I would participate in the protest against current state of environment. Current state of Environment is not good“.

The only negative valued item was E25: „I plan to write a letter to related offices in future in order to raise my contribution to projects and organizations for nature protection“. The rest of Questionnaires were valued as neutral.

Intersexual differences: Average value of boys' attitudes to all environmental realities in questionnaire was 2.43 and value of girls was 2.35. Environmental attitudes of girls were in comparison with boys more positive where the difference was 0.08. J. Burger – J. Sanchez (1998) attain similar results, attitudes of women are more positive in general. From these results it is clear that intersexual differences in environmental attitudes do exist. During analysis of attitudes to each environmental question, we have found items where the difference between boys and girls are minimal (0.01 to 0.08) for example questionnaire items: E6, E12, E7, E17, E18, E8, E9, E5 and E11. Questionnaire items: E3, E19, E21 and E23 showed significant intersexual differences (0, 29 -0, 39). We have found the biggest disparity in statement E23 („ I plan to take part in an event organized by Environmental group“) where the difference between the average values of boys and girls was 0.59. The reason for this difference could be a greater willingness of girls to actively take part in environmental activities (See Table 1).



Table 1. It shows average values of attitudes of pupils of 8th and 9th grade of primary school toward chosen environmental realities together for all respondents, as well as for boys and girls separately. Attitudes with lower values are more positive than attitudes with higher values. The table shows also amount of intersexual attitude differences. In the last column, we can find total average value of all attitudes in individual categories: total, boys, girls, and average value of intersexual difference. E1, E2 up to E25 shows individual questionnaire items of environmental section of used questionnaire. AP stands for arithmetic average or average value of attitudes. The lower the value is, the more positive the attitude is.

Item	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13
Total	2,21	1,60	2,23	1,38	2,84	1,88	2,87	2,05	3,27	2,23	2,84	1,83	1,83
Girls	2,10	1,65	2,43	1,27	2,80	1,88	2,84	2,08	3,31	2,10	2,88	1,84	1,88
Boys	2,31	1,55	2,05	1,47	2,87	1,87	2,89	2,02	3,24	2,35	2,80	1,82	1,78
Difference	0,21	0,10	0,38	0,20	0,07	0,01	0,05	0,06	0,07	0,25	0,08	0,02	0,10
Item	E14	E15	E16	E17	E18	E19	E20	E21	E22	E23	E24	E25	AP
Total	2,09	2,24	3,31	1,97	1,69	3,11	1,77	2,46	2,33	3,45	2,79	3,55	2,39
Girls	1,96	2,16	3,24	2,00	1,76	2,90	1,86	2,31	2,27	3,14	2,65	3,41	2,35
Boys	2,20	2,31	3,36	1,95	1,64	3,29	1,69	2,60	2,38	3,73	2,91	3,67	2,43
Difference	0,24	0,15	0,12	0,05	0,06	0,39	0,17	0,29	0,11	0,59	0,26	0,26	0,17

Using Kolmogorov-Smirnov test we figured out whether mentioned intersexual difference in environmental attitudes of pupils of primary school is statistically significant. We received the following values: DN = 0,207792, K-S statistics = 1, 05777 a P value = 0,213524. When the calculated P value is higher than 0.05 between 2 groups of pupils (girls and boys) then the difference in attitudes to environmental realities it is not statistically significant at 95 % confidence level (See Figure 1).

### Box-and-Whisker Plot

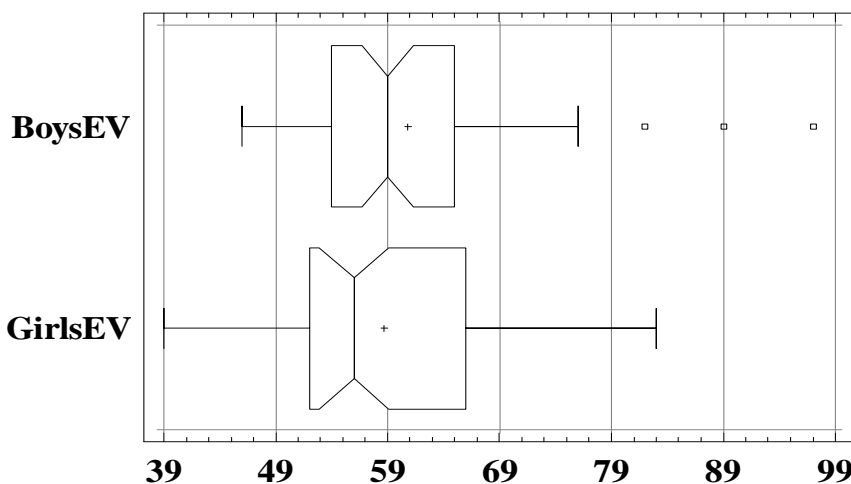
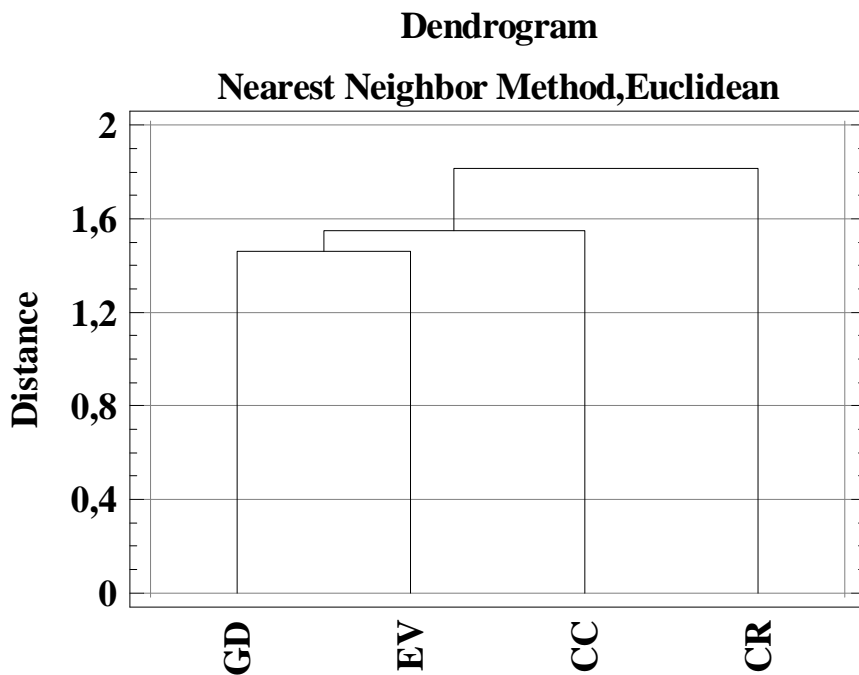


Figure 1. Box and Whisker plot, Kolmogorov-Smirnov test-environmental attitudes (2 groups: boys and girls)

Factor and cluster analysis also showed presence of two elements. First one is connected with attitudes towards environmental education, gender and social support. Second one is connected only with creativity. This means that attitudes toward environmental education are connected with attitudes toward gender and social support. Person that thinks up-to-date, without classical gender stereotypes has also positive opinion about environmental problems. Woman can play football, man can do the ballet and boy can play with dolls as well as with cars. Sex is not important but hobbies and interests are. Environment depends on our tolerance which is transferred from one generation to another, from parents to children (See Table 2. and Figure 2.).

**Table 2. Factor analysis, Factor loading matrix after varimax rotation (4 groups: EV – environmental education, GD – gender, CC – classroom climate, CR – creativity).**

Variable	Factor 1	Factor 2	Communality
EV	0,678331	0,279147	0,538056
GD	0,721696	0,00307245	0,520855
CC	0,582631	-0,487402	0,57702
CR	0,150059	0,859387	0,761064



**Figure 2. Cluster analysis (4 groups: GD – Gender, EV – environmental education, CC – classroom climate, CR – creativity).**

Social support – when social demands of person with good social ties are satisfied, that person can perceive his environment more altruistically. If he (she) can become a part of society in school and create positive ties, he (she) will perceive his (her) environment in positive way. Children, coward or aggressive, have often troubles in school. Their problem is that they are not able to be a part of collective. This people live in their own world and their communication with others is very sporadically or none.

Creativity – one of the most important parts of creativity is thinking. The stress is put upon divergent thinking of students. The ability to think in different way, different approaches in one situation enable creation of new unconventional answers. Very often students use synthetic cogitation – connection of different statements or facts that seems not to be related. Environmental education thinks in the same way. We connect Ethics, Philosophy,

Economics, Law, Biology, Chemistry, and Physics in one coherent unit. Here we assumed primary dependency with environmental attitudes. Missing of primary dependency however does not mean that there is not any dependency. This determination needs to be verified with research concentrated upon creativity.

Using Multiple range test we figured out whether mentioned intersexual difference in environmental attitudes, gender attitudes, classroom climate and creativity of pupils of primary school is statistically significant. Only difference we found was in gender attitudes (See Table 3).

**Table 3. Multiple range test (8 groups: GD – gender, EV – environmental education, CC – classroom climate, CR – creativity, B – Boys, G – Girls, \*denotes a statistically significant difference).**

Contrast	Difference	+/- Limits
EVB - EVG	-0,00176153	0,0907742
GDM - GDG	*-0,285141	0,0907742
CCB - CCG	-0,0652455	0,0907742
CRB - CCG	0,0286024	0,0907742

We assumed statistically significant differences among schools and regions but factor and cluster analysis showed that there are not such differences between schools as well as between regions. The surprising point was factor analysis that showed attitudes of students which are very similar although they are from different schools or regions. First of all we assumed that students from countryside and small villages have stronger ties with the nature than city students. Probably this contrast, that was significant in the past, has slowly disappeared. That can be caused by informational resources and by opportunities in traveling. Population is more homogenous with their knowledge about their own country or some other countries (See Table 4. and Figure 3.).

**Table 4. Factor analysis, Factor loading matrix after varimax rotation (12 groups: Col\_1 – one school).**

Variable	Factor 1	Communality
Col_1	0,935736	0,875602
Col_2	0,83881	0,703602
Col_3	0,929053	0,86314
Col_4	0,944667	0,892396
Col_5	0,967506	0,936069
Col_6	0,935534	0,875224
Col_7	0,929371	0,86373
Col_8	0,96668	0,934471
Col_9	0,964944	0,931117
Col_10	0,960098	0,921788
Col_11	0,926773	0,858908
Col_12	0,983416	0,967108

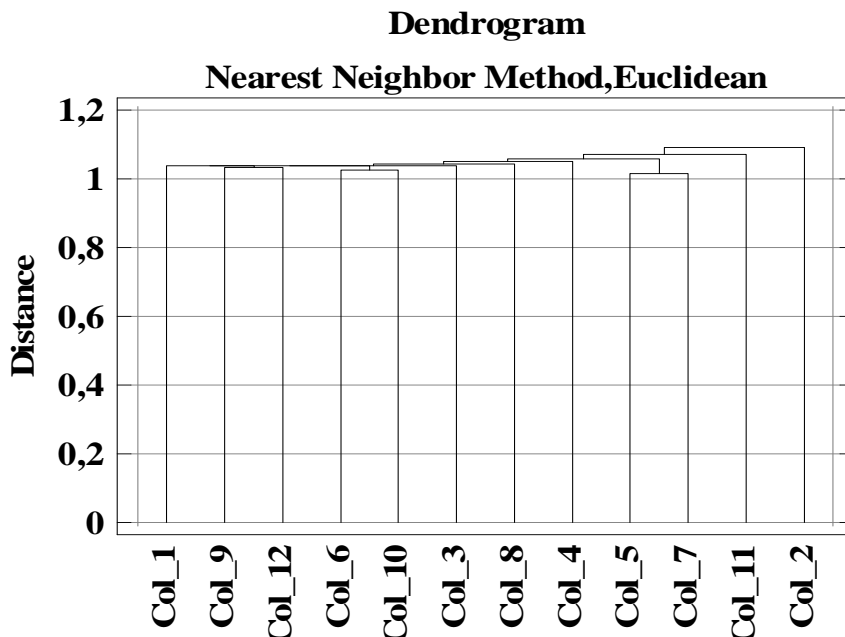


Figure 3. Cluster analysis (12 groups – 12 schools in Slovakia).

## Conclusions and Implications

Environmental attitudes are formed mostly by the influence of environmental education. Very important is also environment of students outside the school for example their family, community, media etc. Gender determinants, gender stereotypes, altruism, good social ties are also dependent variable in relationship with environmental attitudes. Creativity, on the other hand, seems to be independent variable. Our aim for the future is to verify this information by other researches. Altruism was the only variable that was confirmed in connection with environmental attitudes. Geller hypothesis says that man whose material and social needs are satisfied behave altruistically. This relation was documented also in our research. Finally we can say that cognitive and behavioral field of environmental education are on a very good level.

## References

- Pooley, J. A., O'Connor, M. (2000). Environmental education and attitudes. *Environment and Behavior*, 32(5), 711-723.
- Burger, J., Sanchez, J. (1998) Gender differences in recreational use environmental attitudes and perceptions of future land use at the savannah river site. *Environment & Behavior*, 30 (4) 48 –53.
- Messick, D., (1986). Environmental social dilemmas. New York P.Lang,; 210.
- Finger, M. (1994). From knowledge to action? Exploring the relationships between environmental experiences, learning, and behavior. *Journal of Social Issues*, 50 (3) 141-160.
- Dunlap, R., Van Liere, K. (1978). The new environmental paradigm. *Journal of Environmental Education*, 9(4). 10-19.
- Schultz, P. W. (2001). The structure of environmental concern: Concern for self, other people, and the biosphere. *Journal of Environmental Psychology*, 21, 1-13.

## PERCEIVED SERIOUSNESS OF ENVIRONMENTAL PROBLEMS: DILEMMAS AND RESOLUTIONS

Harika Özge Arslan  
Yüzüncü Yıl Üniversitesi

Ceyhan Çiğdemoğlu  
Atılım Üniversitesi

Ömer Geban  
Orta Doğu Teknik Üniversitesi

### Abstract

*The purpose of this multiple data sources study was to describe pre-service teachers' perceptions of the seriousness of environmental problems and their resolutions to environmental dilemmas. A questionnaire having 12 environmental problems (6 global, 6 local) and three distinct environmental dilemmas was administered to 56 pre-service teachers. Participants ranked 12 environmental problems according to their perceived seriousness of the problems and wrote their resolutions to three distinct environmental dilemmas. Semi-structured interviews were conducted with seven of these pre-service teachers to obtain deeper information. In general, the global environmental problems were perceived as more worrying than local ones. Examinations of the pre-service teachers' resolutions to dilemmas indicated that environmental friendly responses were attempt to given. However, interviews showed that they generally could not give justifications to their resolutions. It is so meaningful that the future teachers do not have enough information about most popular environmental problems and dilemmas. Therefore, the results of the study have significant implications for teacher training programs.*

### Introduction

Environmental problems and related research activities are experiencing a period of rapid growth in the last few decades. Pollution, decline of biodiversity, global warming, and diminishing resources such as ocean fish stocks and potable water are basic examples to environmental problems. These problems are likely to present great local and global challenges in the near future. Protecting our future is main issue in environmental education (EE) by growing environmentally aware people. EE requires an interdisciplinary approach and a long term process to develop behaviors necessary to understand the relationship between people, culture and the natural environment. Therefore; students learn to synthesize information and develop the skills to think critically, solve problems, and to prepare practical decision making that lead to responsible environmental friendly behaviors. For that reason EE should be fundamental and integral part of education at any level of education.

Teachers' role in EE is undeniable. When teachers were equipped with environmental issues deeply, by the time, it will raise the society level of awareness regarding environmental problems and students' decision making related with environment. The results of studies shown that the teacher's perceptions and not having adequate background information or training causes that teachers do not provide EE (Lane, Wilke, Champeau, & Sivek, 1994; Paul, & Wolk 2004; Smith-Sebasto & Smith, 1997; Wade, 1996). It is reported that 75% of the responding teachers spent less than 1/2 hour per subject per week teaching about the environment in Wisconsin (Lane, Wilke, Champeau, & Sivek, 1994).

One factor in the weakness of EE efforts and EE curriculum is the insufficient teacher preparation (Knapp, 2000). Therefore, studies with pre-service teachers take great attention for helping future teachers design and implement effective EE curriculum.

## **Rationale**

Whenever the environmental policies are produced, the role of society is important in implementation of them. Therefore, EE is necessary to make society environmentally aware and conscious. People who are well aware of the fact that resources are limited and technology cannot solve all problems are more likely to take action in solving environmental problems (Gigliotti, 1994). Preservice teachers' resolutions to environmental dilemmas may provide a clue to determine their perceptions and environmentally decision making processes.

Horwitz (2000) stated that surprisingly little research has directly studied people's attempts to resolve environmentally dilemmas. His study describes a qualitative investigation of student activists' resolutions to environmental dilemmas. Moreover, there are noticeable limited studies about perceptions of environmental problems (Grodzinska-Jurczak, Stepska, & Nieszporek, 2006; Garcí'a-Mira, Real, & Romay, 2005). On the other hand, there is no study integrating perceptions of environmental problems and resolutions to environmental dilemmas. This study aimed to describe how pre-service teachers perceive environmental problems and their resolutions to environmental dilemmas. This paper investigates related research questions;

1) How pre-service teachers' perceive environmental problems?

2) How pre-service teachers support their resolutions to environmental dilemmas and give justifications to their resolutions?

We hope that the findings of this paper will contribute towards the design and construction of suitable pre-service training programs; and enrich the research data of EE in particular and teacher education in general.

## **Methods**

### **Participants**

The sample of the study consists of 56 pre-service teachers at one of the largest public universities in Turkey with almost 21.000 students. 26 of them were chemistry and 30 of them physics major (23 male and 33 female), and their age range was 22-27. First, a questionnaire was administered to all of them, and then semi-structured interviews were conducted with seven of these pre-service teachers. The four of the interviewee were pre-service physics teachers (two male, two female); the other three were pre-service chemistry teachers (all were male).

### **Data Sources**

This investigation involved a questionnaire and interview questions. The questionnaire has 12 environmental problems (6 global, 6 local) and three distinct environmental dilemmas. Participants ranked 12 environmental problems according to their perceived seriousness of the problems and wrote their resolutions to three distinct environmental dilemmas. Marshall and Rossman (2006) stated that real-life, researcher-generated dilemmas, if well constructed using insights from previous research, can be very useful, especially for focusing and standardizing data collection, when that is appropriate. After the administration of the questionnaire, semi-structured interviews were conducted with seven of these pre-service teachers to obtain deeper information.

The ranking part of the questionnaire having 12 environmental problems, developed by Garcí'a-Mira et al. (2005), was translated and adapted to Turkish by researchers. The first six of the problems were global and other six of them were local including problems in Turkey. Participants were asked to rank each item on the scale according to the perceived seriousness of the problem. In addition to the environmental problems, there were three distinct

dilemmas related with environmental problems in the questionnaire (see Appendix). First dilemma was related with effect of transportation types to the environment, second dilemma was about energy resources and the third one was about product packaging. The first and the third dilemmas were taken from Dovers (2006) and the second one was from the news by Gabriel (2007). The dilemmas were translated into Turkish before the administration. Participants were asked to discuss and give reason to which outcome is more important for each dilemma. According to responses and resolutions obtained from participants, seven of them were selected conveniently and they were interviewed semi structurally in order to determine whether they could support their answers by using environmental knowledge and give reasonable justifications or not. The interviews were conducted in a comfortable, neutral laboratory setting and tape recorded, each takes 15-20 minutes long. The interviewer reminded the environmental problems and dilemmas, read the answer of the participants and then asked four questions:

- Which is the most/least important problem? Why?
- What do you think while ranking the problems?
- What is the reason of your answer to the dilemmas?
- What is the contribution of your department to your knowledge about environmental problems?

## Results

### Perceived Seriousness of Environmental Problems

A descriptive analysis of the mean scores for every item was carried out, with scores on a scale from 1 to 12 (1=the most worrying problem; 12=the least worrying problem). The mean score of the male and females were also calculated. The results are shown in Table 1-2.

**Table1. Averages of Perceived Seriousness of Environmental Problems**

Environmental Problems	Mean
Pollution of the world	4,71
Thinning of the ozone layer	4,82
Climate change and global warming	3,79*
Extinction of animal and plant species	4,57
Genetic manipulation of food	5,50
General desertification	5,66
Incineration of waste in Turkey	8,62
Using polluting energies in Turkey	6,66
Increasing numbers of cars in Turkey	8,82
Forest fires in Turkey	5,79
Depleting of fishing areas in Turkey	8,91**
Accidental oil spills on our coasts	6,70

*Note.* \* The most worrying environmental problem, \*\* the least worrying environmental problem.

The results of the first 12 items indicated that the climate change and global warming is the most worrying problem since the item has the smallest mean score. Moreover, the item “Depleting of fishing areas in Turkey” is seen as the least worrying problem. In general, the global items obtained lower scores than local items.

**Table2. Gender Difference of Perceived Seriousness of Environmental Problems**

Environmental Problems	Male	Female
Pollution of the world	5.0	4.5
Thinning of the ozone layer	5.7	4.2
Climate change and global warming	4.0*	3.6*
Extinction of animal and plant species	4.3	4.7
Genetic manipulation of food	4.8	6.0
General desertification	5.5	5.8
Incineration of waste in Turkey	8.1	9.0
Using polluting energies in Turkey	6.7	6.6
Increasing numbers of cars in Turkey	8.0	9.4**
Forest fires in Turkey	5.0	6.3
Depleting of fishing areas in Turkey	8.9**	8.9
Accidental oil spills on our coasts	6.3	7.0

*Note.* \* The most worrying environmental problem, \*\* the least worrying environmental problem.

The most worrying item does not differ across gender; they have a consensus on the climate change and global warming is the most worrying environmental problem. The least worrying problems changes according to the gender; females rated the item “Increasing numbers of cars in Turkey” as the least worrying, but males rated the items “Depleting of fishing areas in Turkey” as the least worrying.

#### Resolutions to Environmental Dilemmas

The responses of three dilemmas were analyzed and categorized by researchers individually; they compare their codes, discuss the difference and then had a consensus. The percentages of the responses are summarized in Table3.

**Table3. Percentages of responses to environmental dilemmas**

1 <sup>st</sup> Dilemma		2 <sup>nd</sup> Dilemma		3 <sup>rd</sup> Dilemma	
Bike	40 %	Wind	55.8 %	Glass	55.2 %
Public Transport	27.1 %	Nuclear	32.9 %	Paperboard	35.8 %
E-bike	12.9 %	Alternative Sources	4.1 %	New Technology	4.5 %
New Technology	10 %	Fossil Fuels	3.6 %	Plastic	3.0 %
Car	10 %	Sun	1.8 %	Non-recycling	1.5 %
		Water	1.8 %		



Examinations of the pre-service teachers' resolutions to dilemmas indicated that environmental friendly responses were attempted to given. In the first dilemma, participants (40%) most often proposed that bike should be used for the transportation. 27.1 % of them proposed public transportation as a solution of the dilemma. A few said using e-bike do not cause an important effect to the environment. Their written response to the first dilemma showed that they offered bike or public transportation as a solution however their preference were not supported clearly.

In the second dilemma, the most common response of the participants is the wind power. They generally thought that the disadvantages of the wind power can be disregarded. 32.9 % of the participants proposed that nuclear power plants should be built for energy despite concerns about safety and radioactive waste management. Although there are 172 hydroelectric energy plant in Turkey, only 1.8% of the participants offered hydroelectric energy as a solution.

Recyclable options were preferred by 94 % of the participants. If we consider that 4.5% of the participants offered finding new technologies as a solution, they gave environmental friendly answer and did not choose the non-recycling options, so it can be said that 98.5 % of the participants chose recyclable options. Although there were disadvantages of the recycling options in the dilemma, participants did not clarify the reason of their choice.

#### Qualitative Analysis of Interviews

Each researcher coded interviews thematically and discussed their codes. They agreed with 80% of themes and they had a consensus for remaining responses after discussions. Interviewees were given letter nicknames as A to G. The themes that are obtained from the ranking part of the questionnaire are shown under the E. problems subtitle in the Table 4. The response of interviewees to the environmental problems, their reasons; resolutions to environmental dilemmas and their justifications were summarized in the Table 4.

Some of the responses to the interview questions were surprising, for instance Interviewee E proposed using e-bike for the first dilemma as a written response but did not defend and during the interview s/he acknowledged s/he did not understand the dilemma. Although the researcher tried to clarify he could not understand since he did not know the topic. In the second dilemma, interviewee D tried to explain the effect of lead to human tissues by saying “ it is the same as the effect of bullet to human” since the word of bullet is same with lead in Turkish. This response showed that the knowledge of the interviewee is so simple and he could only make relation with the meaning of words. The answer of interviewee C for the dilemma three amazing; “In the future we should collect and send out the garbage to the space”.

**Table 4. Themes of the interviews.**

Int.	E. Problems		1. Dilemma		2. Dilemma		3. Dilemma	
	Response	Reason	Resolution	Justification	Resolution	Justification	Resolution	Justification
A	Thinning of the ozone layer	Human health Irreversible problems	New technology	Could not supported	Nuclear	Supported	Glass Plastics	Supported
B	Climate change and global warming	Media, Human health	e-bike	Could not supported	No answer	Could not supported	Glass	Could not supported
C	Pollution of the world	More dangerous	e-bike	Supported	Nuclear	Could not supported	New technology	Could not supported
D	Climate change and global warming	Media, Global	Bike	Could not supported	Wind	Supported	Glass	Could not supported
E	Forest fires in Turkey	Sustainability of life	e-bike	Could not supported	Wind	Supported	No answer	Could not supported
F	Climate change and global warming	Media, Human health	Car	Could not supported	Fossil Fuel	Could not supported	New technology	Could not supported
G	Pollution of the world	Global, Popular	Bike	Could not supported	Wind	Could not supported	Paperboard	Could not supported

*Note.* E.Problems = Environmental problems, Int.= Interviewees

The responses of the question related with contribution of the department to knowledge about environmental problems indicated little contribution for all interviewees.

## Conclusions and Implications

The results of this study showed that “climate change and the global warming” was perceived as the most worrying environmental problem by preservice teachers. Media and the popularity of the topic is the main reason under their choice. The role of the media on environmental awareness is obvious so there should be more emphasizes to other environmental issues not only climate change and global warming. The participants ranked the most popular environmental problems as the most worrying but it does not mean that they have enough knowledge about them. Most of the participants can not relate the item “increase number of car” to climate change ad global warming. Although they rated “climate change and global warming” as a most worrying problem, the reasons of the global warming is perceived as the least worrying problem.

The preservice teachers’ perceived seriousness of environmental problems is consistent with the results of the Garcí’a-Mira et al. (2005) and they gave more importance to global problems than local ones like the slogan of the Friends of the Earth, “Think Globally, Act Locally”.

Although preservice teachers did resolve dilemmas in the direction of environmental point of view, they generally could not support their ideas in a cause affect relationship. Leaders in EE have suggested that the ultimate EE goal is to help develop citizens who can participate responsibly in environmental issue resolution (Paul, & Wolk,

2004). In the second dilemma, a few of the participants proposed sun and water as energy resources, none of the interviewee suggested sun or water as a alternative resources. The reason of this situation may be aroused from the absence of usage of sun energy systems and recent drought problems in Turkey. The Responses of last dilemma indicated participants proposed desirable answers but justifications were very limited. Only one interviewee could clarify the reason. The results of this study are consistent with Tuncer, Tekkaya, Sungur, Cakiroglu, Ertepinar and Kaplowitz' s (2009) study revealing a majority of preservice teachers do not have enough knowledge.

All of the interviewee stated clearly that their department does not contribute to their environmental knowledge. Limited environmental education in teacher training programs need to be improved in order to increase the donation of departments. Findings of this paper will contribute towards the design and construction of suitable pre-service training programs.

Further research may be conducted by each grade level in primary education and in higher education. The environmental knowledge level obtained from these levels can be used to shape education programs of in service teachers.

## References

- Dovers, S. (2006). 'The dilemma of conflicting environmental outcomes', paper for the 2006 Australian State of the Environment Committee, Department of Environment and Heritage, Canberra, <<http://www.deh.gov.au/soe/2006/emerging/conflictoutcomes/index.html>>.
- Gabriel, G. (2007). Electric Bikes Pose Environmental Dilemma 40 million people use them in China <<http://news.softpedia.com/news/Electric-Bikes-pose-Environmental-Dilemma-70562.shtml>>
- García-Mira, R., Real, J. E., & Romay, J. (2005). Temporal and spatial dimensions in the perception of environmental problems: An investigation of the concept of environmental hyperopia. *International Journal of Psychology*, 40 (1), 5–10.
- Gigliotti, L. M. (1994) Environmental issues: Cornell students' willingness to take action, 1990. *Journal of Environmental Education*, 26(1), 34–42.
- Grodzinska-Jurczak, M., Stepska, A., & Nieszporek, K. (2006). Perception of environmental problems among pre-school children in Poland. *International Research in Geographical and Environmental Education*, 15(1), 62-76.
- Horwitz, W. (2000). Environmental dilemmas: The resolutions of student activists. *Ethics & Behavior*, 10(3), 281–308.
- Knapp, D. (2000). The Thessaloniki Declaration: A Wake- Up Call for Environmental education? *The Journal of Environmental Education* 31(3), 32–39.
- Lane, J., Wilke, R., Champeau, R., & Sivek, D. (1994). Environmental education in Wisconsin: A teacher survey. *The Journal of Environmental Education*, 25(4), 9–17
- Lane, J., Wilke, R., Champeau, R., & Sivek, D. (1995). Strengths and weaknesses of teacher environmental education preparation in Wisconsin. *The Journal of Environmental Education* 27(1), 36–45.
- Marshall, C., & Rossman, G.B. (2006). *Designing qualitative research* (4th edition). California: Sage.
- Paul, G., & Volk, T. L. (2004). Ten years of teacher workshops in an environmental problem-solving model: teacher implementation and perceptions. *The Journal of Environmental Education*, 33 (3), 10-20.

- Smith-Sebasto, N. J., & Smith, T. L. (1997). Environmental education in Illinois and Wisconsin: A tale of two states. *The Journal of Environmental Education*, 28(4), 26–36.
- Tuncer, G., Tekkaya, C., Sungur, S., Cakiroglu, J., Ertepinar, H. & Kaplowitz, M. (2009). Assessing pre-service teachers' environmental literacy in Turkey as a mean to develop teacher education programs. *International Journal of Educational Development* 29, 426-436
- Wade, K. S. (1996). EE teacher in-service education: The need for new perspectives. *The Journal of Environmental Education*, 27(2), 11–17.

## Appendix

### Dilemmas

Which outcome is the most important in such cases? Why?

1. China is the world's largest and most populous country, cities are packed with people. With cities ever expanding and becoming more congested, new automobiles fill the road capacity, and most of the people have to use bikes to get better mobility. Since public transportation services being often incapable of serving such a large population, and bike trips usually taking too long, the Chinese people had to find a faster and reliable source of transportation. Electric bikes are about 35 percent faster than regular bikes, and have a much larger range, but while mobility is achieved, this comes to the price of pollution. E-bikes use car-size lead acid batteries, which emit 30 to 40 percent of the lead to the environment during the production process, meaning about 3 kilograms per battery. When you think that there are more than 40 million such batteries that power the electric bikes on the streets of China, the amount of lead emitted in the environment is colossal. The reduction of energy use and greenhouse effect gas emissions, come to the price of dumping millions of tons of lead.
2. Reducing carbon emissions from energy use may be sought through a shift from carbon intensive fossil fuels. One alternative to coal fired electricity is wind power emitting little carbon involves development, but causes noise pollution, scenic impacts on local environments and damages birds, radio and TV signals. Another alternative is nuclear power, which again will lower carbon emissions but requires uranium mines in sensitive areas and creates problems of radioactive waste disposal.
3. Different product packaging has different environmental impacts. Liquid food packaging choices include reusable (refillable) glass, recyclable glass, plastic or paperboard, and various non recyclable options. Glass is an energy intensive product which may be recycled, like plastic and plastic coated paperboard. All use different resources, involving different extraction impacts, pollutants from manufacture, and transport and storage energy costs. If materials are not recycled, they have different impacts through land fill or incineration disposal processes. Glass is refillable, and although this minimizes material and energy use with sufficient cycles of reuse, significant amounts of water are used for washing and refilling. Therefore, environmentally optimal packaging depends on which particular extraction impacts, resources and pollutants are considered the most important, and on the detail and quality of the manufacturing, transport, use and disposal or recycling systems.

# AN ANALYSIS OF PRESERVICE SCIENCE AND TECHNOLOGY TEACHERS' ATTITUDES TOWARDS ENVIRONMENT

Nevin Kozcu Çakır  
Gazi Üniversitesi

Betül Timur  
Gazi Üniversitesi

Fulya Öner Armağan  
Gazi Üniversitesi

Gülcan Mıhladı  
Gazi Üniversitesi

Serkan Timur  
Gazi Üniversitesi

Alev Doğan  
Gazi Üniversitesi

## Abstract

*Rapid growth of world population, irregular urbanization, yields of science and technology, devastations of natural environment have caused environmental pollution to compensate. Therefore, the awakening of the society and individuals come into prominence so as to resolve the increasing pollution and problems. Education confronts us as an important factor to provide this awakening. This could only possible with a sufficient environment education. While environment education ensures the behaviors grows and changes on individual as a societal culture, but also determines the responsibilities of individual towards environment on all fields. Parallel to this, it is aimed at-in this study- determining the attitudes of preservice science teachers grade 1.,2.,3. and 4. that have studied in Gazi University Faculty of Education. For this reason, Environmental Attitude Questionnaire which was developed by Tuncer, Ertepinar, Tekkaya and Sungur (2005), was administered to 160 students in total. The reliability of the scale was found as  $\alpha = 0,85$ . The obtained data were analyzed using SPSS software program (version 11.5). According to the results of the analysis, while significant differences were found in terms of grade level and gender variables, no meaningful relation was found in terms of parents' level of education.*

## Introduction

Environmental problems have been gradually increased in the changing and developing world rapidly. Especially rapid growth of the world population, irregular urbanization, yields of science and technology, devastations of natural environment, developed countries showing economic interest in developing countries have caused irretrievable environmental pollutions. Therefore, the awakening of the society and individuals come into prominence so as to resolve the increasing pollution and problems. Education confronts us as an important factor to provide this awakening. Environment education could be defined as improving the environment awakening in all levels of society, sensitive to environment, to bring in positive and permanent changes, to protect natural, historical,

cultural, socio-esthetic values- to provide active participation. This could only possible with a sufficient environment education.

While environment education ensures the behaviors grows and changes on individual as a societal culture, but also determines the responsibilities of individual towards environment on all field sand attendance in problem solving (ANON, 2008). The more the levels of individual's education level increase, the more they develop some topics such as: perceiving the problems in environment, realizing problems, producing solutions and applying these solutions (Sülün, 2002). Environmental problems should be dealt with as a problem-based issue so as to provide positive attitudes of students toward the protection of environment. Thus it could be ensured the students to see that issue as a problem, to analyze natural environment, to collect data related to the topic, to make analysis, and to improve decision making skills which is an important process on improvement on awakening (Knamiller, 1987).

When some studies had been analyzed on this field, biology preservice teachers often exposed positive behaviors on environment and its problems; they didn't find out significant difference between attitudes of male and female but more positive attitudes were seen in higher socioeconomic level (Altın, 2001).

In another study conducted to the students in U.S.A, England and Denmark, a meaningful difference had been found between the student's environmental attitudes and economic, politic, technologic dimensions of social dominant paradigm. If points related to social paradigm were high, a decrease would have seen on perceptions related to environment. This case could be explained with different socio-cultural structures of countries (Kilbourne et al, 2001; Şama, 2003).

In this study, researchers aimed to determine the attitudes of university students' towards environmental issues. The sample of this study will be consisted of preservice science teachers grade 1.,2.,3. and 4. that have studied in Gazi University Faculty of Education. At last, the differences between students' attitudes, such as gender, class and education levels of parents that he/she attended have examined.

## **Rationale**

The desire of the mankind to own and direct the world caused irreversible problems and events from past to present. People have societal and individual duties. Therefore, an individual should develop an awakening to protect his/her environment, not to damage his surroundings, and to decrease the affects of pollution level. This awareness firstly occurs within the family. Beginning from pre-school to higher education, it keeps on in several institutions. In order to give an environmental awareness to students, a curriculum should include some topic such as: environmental education, environmental pollution, paying attention to the differences surrounding them, and improving environment awareness. Other individuals who deal with children should know something about this issue, should behave sensitive, and should adapt them towards changing. Positive changes on students' behavior cannot be done only with curriculum in educational institutions. Teachers and families have lots of tasks to make any changes on next generations. When new curriculum at primary level was analyzed, in the Turkish Language, Music, Social Sciences, Science and Technology courses provide information on environmental awareness, environment and its pollution. It shouldn't be omitted that the environment and related issues are mainly the topics of Science and Technology Course. The teachers of Science and Technology should behave sensitive and should have sufficient information, should study in detail and follow new developments and should know the situation of our country and relations to other countries on this issue. In this regard, determining the attitudes of pre-service science teachers towards environment is quite important.

## Methods

This research has been designed as a survey and the Environment Attitude Questionnaire developed by Tuncer, Ertepinar, Tekkaya ve Sungur (2005) has been used as a data collection instrument. Environment Attitude Questionnaire contains 45 items with a 5-point Likert-type scale response system. This Questionnaire has been simultaneously applied to 160 students from 1., 2., 3., 4, grade in Gazi University, Faculty of Education, Science Teaching Department.

### Findings

The reliability of the scale that was developed by Tuncer, Ertepinar and Sungur is used in this research is found as  $\alpha = .85$  While the lowest point which is gained from the environmental attitude scale is 130, the highest score is 207 and the general average is 174.94.

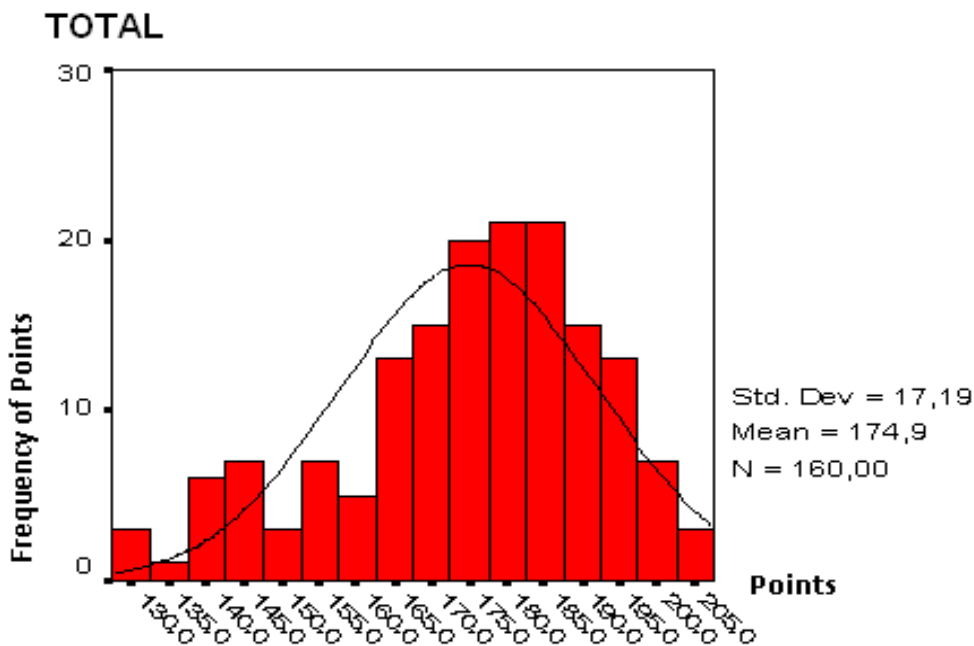


Figure 1. Frequency distribution of the students' scores

### 1. Findings According to The Class Level of The Students on The Attitudes Towards Environment

The arithmetic average attitude scores were given in Table 1. When the arithmetic average attitude scores are analyzed, it is seen that the highest score belongs to the 1<sup>st</sup>. year students and the lowest point belongs to the students in the 3<sup>rd</sup>. year.

Table 1. Arithmetic Average of The Students' Attitude Scores According to Their Class Levels

	<i>N</i>	$\bar{X}$	<i>SD</i>
1. Year	29	183.10	11.54
2. Year	61	180.13	13.94
3. Year	53	163.42	18.78
4. Year	17	178.29	12.37
Total	160	174.94	17.19

One way ANOVA is applied to analyze the relation between the class level of students and their environmental attitude scores, and the significant difference is determined between the groups. ( $F(3,156) = 15.53, p < .05$ ).

**Table 2. Results of One Way ANOVA on The Students' Environmental Attitude Scores Related to Their Class Levels**

	<i>Sum of squares</i>	<i>df</i>	<i>Mean square</i>	<i>F</i>	<i>p</i>
Between groups	10897.34	3	3602.45	15.53*	.00
Within Groups	36182.04	156	231.94		
Total	46989.38	159			

## 2. Findings About Students' Attitudes Toward Environment According to Their Gender

Students' attitudes toward environment according to their gender were given in Table 3. According to 'the independent t-test' which was done to determine the relation between the students' gender and their environmental attitude scores, the significant difference was found favoring the female students ( $t(158) = 2.63, p < .05$ ).

**Table 3. Results of The Independent T-Test On The Mean Attitude Scores of The Students' Gender**

	<i>N</i>	$\bar{X}$	<i>SD</i>	<i>t</i>	<i>p</i>
Female	124	176.83	16.59	2.63	.009
Male	36	168.42	17.87		

## 3. Findings According to Students' Fathers' Education Level on The Attitudes Toward Environment

Arithmetic average scores of the students' attitudes according to their fathers' education level were given in Table 4. According to the arithmetic average scores, we saw that there was a non-linear correlation between students' average scores and their fathers' education level.

**Table 4. Arithmetic Average Scores of The Students' Attitudes According to Their Fathers' Education Level**

	<i>N</i>	$\bar{X}$	<i>SD</i>
Primary School	47	177.72	14.58
Secondary School	21	174.05	21.86
High School	51	173.94	17.25
University	41	173.44	17.49
Total	160	174.94	17.19

The significant difference could not be determined in the one way ANOVA analyze result which is made to determine the relation between students' fathers' education level. ( $F(5,156) = .587, p > .05$ ).



**Table 5. Results of One Way ANOVA on The Students' Attitude Scores According to Their Fathers' Education Level**

	<i>Sum of squares</i>	<i>df</i>	<i>Mean square</i>	<i>F</i>	<i>p</i>
Between groups	524.10	3	174.70		
Within Groups	46465.28	156	297.85	.587	.63
Total	46989.38	159			

#### 4. Findings According to Students' Mothers' Education Level on The Attitudes Toward Environment

Arithmetic average scores of the students' attitudes according to their mothers' education level were given in Table 6. According to the arithmetic average scores, we saw that there was a non-linear correlation between students' average scores and their mothers' education level.

**Table 6. Arithmetic Averages of The Students' Attitude Scores According to Their Mothers' Education Level**

	<i>N</i>	$\bar{X}$	<i>SD</i>
Primary School	94	176.80	15.35
Secondary School	21	174.90	18.60
High School	31	169.87	21.37
University	13	173.69	16.65
Total	160	174.94	17.19

The significant difference could not be determined in the one way ANOVA analyze result which is made to determine the relation between students' mothers' education level. ( $F(4,155) = .961, p > .05$ ).

**Table 7. Results of One Way ANOVA on The Students' Attitude Scores According to Their Mothers' Education Level**

	<i>Sum of squares</i>	<i>df</i>	<i>Mean square</i>	<i>F</i>	<i>p</i>
Between groups	1137.57	4	284.39		
Within Groups	45851.81	155	295.82	.961	.430
Total	46989.38	159			

## Results

The reliability of the scale which is used in this research is found as  $\alpha = .85$ . While the lowest point which is gained from the environmental attitude scale is 130, the highest score is 207 and the general average is 174.94. At the result of analysis which is done according to the class level of the students, when the arithmetic average attitude scores are analyzed, it is seen that the highest score belongs to the students in the 1st year students and the lowest point belongs to the students in the 3rd year students. One way ANOVA is applied to analyze the relation between the class level of students and their environmental attitude scores, and the significant difference is determined between the groups. ( $F(3,156) = 15.53, p < .05$ ). According to the Post Hoc analysis, significant difference was determined between 1st year students and 3rd year students in 1st year students' favor, between 2nd year students and 3rd year students in 2nd year students' favor, between 3rd year students and 4th year students in 4th year students favor. According to 'the independent T-test' which was done to determine the relation between the students' genders and their environmental attitude scores, the significant difference was found in female students' favor ( $t(158) = 2.63, p < .05$ ). The significant difference could not be determined in the analysis which is made to determine the relation between students' fathers' education conditions ( $F(5,156) = .587, p > .05$ ). But according to the arithmetic average scores, we saw that there was a non-linear correlation between students' average scores and their fathers' education level. Any significant difference wasn't found in the analysis made to determine the relation between students' mothers education conditions and their environmental attitudes ( $F(4,155) = .961, p > .05$ ).

## Conclusions and Implications

When the average score from Environment Attitude Questionnaire of University students is taken into consideration, it can be said that these students' environmental attitude scores are high. In the result of the analysis, when the relations between environmental attitude and class levels were scrutinized, while there were significant differences between 1st year students and 3rd year students favoring 1st year students, between 2nd year students and 3rd year students favoring 2nd year students, and between 3rd year students and 4th year students favoring 4th year students; but when the gender variable compared with environmental attitude score, a diversification was determined in female favor. Results related to gender were coherent with similar study results in literature. (Alp et al, 2006, Uzun, 2005, Şama, 2003, Tuncer et al 2007). A relation couldn't found between education level of parent and environmental attitude score; but when looked at arithmetic average scores, it was seen that the more education level increases the least the students get higher scores. This indicates parallel results between the studies in literature. (Gökçe et al, 2007).

## References

- Alp, E., Ertepinar, H., Tekkaya, C. & Yılmaz, A. (2006). İlköğretim Öğrencilerinin Çevreye Yönelik Tutum ve Bilgileri Üzerine Bir Çalışma. *VII. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi Özetler Kitabı*, 110. 07-09 Eylül 2006, Ankara.
- Anon, (2008). <http://www.cedgm.gov.tr/cevreatlasi/cevreegitimi.pdf> adresinden 20.11.2008, tarihinde alınmıştır.
- Gökçe, N., Kaya, E., Aktay, S., Özden, M. (2007). İlköğretim Öğrencilerinin Çevreye Yönelik Tutumları. *İlköğretim Online*, 6(3), 452-468.
- Kilbourne, W. E., Beckman, S. C, Lewis, A. & Dam, Y. V. (2001). A Multinational Examination of the Dominant Social Paradigm İn Environmental Attitudes of University Students. *Environmental Behavior*, 33, 2, 209–229
- Knamiller, G.W.(1987). *Issue-Based Environmental Education in Developing Countries*, The Environment and Science and Technology Education, Ed: A.V.Baez, G.W. Knamiller, J.C.Smyth.
- Sülün, Y. (2002). "Çevre Kirliliği ve Önlemede Eğitimin Rolü", *Muğla Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, Bahar,8,187-195.

- Şama, E. (2003), “Öğretmen Adaylarının Çevre Sorunlarına Yönelik Tutumları”, *Gazi Üniversitesi Gazi Eğitim Fakültesi Dergisi*, 23(2), 99-110.
- Tuncer, G., Ertrpınar, H., Tekkaya, C., Sungur, S. (2005). Environmental attitudes of young people in Turkey: effects of school type and gender. *Environmental Education Research*, 11(2), 215-223.
- Tuncer, G., Sungur, S., Tekkaya, C., Ertepinar, H (2007). A Comparative Study on Pre-Service Teachers' and Elementary Students' Attitudes towards the Environment. *International Research in Geographical and Environmental Education*. 16 (2), 188-198.
- Uzun, N. (2005). Sınıf Öğretmenliği Öğrencilerinin Çevre Sorunlarına Yönelik Tutumları. II. *Sosyal Bilimler Eğitimi Kongresi*, 30-40, 26-28 Mayıs 2005, Ankara.
- Yılmaz, M. (2001). *Biyoloji Öğretmeni Adaylarında Çevre Eğitimi*. Ankara: Gazi Üniversitesi Eğitim Bilimleri Enstitüsü Yayınlanmamış Yüksek Lisans Tezi



# DO SCHOOLS MAKE A DIFFERENCE IN THEIR STUDENTS' ENVIRONMENTAL ATTITUDES AND AWARENESS? EVIDENCE FROM PISA 2006

Jelle Boeve-de Pauw, Liesje Coertjens, Sven De Maeyer & Peter Van Petegem  
University of Antwerp

## Abstract

*The environmental agenda is gaining momentum as an (international) policy issue. This is reflected in an increase in research on environmental education aiming to explain and even change (youngsters') attitudes, beliefs and behaviour towards the environment. In this study we focus on this issue from a school effectiveness research perspective. More specifically we evaluate (1) which student characteristics predict environmental awareness and attitudes, (2) whether schools make a difference in their students' environmental attitudes and awareness and (3) if schools have a differential effect for students with varying levels of science abilities. To this end, the cross-sectional survey data of OECD's Program for International Student Assessment (PISA) 2006 are re-analysed using a multivariate multilevel model. Results show that sex, immigrant status and socio-economic status are important in explaining students' environmental attitudes and awareness. Furthermore schools are shown to matter. Schools in which science is taught in a more hands-on manner stimulate higher environmental awareness while environmental learning activities are associated with more pro-environmental attitudes. After controlling for student characteristics, these school effects do not differ between more science able children and their less or average science literate peers.*

## Introduction

Over the past few decades, rising concerns about the deteriorating state of the natural environment has led to intensified international scientific debate on environmental issues. The international community has recognized that natural resources are being used up at a rate faster than they can be restored and that ecosystem preservation is closely related to human health - and even the preservation of the human species (Hassan, Scholles & Ash, 2005). Wilson (1993, p. 37) pointed out that "in a single life time, humanity is mistreating the natural environment in such a way that we will impoverish our descendants for all time to come". Many believe that environmental problems are due to maladaptive human behaviour (Maloney & Ward, 1973), and are thus anthropogenic of origin (Stern, 1992). Since environmental behaviour is seen as lying at the basis of the current environmental crisis, social scientists have long been interested in the causation of this behaviour. Several researchers underline (e.g. Stern, Dietz & Guagnano, 1995; Kaiser, Oerke & Bogner, 2008) that environmental behaviour originates in part from attitudes - specific and general - towards the natural world. In the 2006 wave of OECD's Program of International Student Assessment, such environmental attitudes were incorporated into the definition of scientific literacy, thus creating an unignorable research opportunity for educational researchers (Anderson, Lin, Treagust, Ross & Yore, 2007).

## Rationale

### Environmental Attitudes

A lot of effort in the field of environmental attitudes research focuses on explaining variation in those attitudes: in other words, what causes one individual to display pro-environmental attitudes and the other to do just the opposite? Classically, research shows a number of demographic factors to explain variation in environmental

attitudes. The following generalizations characterize the literature on demographic correlates of environmentalism: women and girls (Schahn & Holzer, 1990; Goldman, Yavetz & Pe'er, 2006), high income earning, well educated, city dwelling, politically liberal and autochthon individuals (Schultz, Oskamp & Mainieri, 1995; Barr, 2007; Hunter, 2000) tend to display more pro-environmental attitudes than their counterparts. These stereotypes should however not be generalized too easily. Eagles and Demare (1999) for example found no differences between boys' and girls' environmental attitudes.

Apart from demographics, knowledge of the environment has also been shown to affect environmental attitudes (e.g. Schahn & Holzer, 1990). Littleddyke's research (2008) indicates that students' enjoyment of science is also relevant in explaining their environmental attitudes. Most environmental topics (e.g. photosynthesis, biodiversity, nutrient cycling...) and issues (e.g. acid rain, biodiversity loss, habitat fragmentation...) have underlying scientific principles that draw from different fields of science (such as chemistry, physics, biology or maths). Yet the extent to which science abilities (i.e. knowledge, but also skills, of general scientific topics and principals) contribute to one's pro-environmental attitudes remains a gap in the field of research.

### Expanding the focus: schools as context

As sketched above, the main focus of the research on environmental attitudes has been on the individual as the primary explainer of its own (non-)environmentalism. However, concerning attitudes (both environmental and general), the social context should not be neglected (Stern, Dietz & Guagnano, 1995). People grow up in families, belong to sport or cultural groups, have a group of friends etc. These "cultural settings in which we are born and come to maturity [...] influence our behaviour" (Giddens, 1997, p. 41). Though this socialization process is ongoing, some discrete transition phases, of which the age of adolescence is one, can be discerned (Giddens, 1997). An important part of those teenagers' social context is the school; youngsters spend a lot of time in school, form social networks on the playground, experience friendships and cover societal topics in class. Moreover, students' attitudes were found to differ between educational tracks (Klaczynski & Reese, 1990). Therefore, we can expect the school to be an important factor in shaping youngsters' environmental attitudes, that up until now may not have gotten the attention it deserves.

This focus on the school can be framed within the area of school effectiveness research. Most school effectiveness studies take the schools' input characteristics and context into account in assessing the influence of process factors at the school or classroom level on output measures. Examples of such process factors are educational leadership at school level or structured teaching at the classroom level (Scheerens, 1990)<sup>1</sup>. Student achievement on the basic disciplines like mathematics and mother tongue are frequently used as output measures (Scheerens & Bosker, 1997). Davies (1997) emphasizes, however, that the choice of output criteria does not play a neutral role and that an excessively narrow operational definition of school effectiveness indicates an overly restricted vision on the goals of education. Given this criticism, scholars like Reynolds and Teddlie (1999) stress that school effectiveness research should focus on a multitude of output measures. This includes a plea for broadening the research from solely achievement measures towards on attitudes and behaviours as goals of the socialising function of the school (De Maeyer & Rymenans, 2004). In this study, we will focus on environmental attitudes.

### School characteristics at play

We found a small number of studies suggesting which factors at school-level influence students' environmental attitudes. Littleddyke (2008) emphasized that active learning through constructivist pedagogy can enhance environmental attitudes. The author details that such pedagogy is, among others, characterised by experiential and active learning, taking an interdisciplinary approach and making reference to real-life contexts. Lester, Ma, Lee and Lambert (2006) specify that teaching science in a personally meaningful way, providing students with authentic learning experiences, increases awareness of environmental issues. Widening our view to research on science awareness and attitudes, research also confirmed that constructivist instructional methods (like collaborative

group work and problem solving) had a positive impact on the understanding of scientific concepts and attitudes towards science (Gibson & Van Strat, 2001; Liang & Gabel, 2005). Besides constructivist teaching, literature points at outdoor education as a school-level factor. Palmer, Suggate, Bajd and Tsaliki (1998) conclude that (learning) experiences in outdoor informal contexts provoke significant life experiences and thus stimulate youngsters to form pro-environmental attitudes. Brody (2005) confirmed that learning outside the actual classroom stimulates curiosity, improves motivation and attitudes and fosters participation and social interaction. Since informal education activities “commonly involve intellectual or physical tasks of a group it allows learning to have a greater meaning” (Brody, 2005, p. 606).

Research on school characteristics stimulating environmental attitudes and awareness has been primarily qualitative and of educational-philosophical nature (e.g. Brody, 2005; Littledyke, 2008). With this paper we examine whether these findings can be replicated when taking a quantitative, school effectiveness perspective. Furthermore, research points towards the need to examine the differential effects of science abilities. Liang and Gabel (2005) found that lower science performers reacted differently to a new teaching method than their higher achieving colleagues. It would therefore be worthwhile to examine whether the effect of schools on environmental attitudes is different for students with varying levels of science ability.

### Research questions

To examine students’ environmental attitudes, we pose the following research questions:

1. Which individual-level explanatory variables (sex, socio-economic status, immigration status) explain variation in environmental attitudes and awareness of 15-year-olds?
2. Do schools matter? I.e. do schools stimulate their students towards more pro-environmental attitudes and awareness? And if so, are aspects of constructivist teaching and informal learning environments involved in this school effect?
3. Do schools have a differential effect for students with varying levels of science ability?

### Methods

We chose for Flanders (Dutch speaking community of Belgium) as a case for studying the socialising effect of schools on environmental attitudes. In Flanders, environmental education (EE) is characterised by - government-provided - cross-curricular objectives (Ministry of The Flemish Community, 2001), with a main focus on attitudes that contribute to a healthy natural environment and a sustainable future. Flemish formal environmental education (just as health and citizenship education and social skills) is not organised via a specific course, but integrated as much as possible into all subjects (e.g. Dutch language, physics, geography ...). The PISA data confirm this: 91% of all Flemish principals declare that environmental topics are a part of natural science subjects, 85% and 65% of them say they are treated as part of respectively in geography or of another subject. Due to this liberty in organising environmental education, Flemish schools vary in their approach to EE, though all focussing on attitudes. This provides an interesting case to evaluate which school characteristics are more beneficial in stimulating students’ environmental attitudes.

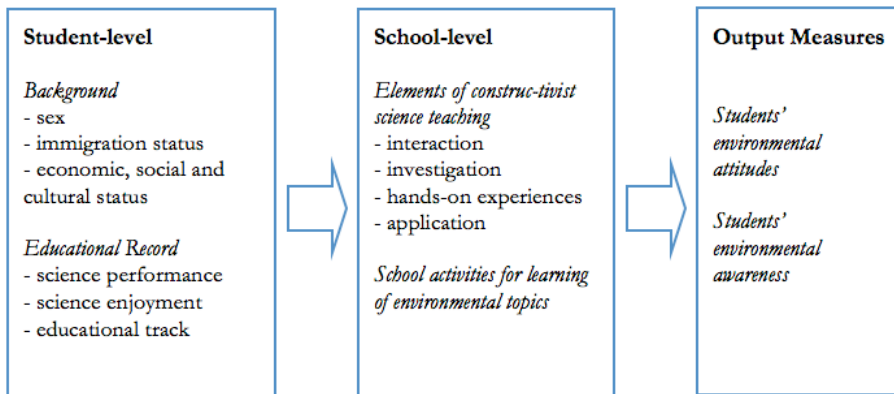
### Sample

For this paper we re-analysed the Flemish data of the OECD’s Program for International Student Assessment (PISA) 2006. Education for Flemish 15-year-olds is provided in four educational tracks: general, technical, vocational and special education (see EAC, 2009). Since the student-data for the special education track formed only a small group (125 students in 6 schools) and had several missing data, they were omitted from the analysis. The final sample thus consisted of 4999 students enrolled in 156 Flemish schools. Due to random selection

of schools and the high level of coverage, the data are a representative sample of the Flemish population aged 15 (OECD, 2007).

### Variables

Three types of variables are included in our analysis: output measures, student-level and school-level explanatory variables (see Figure 1).



**Figure 1:** Scheme of the variables

### *Output measures*

Two output measures are the subject of our analysis. After careful examination of the items, we selected the PISA 2006 variable on students' responsibility for sustainable development as a measure for environmental attitudes (ENVATT). The scale is derived from students' agreement with seven items like "I am in favour of having laws that regulate factory emissions even if this would increase the price of products" on a four-point Likert scale (see Appendix A for a list of all items and response categories, OECD, 2007). The reliability (Cronbach's alpha) of the ENVATT scale for Flanders is at an acceptable 0.76 (see Table 1).

**Table 1: Reliabilities of the used scales (Cronbach's alpha)**

Scale	N° items	Cronbach's alpha
<b>Output measure</b>		
Environmental awareness	5	0.78
Environmental attitudes	7	0.76
<b>Student characteristics</b>		
Science enjoyment	5	0.91
<b>Process characteristics</b>		
Interaction	4	0.75
Investigation	3	0.76
Hands-on	4	0.73
Application	4	0.76

The second output measure is awareness of environmental problems (ENVAWARE) and is more cognitive than the previous one. This index is derived from students' beliefs regarding their awareness of environmental topics. Students answered the question "How informed are you about the following environmental issues?" like for example acid rain on a 4-point Likert scale (see Appendix A). The ENVAWARE scale has an acceptable reliability (Cronbach's alpha: 0.78). Higher scores on ENVAWARE indicate higher levels of students' awareness of environmental issues (OECD, 2007).



---

***Explanatory variables at the student level***

Three variables related to students' background are included in the analyses: students' sex, immigrant status and socio-economic background. There are three immigrant groups: (1) native students being born in the country of assessment or who had at least one parent born in that country, (2) "second-generation" students who were born in the country of assessment but whose parents were born in another country and (3) "first-generation" students, born outside the country of assessment and whose parents were also born in another country (OECD, 2007). The index of economic, social and cultural status (ESCS) is derived from three indexes: (1) students' home possessions, (2) highest occupational status of parents and (3) highest educational level of parents (OECD, 2007).

We also included three variables relating to the students' educational record (see Figure 1). Firstly, science abilities are measured by a 30-minute science assessment on knowledge of physical systems, living systems, earth and space, technology systems and knowledge about scientific enquiry and scientific explanations. The questions were distributed over items concerning identifying scientific issues, explaining phenomena scientifically and using scientific evidence (OECD, 2007). From this assessment, five plausible values for science abilities were constructed by PISA. Since these were highly correlated (all  $r(4997)=0.93$  or higher,  $p<.001$ ), we selected 'plausible value 1' as a measure for science ability (SCIABIL). Secondly, we also included students' enjoyment of science (JOYSCIE), measured by a 4-point Likert scale (sample item: "I like reading about science in general", see Appendix A for all items and response categories, OECD, 2007). The reliability of the JOYSCIE scale was good (Cronbach's alpha: 0.91). Thirdly, educational track (general, technical or vocational) was retained.

***Explanatory variables at the school level***

Regarding the school level, degree of constructivist science teaching and informal learning are retained. The four indicators of degree of constructivist science teaching are constructed using student data. Students answered the question "When learning school science topics at school, how often do the following activities occur?" on a four range scale: 'in all lessons', 'in most lessons', 'in some lessons' and 'never or hardly ever' (OECD, 2007). The first measure of constructivist teaching is the index of interaction in science teaching and learning (SCINTACT), indicating the frequency with which different elements of interactive teaching occur in their classroom (see Appendix A). The SCINTACT scale has an acceptable reliability (Cronbach's alpha: 0.75). The index of occurrence of opportunities for scientific investigation (SCINVEST, Cronbach's alpha: 0.76) and the index of hands-on learning (SCHANDS, Cronbach's alpha: 0.73) are the second and third measure respectively. The last element of constructivist science teaching focuses on applying science to the real life context (SCAPPLY) and showed acceptable reliability as well (Cronbach's alpha: 0.76). The four different scales of constructivist science teaching all resulted reliable at the student level (see Table 1). Subsequently, the student data were aggregated at the school level. Higher scores on a scale of constructivist science teaching indicate that, in that school and according to the students, science is taught in a more constructivist way. In the PISA 2006 school questionnaire the principals of the schools were asked whether activities such as 'trips to science and/or technology centres', 'extracurricular environmental projects (including research)', 'outdoor education', 'trips to the museum' or 'lectures and/or seminars (e.g. guest speakers)' were organised. Higher levels for the index of school activities for learning of environmental topics (ENVLEARN) indicate higher levels of school environmental activities as reported by the schools' principals (OECD, 2007). For this study, we standardised the variables using only the Flemish student data. The output measures and the student-level explanatory variables SCIABIL, ESCS, JOYSCIE, were standardized at student level, while the four indexes of constructivist teaching and ENVLEARN were standardised at the school level.

## Multivariate multilevel analysis

Due to the data's hierarchical structure (students nested within school) and in order to estimate the effect of schools, a multilevel approach was required. Since the dependent variables (or output measures) ENVATT and ENVAWARE correlated significantly (respectively 0.60 and 0.28 on the school and student level), and to attain more statistical power, we opted for a multivariate multilevel analysis (Thum, 1997; 2003) using MLwiN 2.02). Thus, both dependent variables are modelled simultaneously, controlling for the effect of the other. Appendix B provides further detail on this multivariate multilevel model. In the analysis a four-step strategy was used. First, the zero model is estimated, indicating whether a multilevel approach is necessary. Since the relation between science abilities and pro-environmental attitudes was identified as a research gap, our second model aimed at looking closer at this relation. Third, students' sex, immigrant status, ESCS, educational track, and JOYSCIE are added. Process characteristics at the school level (measures of constructivist teaching and the index for school environmental learning activities) are inserted in the final model. We report the deviance of each model, indicating how well the model fits the data. Since we use the maximum likelihood estimation method, the deviances can be used to test whether a more advanced model fits significantly better than a simpler model (that is nested within the advanced model). The difference between deviances approximates a chi-square with degrees of freedom as the difference in the number of parameters of both models (Hox, 2002). In our analyses we work with a 95% confidence interval, corresponding to 1.96 times the standard error. Regression coefficients thus have to be at least 1.96 times bigger than their standard error to be considered significant (Hox, 2002).

## Results

The results are presented for each model that was estimated. We start with the zero model (including no explanatory variables), then add science abilities (model1), student-level explanatory variables (model2), and finally school-level explanatory variables (model3).

The zeromodel: is a multilevel approach appropriate?

The estimated zeromodel shows that a multilevel analysis is the proper technique for the data. Schools explain a significant proportion in students' variability in environmental awareness and attitudes (see Table 2). 17% of the variation in students' environmental awareness (ENVAWARE) and 6.5 % of the variation in environmental attitudes (ENVATT) can be attributed to schools. One school was shown to be a positive outlier to the intercept for environmental attitudes (ENVATT). Since this was not due to outliers at the student level, and this school would remain an outlier throughout the analysis, the school was absorbed into a dummy for all subsequent analyses, which improved the model significantly (decrease in deviance: 19.86,  $p < .001$ ). This school is thus not taken into account for the fixed or random part of ENVATT (Rasbach, Steele, Browne & Prosser, 2005). Since the school was no outlier for ENVAWARE we did include it for the estimation of this output measure.

Model 1: science abilities

Do more science able students show more pro-environmental attitudes? The first model shows a rather strong effect; students scoring one standard deviation higher on science abilities, attain on average almost 0.60 standard deviation higher on environmental awareness (see Table 2). For environmental attitude this is 0.25 of a standard deviation. This effect could however be due to other variables like students' background or educational record as well. But before controlling for this (in model 3), we will first examine the random part of the first model for both dependent variables to determine whether schools have a differential effect for students with varying levels of science ability.

**Science abilities – environmental awareness**

The random part of this model reveals that the effect of science abilities on environmental awareness does not vary between schools. In other words, the impact of schools on environmental attitudes is the same for less, average or more science literate students. The variation within schools, however, is different for varying levels of science abilities (cov= -0.043, SE=0.007, see Table 2). Figure 2a illustrates this fanning pattern; it represents the estimated regression line, showing a positive trend; more science able students tend to be more environmentally aware. The line under and above this regression line represent the 95% confidence interval (95% of all students fall somewhere between these two lines). It can be seen that the highest and the lowest line are more apart at the start than at the end, indicating heteroskedacity in the data. The less and average science literate students are more variable in their awareness of environmental issues than their more able peers. To put it differently, for average and less science able students, science ability is a less accurate predictor of environmental awareness.

**Table 2: Fixed and Random coefficient estimates and standard errors for the zeromodel and model 1**

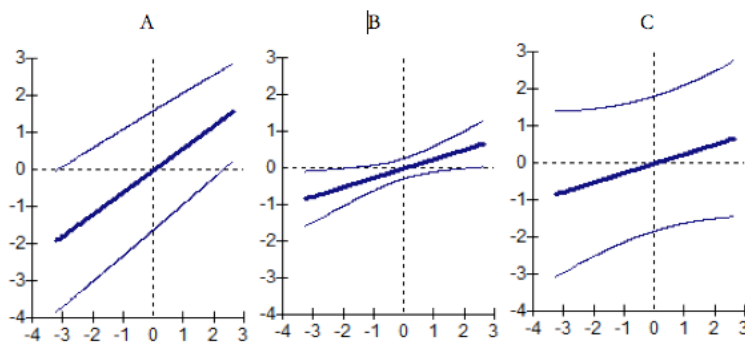
	Zeromodel		Model 1	
FIXED PART	ENVAWARE	ENVATT	ENVAWARE	ENVATT
<b>Intercept</b>	-0.22(.036)	-.010(.025)	-.041(.017)*	-.034(.018)
dummy outlier				.987(.209)*
<b>Student Characteristics</b>				
SCIABIL			.596(.015)*	.255(.019)*
<b>RANDOM PART</b>				
<b>Student Level</b>				
intercept ENVAWARE variance	.838(.017)*		.674(.014)*	
Intercepts covariance	.209(.013)*		.141(.011)*	
intercept ENVATT variance		.935(.019)*		.864(.023)*
covariance SCIABIL ENVAWARE-			-.043(.007)*	
intercept ENVAWARE				
variance SCIABIL ENVATT				.041(.017)*
<b>School Level</b>				
intercept ENVAWARE variance	.171(.022)*		.025(.005)*	
intercepts covariance	.080(.013)*		.009(.004)*	
intercept ENVATT variance		.065(.011)*		.020(.006)*
variance SCIABIL ENVATT				.012(.006)*
<b>Deviance</b>	26777.370		25385.050*	

Note: For the fixed part, effect sizes are shown with their standard error (between brackets). Significant values are marked \*. Significance is set at a 5% level. Values are considered significant if the coefficient exceeds the threshold of 1.96 times the standard error.

**Science abilities – environmental attitudes**

Our results indicate that schools do have an impact on the relation between science abilities and environmental attitudes (var=0.012, SE=0.006, see Table 2). Figure 2b shows that schools are of little difference in stimulating pro-environmental attitudes in students with average science abilities. Where the x-axis is at 0.0 (the average for standardised variables), the lines of the confidence interval are quite close. However, for less and more science literate students, the impact of schools on environmental attitudes varies more. Some schools manage to stimulate their low science able students in such a way they almost attain the average pro-environmental attitudes level (point 0.0 at the Y-axis) and in others those students on average score 1.7 standard deviations lower. The same holds for more science able students: there are schools in which they do not score above average on the attitudes scale and others in which they attain more than 1 standard deviation above the mean value. A similar pattern emerges when examining the variation within school (var=0.041, SE=0.017; Figure 2c). The environmental attitudes

of students with an average score on the science ability test vary less within their school than their less or more science able peers do.



**Figure 2:**

- A:** Within school variation in environmental awareness (95% Confidence interval)
- B:** Between school variation in environmental attitudes (95% Confidence interval)
- C:** Within school variation in environmental attitudes (95% Confidence interval)

### Model 2: controlling for student demographics

In the second model, variables on students' background and educational record are added. Looking at the fixed part, we note that the effect of science abilities – though decreased – remains quite large (0.44 and 0.18 standard deviation for environmental awareness and attitudes respectively with an increase of 1 standard deviation in science ability). Students' enjoyment of science (JOYSCIE) proves an important predictor for the awareness of environmental issues and attitudes towards the environment too (respectively an increase of 0.19 and 0.22 for an augmentation of 1 standard deviation in enjoyment of science). Students in vocational schooling tend to have lower awareness levels but more pro-environmental attitudes than their general education peers. Fifteen-year-olds in the technical education track do not score differently on environmental awareness, but their attitudinal level is significantly lower than that of the general education-students. Regarding students' background characteristics, results indicate that, on average, girls score lower on the environmental awareness than boys but higher on attitudes. Native students do not differ from their first generation immigrant peers (and for parsimonious sake the dummy for first generation was thus not retained in the model). Second generation immigrants do not differ from their native and first-generation peers on awareness either, but do show more pro-environmental attitudes. Socio-economic and cultural status has a moderate but significant influence on both environmental awareness and attitudes (an increase of 1 standard deviation in ESCS provokes an augmentation of 0.08 and 0.05 respectively). In model 1 we found three effects in the random part: within school variation for environmental awareness and within and between school variation for environmental attitudes (see Figure 2). Examining the random part of model 2, we note that the within school covariance between environmental awareness and science abilities remains significant (cov=-0.045, SE= 0.007). Within schools, more science able children score more alike with respect to awareness of environmental issues than their average or less science able peers, even after controlling for student characteristics (see Figure 2). Furthermore, the between school variation for environmental attitudes has disappeared; mainly due to the inclusion of educational track into the analysis<sup>2</sup>. Finally, the within school variation for environmental attitudes falls out of the boundaries of significance as well, indicating that within schools the more science literate children are as variable in their environmental attitudes as their average or low science able peers.

### Model 3: process characteristics at school level

In the third model, we examine how schools can foster awareness and sustainable attitudes towards the environment. Four teaching strategies as well as information about whether or not schools offered environmental learning projects were included in the model (see model 3, Table 3). Results indicate that teaching using more interaction, investigation or application does not improve environmental awareness and attitudes. More hands-on teaching, however, tends to go together with slightly higher environmental awareness (0.059 of a standard deviation by 1 standard deviation increase in hands-on teaching).

School environmental learning activities (ENVLEARN) have a small positive effect on environmental attitudes (0.036 of a standard deviation by 1 standard deviation increase in ENVLEARN). Adding these school characteristics alters few coefficients at the student level. Only the effect of the studying in the technical education-track on environmental attitudes falls beyond the boundaries of significance. This implies that when taking into account schools' average teaching styles and their efforts on environmental learning, students from the technical education

**Table 3:** Fixed and Random coefficient estimates and standard errors for model 2 and 3

Term	Model 2		Model 3	
FIXED PART	ENVAWARE	ENVATT	ENVAWARE	ENVATT
<b>Intercept</b>	.124(.030)*	-.064(.034)	.129(.031)*	-.067(.035)*
Dummy outlier		.943(.199)*		1.097(.211)*
<b><i>Student Characteristics</i></b>				
SCIABIL	.441(.020)*	.186(.023)*	.444(.020)*	.188(.023)*
JOYSCIE	.191(.014)*	.224(.016)*	.190(.014)*	.225(.016)*
technical education	-.048(.035)	-.076(.039)*	-.054(.039)	-.061(.043)
vocational education	-.151(.050)*	.126(.056)*	-.153(.054)*	.141(.060)*
Girl	-.239(.025)*	.093(.029)*	-.244(.025)*	.089(.029)*
2 <sup>nd</sup> generation immigrant	.115(.074)	.202(.081)*	.109(.074)	.206(.081)*
ESCS	.087(.015)*	.058(.018)*	.088(.015)*	.057(.018)*
<b><i>Process characteristics</i></b>				
SCINTACT			-.021(.021)	-.034(.023)
SCINVEST			-.004(.024)	.029(.025)
SCHANDS			.059(.025)*	-.007(.027)
SCAPPLY			-.029(.025)	.008(.026)
ENVLEARN			.002(.017)	.036(.018)*
<b>RANDOM PART</b>				
<b><i>Student Level</i></b>				
intercept ENVAWARE variance	.630(.013)*		.630(.013)*	
intercepts covariance	.111(.011)*		.111(.011)*	
intercept ENVATT variance		.864(.018)*		.864(.018)*
covariance SCIABIL ENVAWARE- intercept ENVAWARE	-.045(.007)*			-.045(.007)*
<b><i>School Level</i></b>				
intercept ENVAWARE variance	.018(.004)*		.016(.004)*	
intercepts covariance	.006(.003)*		.006(.003)*	
intercept ENVATT variance		.013(.005)*		.012(.005)*
Deviance	24390.100*		24376.400	

*Note: For the fixed part, effect sizes are shown with their standard error (between brackets). Significant values are marked \*. Significance is set at a 5% level. Values are considered significant if the coefficient exceeds the threshold of 1.96 times the standard error.*

## Conclusions and Implications

To examine whether schools influence students' environmental awareness and attitudes, the Flemish data of PISA 2006 were analysed from a school effectiveness point of view. Results indicate that both the level of the individual student and that of the school are important to explain variance in students' environmental attitudes and awareness.

## Individual-level explanatory variables

The first research question asked which individual-level explanatory variables explain variation in environmental attitudes and awareness of 15-year-olds. Our results confirmed that girls are more pro-environmentally orientated (higher on ENVATI), but less aware of environmental issues than boys. This could partly be due to the fact that the ENVAWARE scale is largely cognitive of nature and girls commonly score lower on science related cognitive test (Spelke, 2005). An alternative explanation could be found in the construction of the self-reported scale: perhaps girls tend to underestimate their level of knowledge. We found a small but significant effect of the social, economic and cultural status (ESCS) on environmental attitudes. Although socio-economic status is often described as one of the key explanators of differences in environmental attitudes, our results indicate it influences environmental attitudes and awareness only to a limited extent. A possible explanation might lie in the fact that the ESCS variable, as constructed by PISA, catches diverse aspects of the students' background. It is possible that the subdomains of the ESCS variable have a differential effect on environmental attitudes and awareness, thus tempering the overall effect. Future research could consider splitting the ESCS variable into three different status variables (economic, social and cultural) and assess the influence of each of them separately. As educational track is concerned, students enrolled in the technical education track score alike on environmental awareness than their general education peers, but (slightly) lower on the environmental attitudes. Students from vocational educational on the contrary showed to be less aware of environmental issues but at the same time hold more positive environmental attitudes, even after controlling for sex and ESCS. Furthermore, results indicate that second generation immigrants are significantly more pro-environmental than their native and first generation fellow-students. These are surprising findings, given that previous research suggested the opposite to be true (e.g. Hunter, 2000). Further research seems appropriate since these findings might be specific for the Flemish society.

## Do schools matter?

The second research question centred on whether schools stimulate their students towards more pro-environmental attitudes and awareness and if so which aspects of constructivist teaching and informal learning environments are involved in this school effect. Results indicate that, besides the characteristics of individual students, schools explain a significant proportion of variation in students' environmental attitudes and awareness as well. For environmental attitudes, about 6.5% of the variation can be attributed to the school. For environmental awareness this amounts to 17%. Though most Flemish 15-year-olds do not follow a specific environmental course, schools do influence students' environmental awareness and attitudes. One possible explanation is that certain schools attract more environmentally aware students with more pro-environmental attitudes. However, controlling for student characteristics diminishes the school-effect but does not eliminate it. An alternative reason is that other courses (like natural science courses or geography courses) indirectly educate on environmental issues. This characterises the cross-curricular approach of EE in Flanders, in which schools are encouraged to include environmental topics in all classes. As to precisely which elements in schools' cross-curricular approach of EE are of importance, our results are consistent with Brody's (2005) findings on informal learning. Students from schools emphasising environmental learning activities show more positive environmental attitudes, though the effect is rather small. Littleddyke's (2008) claim that constructivist teaching enhances environmental awareness and attitudes was confirmed to a certain degree. Hands-on teaching seems the element of constructivist teaching able to influence students' environmental awareness. We need to note that this effect was not that large either. Lester's et al. (2006) conclusions were partially overturned by our findings: students' science literacy and environmental awareness and attitudes are positively associated, but emphasising personal meaning when teaching science did not increase awareness of environmental issues. Students in schools stressing the relevance of science to society and the world outside (the science application scale) do not denote more pro-environmental attitudes. Looking back at the four items that underlying the scale for hands-on teaching, students frequently report having to conduct experiments following the instructions of the teacher (1) and having to draw conclusions from them (2). Designing their own laboratory investigation (3) and doing practical experiments in the laboratory (4) happens less often in science

classes according to Flemish 15-year-olds. A possible explanation for why drawing their own conclusions and conducting an experiment stimulates students' awareness can therefore be found in research on constructivist learning (e.g. De Corte, 1996; Gijbels, Van de Watering, Dochy & Van den Bossche, 2006). Compared to the investigation and application index the hands-on scale stresses the students' construction of knowledge and active participation, thus possibly generating a stronger learner experience. However, we need to note that the elements of constructivist teaching were only roughly assessed in the PISA data.

A question that arises by our results is why constructivist teaching does not influence students' pro-environmental attitudes, since studies on constructivist teaching and science attitudes suggest the opposite (e.g. Gibson & Van Strat, 2001). However, Liang and Gabel (2005) could not reproduce this finding. One explanation could be that the effect of constructivist teaching on attitudes only manifests after a certain time. In our study it remains unclear for how long students have been (consistently) taught in a constructivist manner. For future research we would plea for a longitudinal approach assessing the change in environmental attitudes and awareness.

Some schools also take on more environmental education projects than others. This is important since environmental learning activities influence students' attitudes on the issue. Studying the items underlying the construct 'environmental learning activities', we note that 80% of Flemish schools organised outdoor education, two-third of schools organised a trip to science and/or technology centre and 69% declared that their students went on a trip to a museum. Extracurricular environmental projects and lectures and/or seminars are less frequent (with respectively 52% and 25% of schools). Thus, we might conclude that learning in environmental learning activities was situated predominantly outside the actual classroom. Research on significant life experiences in the formation of environmental attitudes confirms that such learning initiatives can stimulate attitudes (Palmer et al., 1998). Our results support these findings and add that this can be done without necessarily stimulating awareness. This may also clarify why fifteen-year-olds from the vocational schooling tend to have more pro-environmental attitudes than their general education peers: eeducation in the vocational track is provided through a more project based approach than in technical and general education. This approach might be more activating, resulting in a higher score on the PISA environmental attitudes scale. Yet the full extent of the differences between the educational tracks can only be understood through further research.

The school-effects are rather small, certainly when compared to the impact of individual characteristics. However, this could also be due to the fact that we control for science ability before adding school characteristics into the model. Perhaps there is an indirect link (too): constructivist teaching influences students' science abilities and subsequently science abilities stimulate environmental awareness and attitudes. Future research should therefore consider testing a multilevel path-model with a multilevel structural equation analysis (De Maeyer, Rymenans, Van Petegem, van den Bergh & Rijlaarsdam, 2007).

Lastly, including school characteristics does not nullify the effect of schools themselves. Though a large amount of school level variation is explained throughout the subsequent models, a significant portion of school level variation in both dependent variables remains unaccounted for. From the school effectiveness perspective we expect that classical process characteristics elements such as educational leadership, school climate or degree of achievement oriented policy are key in explaining variation too (Scheerens, 1990). However, this wave of PISA did not include measures to assess the effects of these elements.

Science abilities, environmental attitudes and awareness

The last research question inquired whether schools have a differential effect for students with varying levels of science ability. Our findings suggest that students' science ability and environmental awareness and attitudes are positively associated. Students with higher scores on the science ability assessment tend to be more environmentally aware and have more pro-environmental attitudes. Our results indicated the school effect to be different for students with varying levels of science abilities; however, the differential effect of schools did not maintain after controlling for student characteristics. This implies that the school is not more important in stimulating

environmental awareness and attitudes for an average science able child than for a less or more science able youngster.

When examining the variation within schools, we noted that more science able children score more alike with respect to awareness of environmental issues than their average or less science able peers. This effect holds strong even after controlling for student characteristics. One possible explanation is a ceiling effect on the environmental awareness scale. This occurs when scale items are insufficiently difficult for environmentally aware students, resulting in a large amount of students scoring at or near the upper limit. Another reason is that students scoring higher on science abilities are provided extra information in the science classes on environmental issues. Due to the socialising function of the school we would thus expect students to score more alike on environmental attitudes as well. Yet, we did not observe this. A third explanation could be that high achieving science students seek extra information on science related issues outside the classroom.

### Advantages of and limitations to working with the PISA data

Although the large dataset we were able to work on was an advantage, a number of limitations of our study need to be acknowledged for, most notably the fact that the scales of environmental awareness and attitudes are self-reported and over- or underestimate might be systematically linked to other predictors (like students' sex). A second drawback to the Flemish PISA-data was the absence of parent data. Schools as well as the home environment are known to play an important role in stimulating students' awareness and attitudes (Palmer et al., 1998).

In spite of these downsides we believe that the PISA 2006 data offers an opportunity to test the qualitative findings in the field of environmental education in a quantitative manner. It would be beneficial to replicate this exploratory study in other settings. Our focus was on the PISA 2006 data from Flanders, due to its cross-curriculum final objectives for environmental education focussing on attitudes. Therefore, international comparative research is necessary to confirm these results in other educational, cultural and economical settings.

In conclusion, despite the limitations of this study, following recommendations for practice can be put forward. Firstly, schools do have an impact on students' environmental awareness and attitudes and can therefore be drawn upon by EE policy makers as means of fuelling students' awareness and attitudes. Secondly, our results suggest that schools can stimulate students' environmental awareness by teaching in a more hands-on manner. For example letting students do practical experiments and drawing conclusion from them seems beneficial to students' environmental awareness. Thirdly, schools can engender more pro-environmental attitudes in their students by focussing on environmental learning projects, like outdoor education or trips to the museum.

## Notes

<sup>1</sup> See Scheerens (1990) for more detail on the integrated model of school effectiveness.

<sup>2</sup> When only educational track is added, the relation between science ability and environmental attitudes falls out of the boundaries of significance (mean estimate of 0.010 and standard error of 0.006).



## References

- Anderson, J.O., Lin, H.S., Treagust, D.F., Ros, S.P., & Yore, L.D. (2007). Using large-scale assessment datasets for research in science and mathematics education: programme for international student assessment (PISA). *International Journal of Science and Mathematics Education, 5*, 591-614.
- Barr, S. (2007). Factors influencing environmental attitudes and behaviors. A U.K. case study of household waste management. *Environment and Behavior, 39*, 435-473.
- Brody, M. (2005). Learning in nature. *Environmental education research, 11*, 603-621.
- Davies, L. (1997). The rise of the school effectiveness movement. In J. White & M. Barber (Eds.), *Perspectives on school effectiveness and school improvement* (pp. 25-40). London: Institute of Education, University of London.
- De Corte, E. (1996). Instructional Psychology: Overview. In E. De Corte & F. Weinert (Eds.), *Encyclopedia of developmental and Instructional Psychology* (pp. 33-43). London: Pergamon.
- De Maeyer, S., & Rymenans, R. (2004). *Onderzoek naar kenmerken van effectieve scholen. Kritische factoren in een onderzoek naar schooleffectiviteit in het technisch en beroepssecundair onderwijs in Vlaanderen* [Research on school effectiveness-enhancing factors. Critical factors in a research on school-effectiveness for technical and vocational secondary education in Flanders]. Ghent: Academia Press.
- De Maeyer, S., Rymenans, R., Van Petegem, P., van den Bergh, H., & Rijlaarsdam, G. (2007). Educational leadership and pupil achievement: The choice of a valid conceptual model to test effects in school effectiveness research. *School Effectiveness and School Improvement, 18*, 125-145.
- EAC, Education, Audiovisual & Culture Executive Office of the European Commission (2009). *National Summary Sheets on Education in Europe and Ongoing Changes*. Belgium: Flemish Community.
- Eagles, F.J., & Demare, R. (1999). Factors Influencing Children's Environmental Attitudes. *Journal of Environmental Education, 30*(4), 33-37.
- Gibson, H.L., & Van Strat, G.A. (2001, March). *A longitudinal study of the impact of constructivist instructional methods on preservice teachers' attitudes toward teaching and learning mathematics and science*. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, St. Louis.
- Giddens, A. (1997). *Sociology*. Cambridge: Blackwell Publishers.
- Gijbels, D., Van de Watering, G., Dochy, F., & Van den Bossche, P. (2006). New learning environments and constructivism: the students' perspective. *Instructional Science, 34*, 213-226.
- Goldman, D., Yavetz, B., & Pe'er, S. (2006). Environmental Literacy in Teacher Training in Israel: Environmental Behavior in New Students. *Journal of Environmental Education, 38*(1), 3-22.
- Hassan, R., Scholles, R., & Ash., N. (Eds.). (2005). *Ecosystem Conditions and Human Well-being: Current state and Trends: Findings of the Condition and Trends Working Group*. Washington (D.C.): Island Press.
- Hox, J. (2002). *Multilevel Analysis : Techniques and applications*. Mahwah, NJ: Lawrence Erlbaum.
- Hunter, L.M. (2000). A comparison of the environmental attitudes, concern, and behaviors of native-born and foreign-born U.S. Residents. *Environment & Population, 21*(6), 565-580.
- Kaiser, F.G., Oerke, B., & Bogner, F.X. (2007). Behavior-based environmental attitude: Development of an instrument for adolescents. *Journal of Environmental Psychology, 27*, 242-251.
- Klaczynski, P.A., & Reese, H.W. (1990). Educational trajectory and "action orientation": Grade and track differences. *Journal of Youth and Adolescence, 20*(4), 441-462.
- Lester, B.T., Ma, L., Lee, O., & Lambert, J. (2006). Social Activism in Elementary Science education: A science, technology, and society approach to teach global warming. *International journal of science education, 28*, 315-339
- Liang, L.L., & Gabel, D.L. (2005). Effectiveness of a constructivist approach to science instruction for prospective elementary teachers. *International Journal of Science Education, 27*, 1143-1162.
- Littledyke, M. (2008). Science education for environmental awareness: approaches to integrating cognitive and affective domains. *Environmental Education Research, 14*, 1-17.
- Maloney, M.P., & Ward. M.P. (1973). Ecology: Let's hear it from the people. An objective scale for measurement of ecological attitudes and knowledge. *American Psychologist, 28*, 583-586.

- Ministry of The Flemish Community, Education Department, Department for Educational Development. (2001). *Cross-curricular final objectives in mainstream secondary education*. Brussels: Flemish Government.
- OECD, (2007). *Science competencies for tomorrow's world*, Paris: OECD Publications.
- Palmer, J.A., Suggate, J., Bajd, B., & Tsaliki, E. (1998). Significant Influences on the Development of Adults' Environmental Awareness in the UK, Slovenia and Greece. *Environmental Education Research*, 4(4), 429-444.
- Rasbach, J., Steele, F., Browne, W., & Prosser, B. (2005). A user's Guide to MLWin. Version 2.0. [Computer software and manual]. Retrieved July 14, 2009, from <http://www.cmm.bristol.ac.uk/MLwiN/download/MLwiN-userman-09.pdf>
- Reynolds, D., & Teddlie, C. (1999). The future agenda of studies into effectiveness of schools. In R.J. Bosker, B.P.M. Creemers & S. Stringfield (Eds.), *Enhancing educational excellence, equity and efficiency* (pp. 223-251). Dordrecht/Boston/London: Kluwer Academic Publishing.
- Schahn, J., & Holzer, E. (1990). Studies of environmental concern. The role of gender, knowledge and background variables. *Environment and Behavior*, 22, 767-786.
- Scheerens, J. (1990). School effectiveness research and the development of process indicators of school functioning. *School Effectiveness and School Improvement*, 1, 61-80.
- Scheerens, J., & Bosker (1997). *The foundations of educational effectiveness*. Oxford: Elsevier - Pergamon.
- Schultz, P.W., Oskamp, S., & Mainieri, T. (1995). Who recycles and when? A review of personal and situational factors. *Journal of Environmental Psychology*, 15(2), 105-121.
- Spelke, E. (2005). Sex Differences in Intrinsic Aptitude for Mathematics and Science? A Critical Review. *American Psychologist*, 60(9), 950-958.
- Stern, P.C. (1992). Psychological dimension of global environmental change. *Annual Review of Psychology*, 43, 269-302.
- Stern, P.C., Dietz, T., & Guagnano, G.A. (1995). The New Ecological Paradigm in social-psychological context. *Environment and Behavior*, 27, 723-743.
- Thum, Y.M. (1997). Hierarchical linear models for multivariate outcomes. *Journal of Educational and Behavioural Statistics*, 22(1), 77-108.
- Thum, Y.M. (2003). Measuring progress toward a goal: estimating teacher productivity using a multivariate, multi-level, value-added model. *Sociological Methods & Research*, 23, 208-252.
- Wilson, E.O. (1993). Biophilia and the conservation ethic. In S.R. Kellert & E.O. Wilson (Eds.), *The Biophilia Hypothesis* (pp. 31-41), Washington, DC: Island Press.

Appendix A : Item list of used scales

Scale	Items	Response categories
<b>Output measure</b>		
Environmental awareness	<p>“How informed are you about the following environmental issues?”</p> <ol style="list-style-type: none"> <li>1. The increase in greenhouse gases in the atmosphere</li> <li>2. The use of genetically modified organisms</li> <li>3. Acid rain</li> <li>4. Nuclear waste</li> <li>5. The consequence of clearing forests for other land use</li> </ol>	<ol style="list-style-type: none"> <li>1. I have never heard of this</li> <li>2. I have heard about this but I would not be able to explain what it is really about</li> <li>3. I know something about this and could explain the general issue</li> <li>4. I am familiar with this and I would be able to explain this well</li> </ol>
Environmental attitudes	<p>“How much do you agree with the statements below?”</p> <ol style="list-style-type: none"> <li>1. It is important to carry out regular checks on the emissions from cars as a condition of their use</li> <li>2. It disturbs me when energy is wasted through the unnecessary use of electrical appliances</li> <li>3. I am in favour of having laws that regulate factory emission even if this would increase the price of products</li> <li>4. To reduce waste, the use of plastic packaging should be kept to a minimum</li> <li>5. Industries should be required to prove that they safely dispose of dangerous waste materials</li> <li>6. I am in favour of having laws that protect the habitats of endangered species</li> <li>7. Electricity should be produced from renewable sources as much as possible, even if this increases the cost</li> </ol>	<ol style="list-style-type: none"> <li>1. Strongly agree</li> <li>2. Agree</li> <li>3. Disagree</li> <li>4. Strongly disagree</li> </ol>
<b>Student characteristics</b>		
Science enjoyment	<p>“How much do you agree with the statements below?”</p> <ol style="list-style-type: none"> <li>1. I generally have fun when I am learning science topics</li> <li>2. I like reading about science</li> <li>3. I am happy doing science problems</li> <li>4. I enjoy acquiring new knowledge in science</li> <li>5. I am interested in learning about science</li> </ol>	<ol style="list-style-type: none"> <li>1. Strongly agree</li> <li>2. Agree</li> <li>3. Disagree</li> <li>4. Strongly disagree</li> </ol>

<b>Process characteristics</b>	“When learning science topics at school, how often do the following activities occur?”	<ol style="list-style-type: none"><li>1. In all lessons</li><li>2. In most lessons</li><li>3. In some lessons</li><li>4. Never or hardly ever</li></ol>
Interaction	<ol style="list-style-type: none"><li>1. Students are given opportunities to explain their ideas</li><li>2. The lessons involve students’ opinions about the topics</li><li>3. There is a class debate or discussion</li><li>4. The students have discussions about the topics</li></ol>	
Investigation	<ol style="list-style-type: none"><li>1. Students are allowed to design their own experiments</li><li>2. Students are given the chance to choose their own investigations</li><li>3. Students are asked to do an investigation to test out their own ideas</li></ol>	
Hands-on	<ol style="list-style-type: none"><li>1. Students spend time in the laboratory doing practical experiments</li><li>2. Students are required to design how A science question could be investigated in the laboratory</li><li>3. Students are asked to draw conclusions from an experiment they have conducted</li><li>4. Students do experiments by following the instructions of the teacher</li></ol>	
Application	<ol style="list-style-type: none"><li>1. The teacher explains how a science idea can be applied to a number of different phenomena (<i>e.g.</i> the movement of objects, substances with similar properties)</li><li>2. The teacher uses science to help students understand the world outside school</li><li>3. The teacher clearly explains the relevance of science concepts to our lives</li><li>4. The teacher uses examples of technological application to show how science is relevant to society</li></ol>	

---

## Appendix B : The multivariate multilevel model

The multivariate model contains three levels: the dependent variables level, the student level and the school level. The underlying assumption is that the output measures (the dependent variables, level 1) are nested within students (level 2), who in turn are nested within schools (level 3). The data are strictly hierarchical: each student belongs to one school only. In our study, we estimated four models. Here, we will discuss the last, most complex one. Formula (1) shows how the multivariate model is put together.

$$Y_{ijk} = [(\beta_0 + \mathbf{u}_{0k} + u_{0jk}) X_{0jk}] + [(\beta_1 + \mathbf{u}_{1k} + u_{1jk}) X_{1jk}] + (\beta_2 X_{2jk}) + \dots + (\beta_{17} X_{17jk}) + \alpha_1 W_{1k} X_{0jk} + \alpha_2 W_{2k} X_{0jk} + \dots + \alpha_{11} W_{11k} X_{1jk} \quad (1)$$

$Y_{ijk}$  stands for the score on one of the two dependent measures  $i$  of student  $j$  in school  $k$ . The model includes two dummies ( $X_{0jk}$  and  $X_{1jk}$ ), one for each dependent variable. When estimating the score for environmental awareness for example,  $X_{0jk}$  has the value 1 while  $X_{1jk}$  is zero. The intercept  $\beta_0$  represents the mean score on the environmental awareness scale for a boy in the general education with average science ability and enjoyment, of an average economic, social and cultural status in a school with average hands-on learning (a zero on all the significant predictors for ENV-AWARE, see Table 3). The  $\beta_1$  gives the mean score on the pro-environmental attitudes scale for a native boy in the general education in any but the outlier school with average science ability and enjoyment, of an average economic, social and cultural status in a school with average environmental learning activities (significant predictors for ENV-ATT, see Table 3).

Besides the intercepts, the model also includes 16 student level variables:  $X_{2jk} \rightarrow X_{17jk}$ . The estimates for these variables ( $\beta$ 's) indicate the effect of a predictor on the output measure, for example the effect of being a girl (as opposed to being a boy) on environmental awareness or the impact of a one standard deviation increase in science enjoyment on environmental attitudes. The model contains 11 school level predictors as well ( $W_{1k} \rightarrow W_{11k}$ ): 5 predictors per dependent variable and one dummy for an outlying school on the environmental attitudes scale (see Results).

The model assumes that the average score of one particular school on both output measures can deviate from the average score of all schools combined. These deviations are represented in the model by the residuals  $\mathbf{u}_{0k}$  and  $\mathbf{u}_{1k}$ . The variance of these residuals is labelled 'between school variance' and denoted by  $\sigma_{v0}^2$  and  $\sigma_{v1}^2$  (see formula 2). Variances deviating significantly from zero indicate that schools differ from each other with regard to their scores on the output measure concerned. This suggests that a multilevel model is necessary to accurately estimate the regression coefficients.

$$\begin{bmatrix} v_{0k} \\ v_{1k} \end{bmatrix} \sim N(0, \Omega_v) : \Omega_v = \begin{bmatrix} \sigma_{v0}^2 & \\ \sigma_{v01} & \sigma_{v1}^2 \end{bmatrix} \quad (2)$$

Besides variances between schools, the covariance between the residuals at school level is calculated ( $\sigma_{v01}$  in formula 2). If this measure is for example significant and positive, it can be concluded that schools performing well on one dependent variable (environmental awareness) on average score well on the other (environmental attitudes) too.

Besides 'between school variance' there is also 'within school variance'. Not all students in the same school perform equally well. For this reason pupils' deviations to the school average are included in the multivariate model:  $u_{0jk}$  and  $u_{1jk}$  (formula 1). The variance components of these estimates are labelled  $\sigma_{u0}^2$  and  $\sigma_{u1}^2$  respectively (formula 3). The covariance between the two error terms is estimated as well ( $\sigma_{u01}$ ). Analogously, a significant positive effect indicates that students scoring higher on the first dependent tend to score higher on the second as well.

$$\begin{bmatrix} u_{0jk} \\ u_{1jk} \\ u_{13jk} \end{bmatrix} \sim N(0, \Omega_u) : \Omega_u = \begin{bmatrix} \sigma_{u0}^2 & & \\ \sigma_{u01} & \sigma_{u1}^2 & \\ \sigma_{u013} & 0 & 0 \end{bmatrix} \quad (3)$$

Lastly, the heteroskedacity in the effect of science ability on environmental awareness was modelled. This heteroskedacity can be modelled by two parameters (a variance and covariance component), though the figure (3) suggests three. The middle one can not be estimated (it is a structural zero). Since the variance of science abilities did not result significant, this was put to zero (Rasbach *et al.*, 2005), leaving the covariance between the intercept of environmental awareness and science ability ( $\sigma_{u013}$ ). A significant negative score suggests a fanning in pattern in the residuals within schools for science abilities on environmental awareness (Rasbach *et al.*, 2005). Scoring higher on science abilities goes together with less heterogeneity in the errors of environmental awareness at the student level.

**PART 4**  
**CULTURAL, SOCIAL, AND GENDER ISSUES**





# SEX EDUCATION: TEACHERS' SOCIAL REPRESENTATIONS, CONCEPTIONS AND PRACTISES

Dominique Berger

Université Claude Bernard, Lyon 1-IUFM, EA n°4281, PAEDI

Sandie Bernard

Université Claude Bernard, Lyon 1-IUFM, EA n°4281, PAEDI

Graça Simoes de Carvalho

Universidade do Minho – Braga - Portugal

## Abstract

*School Sex Education is nowadays an important public health issue as it concerns not only youth AIDS prevention (and other sexually transmitted infections) and adolescent pregnancy prevention but also interpersonal relationships and psychosocial issues. Therefore school sex education contributes to promote better citizenship. The European FP6 Biohead-Citizen research project aims to understand how biology, health and environmental education can contribute to improving citizenship. It analyses the social representations and practices of teachers in several countries, focusing on their differences and associating them to controlled parameters (e.g. social context, religion, gender). In this communication we analyse data concerning teachers' and future teachers' conceptions on the topic of sex education derived from a questionnaire that was constructed and tested during the first year of the project. The questionnaire was completed by 6001 teachers and future teachers from 15 countries. We used statistical multivariate analyses, a method that has become standard for investigating complex data derived from many individuals that needs to be analysed according to many variables (here we have used the responses to the questions as variables). The results show that the factors that correlate most closely with the teachers' and future teachers' conceptions are religion, the level of belief in God and the level of religious practices. It was also found that the level of teaching (primary versus secondary school) is also correlated with different conceptions on sex education. Detailed results will be presented and discussed.*

## Introduction

This study is included in the Biohead-Citizen research project «Biology, Health and Environmental Education for better Citizenship» (FP6, CIT2-CT2004-506015, Carvalho et al. 2004). We will present here the results coming from 15 countries on the reproductive health education /sexuality education [RHE/SE].

Our objective is firstly to identify the teachers' conception variation, in each country and between countries. Are these conceptions linked with knowledge, with believes, philosophical or/and political issues? What is the role of local and social practices in each country? How are the interactions between “knowledge”, “values” and “social practices” (Clément, 2004)? In fine, what are the in service teachers or pre-service teachers' conceptions on RHE/SE and on the impact of RHE/SE would be promote better citizenship. We aim to build training

programmes on teachers' knowledge of and attitude towards reproductive health education /sexuality education [RHE/SE].

## **Rationale**

Sex education, sometimes called sexuality education or sex and relationships education, is the process of acquiring information and forming attitudes and beliefs about sex, sexual identity, relationships and intimacy. It is also about developing young people's skills so that they make informed choices about their behaviour, and feel confident and competent about acting on these choices. It is widely accepted that young people have a right to sex education, partly because it is a means by which they are helped to protect themselves against abuse, exploitation, unintended pregnancies, sexually transmitted diseases and HIV/AIDS (WHO, 1999).

Human sexuality is not enclosing in the life transmission and includes four important dimensions:

- Anatomy and biology with sex physiology, procreation and survival mankind
- Social dimension with cultural influence, social norms and rules and theirs political, juridical and religious incidences
- Psychological dimension with gender issue, the personality's construction and self esteem.
- Affective and relational dimension with feelings (love, desire), points of vue and emotions...

Sexuality presents a multidimensional aspect and concern deeply humans in the interweaving between sexuality, social influences, cognitive and affective development. So sexuality can be reduce in a dichotomy biology/psychology and involve in same time psycho-affective and biological maturation and social learning. Sexuality education seeks both to reduce the risks of potentially negative outcomes from sexual behaviour like unwanted or unplanned pregnancies and infection with sexually transmitted diseases, and to enhance the quality of relationships. It is also about developing young people's ability to make decisions over their entire lifetime. Sex education that works, by which we mean that it is effective is sexuality education that contributes to this overall aim.

Although most interventions on Sex education concern teenagers (see ref in Kirby, 2002) or young adults (Ergene and al., 2005), the WHO texts insist on the necessity for implementing early sexuality education, particularly in primary schools (WHO, 1999; 2004a). Many authors underline the importance of the educational dimension of this: "the action must be integrated into a global life-education strategy; the way it is spoken of must be adapted to the situation, the parents' involvement, as they are the first resource for the children, must be as great as possible, and the educators must come from different fields" (AFLS, 1993).

It is necessary, in order to go beyond a prescriptive approach, and adopt a decidedly educational perspective, to implement a learner-centred approach (Develay, 1993), taking into account the children's peculiarities, expectations, needs, and also their own representations (Fischer, 2001). In this way, taking into account pupils' representations is an important part of the learning process. The interest of taking them into account in an HIV/AIDS or sex education programme for children under twelve has already been underlined (Fassler and al., 1989; Ferron and al., 1989; Thomas, 1991; Sly and al., 1992; Schaalma, Kok and Peters, 1993; Shonfeld and al., 1993; Kelly, 1995; WHO, 1999 ; 2004a ; 2004b).

The model on which these propositions was based assumes that learners build knowledge from their own lives. They learn through their mental representations, which depend on each person's social and biological experience, and individual disposition. Learning is a highly active mental process which works in an integrative mode in the conflict between what the learner has in his mind and what he can find and understand through his conceptions about his environment. When a learner makes a new model, all his mental models must be rebuilt in an interaction between the pre-existent representation and outside information (Giordan, 2000). Sex education requires the teacher to take into account the pupils' representations and to help them build other more relevant ones.

Moreover, the child's environment must be taken into account in the programme as children's representations are not only based on what they learn at school, but also on all the other aspects of a child's life (Downie, Tannahill and Tannahill, 1996).

Representations are to be taken as coherent models used by learners and teachers to reason when faced with a problematic situation (Jodelet, 1991; Farr, 1997; Khazmi & Berger, 2008; Berger, 2009). The building of these is rather complex and depends on values and beliefs shared by a social group and which give rise to a common outlook manifest during social interactions. As these representations are linked to the subject's emotional responses, the cultural and social group he belongs to, and constitute a decisive element in his relationship with the world, they are resistant to change. Representations are closely linked to behaviour (Abrie, 1997) and they could be considered as being a good target, as it is well known that knowledge is easy to change, but behaviours are much more challenging. Thus if a study aiming at impacting these representations is to be relevant, it has not only to target the transmission of knowledge, but also to take into account the social and cultural aspects of the children's and teacher's daily environment (Doise and Mugny, 1997).

Most researches are quasi-experimental designs. This method is of great evidentiary value but, due to its peculiarities, sex education also needs other designs (Victoria and al. 2004). In our context using the controlled randomized trial as a method for assessing the effects of the social representations is really difficult. The impact of representations means that using a control group is delusive, and that randomisation is tricky (Tones and Tilford, 2001). This is mainly because causal chains in public health interventions are very complex. Although such an approach has its limits, several authors conclude that they are in favour of new research on teachers' representation being set up, aiming at determining exactly what content and what tools would be most suitable (Darroch J. & al., 1989 ; Heymans, 1993 ). Associating multidisciplinary partners in the drawing up and the implementation of the researches' programmes makes it possible to better understand the interactions between teachers' representations and social issues (beliefs, knowledge and practices) (Martinand, 2003; Clément, 2005). If these interactions were not considered, they would be confounding factors.

## Methods

The questionnaire was elaborated in the Biohead-Citizen Project in a common work with all the research teams and translated in national language (validate by retro-translation). It was pre-tested before implementation in each country. 15 countries (12 of the Biohead-Citizen project) give us data on RHE/SE. Six are outside Europe and widely (Algeria, Tunisia, Morocco, Senegal) or in large part (Lebanon, Burkina Faso) muslim. Height countries are Europeans members (Portugal, France, Italy, Finland, Cyprus, Estonia, Hungry and Romania) and resent different characteristics: north and south, east and west Europe, catholic, protestant or orthodox culture. In each country, we have data coming from pre (PRE) and in (IN) service teachers in primary school (P) and in secondary schools in biology (B) and national language (L) in 6 balanced data groups.

The corpus include responses from 6001 questionnaires: Algeria (AL, 217), Burkina-Faso (BF, 296), Brazil (BR, 300), Cyprus (CY, 322), Estonia (ES, 183), Finland (FI, 306), France (FR, 732), Hungry (HU, 334), Italy (IT, 559), Lebanon (LB, 722), Morocco (MA, 330), Portugal (PT, 350), Romania (RO, 273), Senegal (SN, 324), Tunisia (TN, 753).

## Questionnaire

In the Biohead corpus, our work concerns only Sex education and 35 questions (A2, A9, A21, A 30, A31, A36, A41, A 46, A57 to A60, A65, A85 to A90, B3, B5, B11, B13, B17 to B19, B24, B30 to B32, and B37 to B41).

Few questions are on values (e.g. A41: "Homosexual couples should have the same rights as heterosexual couples"), on biological knowledge (e.g. « B17: After ovulation, the follicle changes into corpus luteum which produces high levels of progesterone and estrogens"). More are on teaching practices, values and knowledge (e.g.

B19: Psychological and social aspects of sex education should be taught primarily by biology teachers). Questions A57 to A59 and A65 are about abortion. Responses are coding from 1 “In this case, abortion is morally acceptable” to 4 “In this case, abortion is morally unacceptable” and in A 65 “Abortion is acceptable” , from 1 “never” to 5 “at any moment”.

Question A 60: “There are several behaviours that can help to decrease the spreading of AIDS world-wide. In your view, what is the behaviour you find most relevant to be considered in school sexual education? “, is coded from 1 “To have sex only within a stable relationship (not have several sexual partners)” to 4 “To have safer sex, for instance by using a condom in sexual intercourse”.

The questions A85 to A90 and B37 to B41 are on the age teachers think the following topics should be first introduced at school by teachers and/or external specialists. Responses are coded from 1 “less than 6 years old” to 5 “never in school”.

## Responses’ Analysis

Our hypothesis is that teachers’ personal values influence their conceptions on HRE/SE. These conceptions may be linked to the school disciplinary (biology or national language), to the teaching level (primary or secondary level), to the training (in service or pre service). But the variables linked to country’s context, religion or gender, are determining. What may most differentiate the conceptions of individuals with varying religions, specialities or any other feature? In fact, how to highlight the link between conceptions related to scientific knowledge or educative system in one hand and the teacher’s personal, social and cultural background, namely their values on the other hand?

Multivariate analysis allows representing the more structuring components of individuals. These components state better individual’s variance. Statistical multivariate analysis has become a standard to investigate complex data featuring the behaviour of many individuals, according to many variables (Lebart et al., 1995). Here variables are questions in a questionnaire for which we gathered answers. To analyse the HRE/ SE and teaching practices data, we use principal component analysis (PCA, Lebart et al., 1995). Variables are coding as numbers. We have done a discriminating analysis (Between group analysis, Dolédec & Chessel, 1987) in complement of PCA to show differences between groups’ conceptions (country context, religion, faith and gender). We use instrumental variables in responses’ structures as disciplinary (P, B, L), training (In or Pre service) and countries.

## Results

In this results’ presentation, we have chosen to don’t show calculation, just graphics which are more explicit. We present the first results and just few variables. We don’t propose an exhaustive study, just a skimming over to explore the new research field founded by Biohead-Citizen Project.

### Global approach

The schema shows us three distinct groups of variables. The group of questions (A) contributes strongly to axe 1 and illustrate that teachers think it is not possible to teach the social components of sexuality education to young pupils. Moreover they don’t agree to teach in school before 15 years old contents as homosexuality, paedophilia, pleasure organs, abortion, incest and sex violence, orgasm and pleasure, eroticism and pornography (A85 to A90 and B37 to B41). Netherless, pupils found all these topics in their daily life with their peers, in the streets or in the media (press, radio, TV...).

There is another interesting correlation. We found a group (B) composed by questions about possibility of abortion (A57 to 59); the respondents who don’t agree with abortion think also that women have not the same rights then men (A2), that it’s not important to have same number women deputies than men (A30) and that

women, biologically, have not same intelligence than men (A21). For them, Homosexual couples must not have the same rights then other couples... And they think also, it's the hazard who determines the sex of a baby (B30).

The group (C) of questions is defining the same oblique axis as the group (B), with just opposite positions: it's possible to try to choose baby sex by specific diet or medically assisted techniques (B31, B32) and who agree with the idea that abortion would be acceptable at any time (A65); a man can be as sensitive and emotional as women (A46) and there is no biological reason which would justify inequality between men and women (A6, A36, A46). Finally the question related to safer sex (as a behaviour most relevant to be considered in school sexuality education) is included in this group (C) of questions.

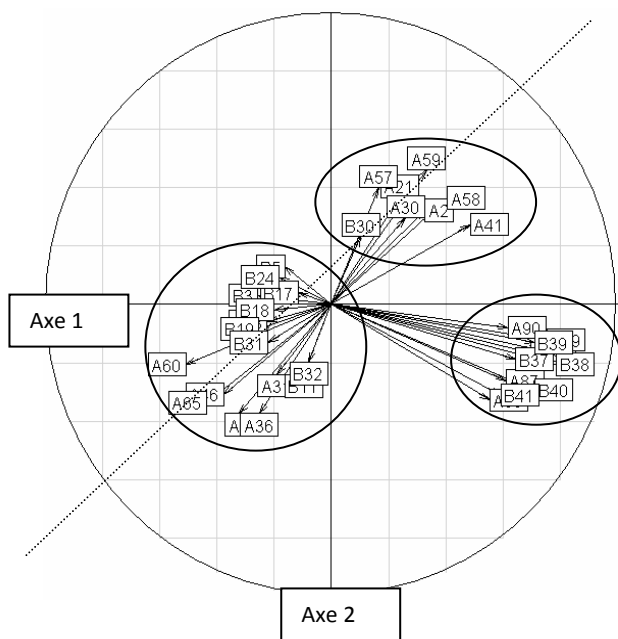


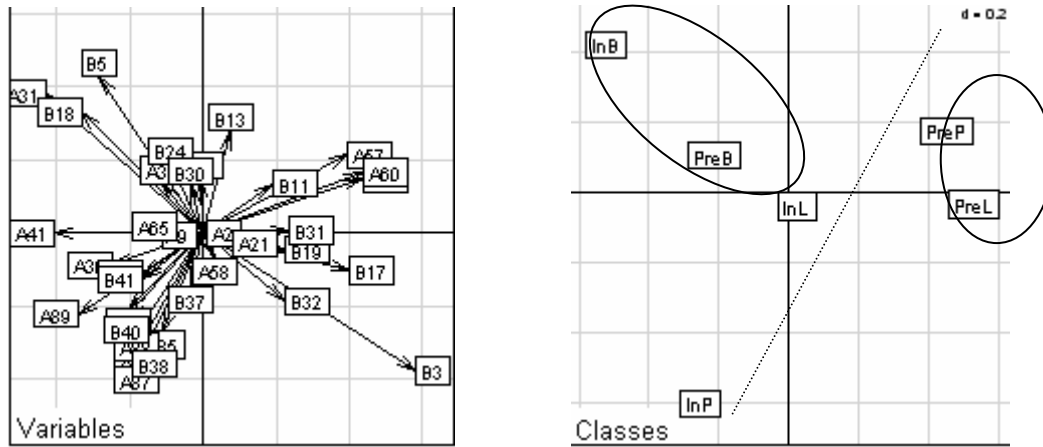
Figure 1: Principal component analysis (PCA), global correlation circle

### Training issue

The analysis (figure 2) shows us a difference between training. A PCA has been done to differentiate the six "groups of teaching" controlled in our sampling design (pre or in service, primary or secondary level, biology or letters. In fact Biology teachers (in service or pre service) have conceptions more based on knowledge and on the conviction that they can teach the whole dimensions of sexuality education (Q A31, B5, B18 B17, B22, B3 B24, B30). They think that they have to teach biological aspects of sexuality (human reproduction and ISD) and say that they are able o speak with their pupils about emotion, feelings, pleasure but they have the same difficulties as the others with In relation with the others groups, we found a clear difference between in service and pre service teachers in particular for primary teachers. The in service primary teachers are in difficulty in front of the content of sexuality education especially with social and affective issues like homosexuality, abortion, contraception, pleasure organs, paedophilia, safer sex (Questions : A 85 to A90, A 60) for example their conception is based on a false knowledge about the homosexuality origin (Question: B11).

The pre service primary teachers are in opposition with in service primary teachers and agree with safer sex, abortion, homosexual rights... and prefer teach these contents early in the curriculum.

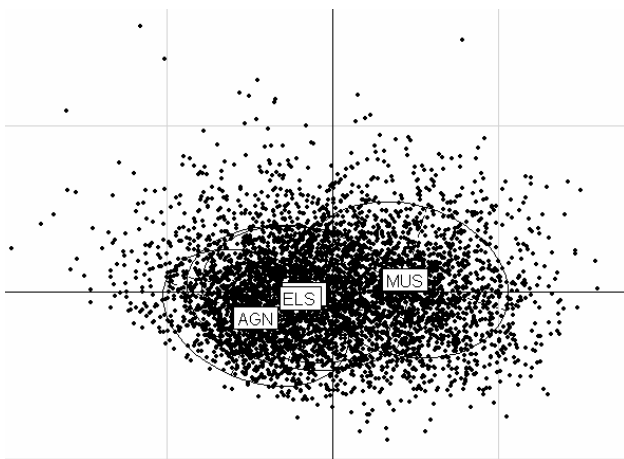
Figure 2 : teachers' statute variable



There is an effect of age in the teachers' conceptions. Inside the three thematic groups (primary, secondary biology and secondary letters), older teachers (in service; mean age = 40 years old) are always on the upper part of the axis 2 and the younger teachers (pre service; mean age = 23 years old) are in the lower position (figure 3).

### The religious impact

Figure 3: religion distribution (MCA)



The four categories (AGN, agnostic, atheist, without religion; MUS, moslem [Sunnite, chiite, druze, alevi]; ELS, other religions or believes [jewish, hinduist, animist...]; CHR, [catholic, protestant, orthodox]). We have two poles on an axe with in one hand Moslem and in the other hand Agnostic. In the middle part, we found others religions and Christians. With a similar process; we have crossed religion and teachers' conceptions (cf. fig1).

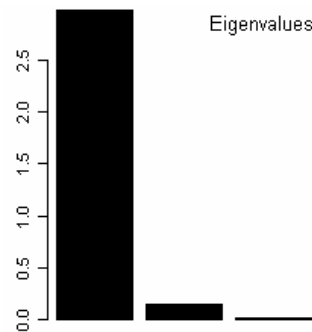
There is a strong correlation between religion and teachers' conceptions. Agnostics and atheists agree with the idea that abortion would be acceptable at any time (A65). They think also that a man can be as sensitive and emotional as women (A46) and there is no biological reason to inequality between men and women (A6, A36, A46).

For them, safer sex is the behaviour they find most relevant to be considered in school sexuality education. They agree with rights' equality between men and women and homosexual couples. At the opposite we find Moslem. This statement needs to be qualified. So, we crossed this data with God's believe levels.

Crossing the data with God's believe levels.

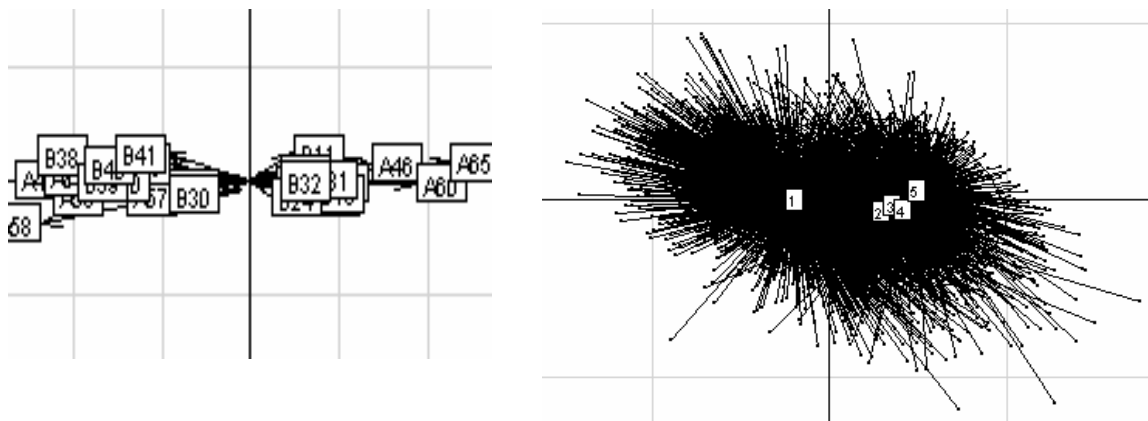
In this question, the responses are coded from 1 "most important" to 5 "I don't believe in God". To do that, we use a PCA which illustrate that the level of faith is an important variable more than religion's membership (Fig 4).

**Figure 4: relative contribution of main factors (faith's level)**



**Figure5: Between groups analysis, faith's distribution**

The variable "faith" contributes heavily to axe 1 as also shown by this graph.



There is a great difference between those who have a high level in faith (1) and all the others (2, 3, 4 and 5). We note a small scale progression between 2 to 5 along axe 1. All the data are clearly oriented in two blocks. Those who believe deeply in God are positioned on conservative point of view about men and women equality about women rights and homosexual rights. They don't agree with abortion and they think that it is not to school to teach social content in sexuality education. In the opposite, more the teachers don't believe in god more they agree with social contents of SE and think that men and women are equal, more they agree with women rights an homosexual rights. They think also it's possible to teach social contents as paedophilia, homosexuality, incest and violence, sexual intercourses... pregnancy and birth and they agree abortion at any moment.

It is also interesting to cross these data (faith level) with religion. In fact the results show us that faith' level is the most important factor which impact on teachers' conceptions. Christians with high faith's level have same kind of responses to the questionnaires than Moslem with same level.

## Conclusions and Implications

The implementation of early educational actions on health risk behaviours (e.g. nutrition, drugs abuse and sexually transmitted infections) can answer more effectively to the strong social demand, which has also been taken constantly by the political sector for many years in order to answer to major societal needs (WHO, 2001). Since the efficacy of the preventive policies is largely dependent of the citizens' adhesion to them, Health Education and Sexuality education turned out to be a rather important social issue. Although being a school mission, health authorities have reinforced the idea that Sexuality Education should be carried out in partnership with other social organisations involved in Health Education, in particular local organisms of the Health sector (WHO, 2006).

To study the effects of the context components and to identify the elements that interact with the sexuality learning domain has been a rather difficult task due to the lack of adequate instruments of research. It is in this field of educational determinants of the person's structuration (especially his/her self-esteem) and his/her ability to communicate, that educational actions must be taken, contributing in particular to the development of the psychosocial competencies. This involves moving beyond practices that rely mainly on classroom-based sexuality education models, to a more comprehensive, integrated approach that focuses both on child-youth attitudes and behaviours, and their environment. Sexuality is regarded as an important determinant of the personal development and wellbeing.

These results must be considered with prudence. Deep analysis must be done to highlight precisely the variances between groups and their links with social representations and individuals' conceptions. Forever, we have found that individuals' conceptions have a great incidence on teachers' social representations and on their practices. Recent publications (St Léger, 1998; Lister-Sharp et al. 1999; INSERM, 2001; WHO 2006) have shown that certain pedagogical activities have some positive effect, others no effect at all and yet other ones have a negative effect. This negative impact can be due not only to the quantitative increase of pupils' risk behaviours but also to the intensification of pupils' uneasy feeling or of their perception of a tension between their social/family life experience and the school prescriptions. So the teacher's conceptions are really important especially in prevention to promote health and sexual health. Sexuality Education is determined directly by both the teaching pedagogical practices and the social context (Allensworth and Kolbe, 1987; Gold, 1994) especially in skills developments.

To be effective, sexuality education needs to include opportunities for young people to develop skills, only having information is not sufficient. The kinds of skills young people develop as part of sexuality education are linked to more general life-skills. Being able to communicate, listen, negotiate, ask for and identify sources of help and advice, are useful life-skills and can be applied in terms of sexual relationships. Effective sexuality education develops young people's skills in negotiation, decision-making, assertion and listening. Other important skills include being able to recognise pressures from other people and to resist them, deal with and challenge prejudice, seek help from adults - including parents, carers and professionals - through the families, community and health services. Sexuality education also helps young people to be able to differentiate between accurate and inaccurate information, discuss a range of moral and social issues and perspectives on sex and sexuality, including different cultural attitudes and sensitive issues like sexuality, abortion and contraception.

The first prevention level is to be in capacities to access to information (WHO). Sexual health education involves a combination of educational experiences that allows individuals to do the following:

- to acquire knowledge that is relevant to their specific sexual health issues;
- to develop the motivation and personal insight that they will need to act on the knowledge;
- to acquire the skills necessary to enhance sexual health and avoid negative sexual health outcomes;
- and to help create an environment that is conducive to sexual health.

Research consistently shows that positive sexual health outcomes are most likely to occur when sexual health education integrates knowledge, motivation and skill-building opportunities and occurs in an environment conducive to sexual health. School-based sexuality education is an important and effective way of enhancing young people's knowledge, attitudes and behaviour (Kirby, 2001, 1992). There is widespread agreement that formal education should include sexuality education and what works has been well-researched. Evidence researches suggests that effective school programmes will include the following elements:



- A focus on scientific information about human reproduction , providing accurate information about contraception and birth control;
- A basis in theories which explain what influences people's sexual choices and behaviour and gender issue
- A clear, and continuously reinforced message about sexual behaviour and risk reduction;
- Working on psychosocial abilities, self esteem,dealing with peer and other social pressures on young people; providing opportunities to practise communication, negotiation and assertion skills;
- Uses a variety of approaches to teaching and learning that involve and engage young people and help them to personalise the information;
- Uses approaches to teaching and learning which are appropriate to young people's age, experience and cultural background.

Formal programmes with these elements have been shown to increase young people's levels of knowledge about sex and sexuality, decrease risk when they do have sex . All the elements are important and inter-related, and sexuality education needs to be supported by links to sexual health services, otherwise it is not going to be so effective. It also takes into account the messages about sexual values and behaviour young people get from other sources, like friends and the media. It is also responsive to the needs of the young people themselves - whether they are girls or boys, on their own or in a single sex or mixed sex group, and what they know already, their age and experiences.

Therefore the great challenge we have done with this study, is to identify better not only the nature of the teaching practices but also the teachers' conceptions, especially in sexuality education and their links with the practices. When teacher's have a high level in believes in God, they don't agree to men and women equality, homosexual rights, abortion and safer sex. They don't agree to teach social component of sexuality education before 15 years old. Or, the early access to information is the best way to prevent sexual violence, sexual transmitted diseases, and to promote sexual health and more largely health education. Providing effective sexuality education can seem daunting because it means tackling potentially sensitive issues. However, because sex education comprises many individual activities, which take place across a wide range of settings and periods of time, there are lots of opportunities to contribute. School-based education programmes are particularly good at providing information and opportunities for skills development and attitude clarification in more formal ways, through lessons within a curriculum. So it's very important to Public Health, especially to prevent AIDS and sexual transmitted diseases and sexual violence to well know the obstacles to sexuality education's implementation.

## References

- Allensworth, D. & Kolbe, L.J. (1987). The comprehensive school health program: exploring an expanded concept. *Journal School Health*, 57 (10), 409-412.
- Arwidson, P. (2001). Démarches et méthodes en éducation pour la santé des jeunes . In 4ème Journées d'assurance maladie de la CANAM, Education et prévention chez l'enfant et l'adolescent, Paris.
- Bandura, A. (1992) self-efficacy mechanism in psychobiologic functioning, self -efficacy: thought control of action pp. 155-189 Washington: Hemisphere.
- Bernard, S. & al (2007). Sexual transmitted diseases and control of reproduction in biology textbooks. A comparative analysis in 16 countries. In proceedings of IOSTE conference 'Critical analysis of school sciences textbooks', Tunisia, 7-10 February 2007.
- Carvalho, G. et al (2007). Health education approaches in school textbooks of 16 countries: biomedical model versus health promotion. In proceedings of IOSTE conference 'Critical analysis of school sciences textbooks', Tunisia, 7-10 February 2007.
- Bury, J. (1988). Éducation pour la santé : concepts, enjeux, planifications. Bruxelles : De Boeck.
- Carvalho, G., Clément, P., Bogner, F. (2004). Biology, Health and Environmental Education for better Citizenship. STREP CIT2-CT-2004-506015, E.C., Brussels, FP6, Priority 7. <http://www.biohead-citizen.net>
- Clément P. (2004). Science et idéologie : exemples en didactique et épistémologie de la biologie. In actes du Colloque Sciences, médias et société. ENS-LSH, p.53-69 <http://sciences-medias.ens-lsh.fr>
- Deschamps, J.P. (1984). Porter un regard nouveau sur l'éducation pour la santé. *La revue du praticien*, 34, (11), 485-497.

- Dickson, R., Fullerton, D., Eastwood, A., Sheldon, T., Sharp, F et al. (1997) *Effective Health Care: Preventing and reducing the adverse effects of unintended teenage pregnancies*, National Health Service Centre for Reviews and Dissemination University of York.
- Dolédec S. & Chessel D., 1987. Rythmes saisonniers et composantes stationnelles en milieu aquatique I- Description d'un plan d'observations complet par projection de variables. In *acta Oecologica, Oecologia Generalis*, 8 :3, 403–426.
- European Convention on the Exercise of Children's Rights  
<http://conventions.coe.int/Treaty/EN/Treaties/Html/160.htm>
- Expertise collective INSERM (2001). *Education pour la santé des jeunes, démarches et méthodes*.
- Forrest, S., Strange, V., Oakley, A., and the RIPPLE team (2002) "A comparison of student evaluations of a peer-delivered sex education programme and teacher-led programme", *Sex Education*, 2(3): 195-214
- Gold, (1994). The science base for comprehensive health education. In P. Cortese and K. Middleton (Eds) *The comprehensive school health challenge: promoting health through education*. Santa Cruz CA ETR Editor.
- HCSP (1997). *Rapport du Haut Comité de Santé Publique, Santé des enfants, santé des jeunes : rapport adressé à la conférence nationale de santé 1997 et au parlement*, Editions ENSP, Collection Avis et rapports.
- International Planned Parenthood Foundation [www.ippf.org](http://www.ippf.org)
- Kirby, D., Barth, R., Leland, N. and Fetro, J. (1991) Reducing the risk: a new curriculum to prevent sexual risk-taking, *Family Planning Perspectives* 23 pp.253-263
- Kirby, D., Short, L., Collins, J., Rugg, D., Kolbe, L., Howard M et al. (1994) School-based programmes to decrease sexual risk behaviours: a review of effectiveness, *Public Health Report* 109 pp.336-360
- Ministère de l'Éducation nationale (1998), circulaire N°: 98-237, BOEN: n°45 du 03-12-1998, Orientations pour l'éducation à la santé à l'école et au collège. Paris, CNDP.
- Ministère de l'Éducation nationale (2003), circulaire N°: 2003-027, BOEN: n°9 du 27-02-2003, L'éducation à la sexualité dans les écoles, les collèges et les lycées. Paris, CNDP.
- Ministère de la Santé et de la solidarité nationale (2001), Plan National d'Éducation pour la Santé, Circulaire DGS 2001/504 du 22/10/01.
- Robert C.P. & Casella G. (2004). *Monte Carlo Statistical Methods* (second edition). Springer-Verlag, New York.
- St Leger, L. & Nutbeam, D. (1999). Evidence of Effective Health Promotion in Schools. In Boddy, D. (ed). *The Evidence of Health Promotion Effectiveness: Shaping Public Health in a New Europe*. European Union, Brussels.
- Schaalma, R., Kok, G. and Peters, L. (1993) Determinants of consistent condom use by adolescents: the impact of experience of sexual intercourse, *Health Education Research, Theory and Practice* 8 pp.255-269
- Stephenson, J M., Strange, V., Forrest, S., Oakley, A., Copas, A., Allen, E., Babiker, A., Black, S., Ali, M., Monteiro, H., Johnson, A M., and the RIPPLE study team. (2004) "Pupil-led sex education in England (RIPPLE study): cluster-randomised intervention trial", *The Lancet*, 364 (9421): 338-346
- Tones, K. et Tilford, S. (1994). *Health education, effectiveness, efficiency and equity*. London : Chapman and Hill.
- United Nations Universal Declaration of Human Rights [www.un.org/rights/HRToday](http://www.un.org/rights/HRToday) (accessed 15.04.02)
- United Nations Declaration on the Rights of the Child, [www.un.org/rights/HRToday](http://www.un.org/rights/HRToday) (accessed 15.04.02)
- United Nations General Assembly, Declaration of commitment on HIV/AIDS August 2nd 2001 [www.un.org/ga/aids/docs/aress262.pdf](http://www.un.org/ga/aids/docs/aress262.pdf) (accessed 15.04.02)
- WHO (1997). *Promoting health through school*. Geneva.
- WHO (1999). *Preventing HIV/AIDS/STI and related discrimination : an important responsibility of health promoting schools*. WHO information series on school health. WHO Editor Geneva.
- Wight, D., Abraham, C. and Scott, S. (1998) Towards a psychosocial theoretical framework for sexual health promotion. *Health Education Research*, 13 pp.317-330

# SCHOOL HEALTH EDUCATION: IMPACTS OF A PREVENTION AIDS PROGRAMME IN CHILDREN 9 TO 11 YEARS OLD

Dominique Berger

Université Claude Bernard, Lyon 1-IUFM, EA n°4281, PAEDI

Didier Jourdan & Franck Pizon

Université Blaise Pascal, Clermont-Ferrand 2-IUFM, EA n°4281, PAEDI

Mabrouk Nekaa

Inspection académique de la Loire,

Sylvie Pierre

IUFM de Lorraine

## Abstract

*Health education is a part of the primary school science curriculum in France. Teachers often consider sexuality education and sexually transmitted diseases prevention as a topic they cannot teach without the help of partners. This paper is an account of a research carried out to study the representations of primary school pupils (Key Stage 2, French children, from 9-11) about HIV/AIDS and to analyze the impact of an educational programme on these representations. The programme was based on a socio-constructivist approach to learning. It aimed to modify pupils' representations through regular teacher's activities and interventions of health educators. The results indicate that after the intervention, pupils' scientific knowledge was more precise, and communication about HIV/AIDS between members of the family improved. The representations shifted from a sense of powerlessness and fatality towards a sense of the possibility of acting to forestall infection. Nevertheless, the impact of the intervention was weaker on under-privileged pupils.*

## Introduction

In France, health education is included in the primary school science curriculum. A part of this curriculum is called "human body and health education" (MEN, 2002, 2008). A quantitative study that focused on teachers' practices showed that health topics are mainly nutrition, hygiene, and dental health (Jourdan & al., 2002). In the curriculum, the topic "Reproduction of living beings and sexuality education" concerns children aged 9-11 (Key Stage 2). Teachers often acknowledge that teaching about sexuality education and prevention of sexually transmitted diseases is difficult, because they do not feel comfortable with the subject matter. In the previous study (Jourdan et al., 2002), it had been shown that sexuality and AIDS were tackled by only 8 teachers out of 286 that were involved in the study. However, the curriculum guidelines of the French ministry of education (MEN, 2003) and the World Health Organisation (WHO, 1999, 2004a) texts insist on the necessity for implementing early sexuality education and HIV/AIDS prevention programs, particularly in primary schools. In this context, developing exchanges of experiences and partnership between teachers and health educators (school health services and health education NGOs) seems to be quite relevant.

The nature of health education in schools also demands to take ethical questions into account. The aim is not to promote a new secular morality defining the "good" (the health) and the "bad" (the risky behaviors), but to prepare the children for responsible citizenship. Then, teachers in health education should not attempt to impose norms of acceptable behaviors, while taking into account children's peculiarities, expectations, needs, and also their own conceptions.

Children's conceptions are defined as coherent models used by learners to reason when faced with a problematic situation (Jodelet, 1991; Farr, 1997). The construction of these conceptions is a rather complex phenomenon and depends on the social representations shared by a social group that give rise to a common out

look manifested during social interactions. As these individual conceptions are linked to the individual emotional responses, the cultural and social group(s) he belongs to, they constitute a decisive element in his/her relationships with the world, and are resistant to change. Individual conceptions and social representations seem very essential (Fischer, 2001), are closely linked to behavior (Abric, 1997), and cannot be change so easily as knowledge. Any programme attempting to change conceptions should not only take into consideration the relevant knowledge, but also the social and cultural aspects of the children's daily environment. (Doise & Mugny, 1997). The interest of taking into account pupils' conceptions in an HIV/AIDS education programme for children under twelve has been already justified (Fassler & al., 1989; Ferron & al., 1989; Thomas, 1991; Sly & al., 1992; Schaalma & al., 1993; Shonfeld et al., 1993; Kelly, 1995; WHO, 1999, 2004a, 2004b).

The model on which this study was based relates to the "allosteric learning model" (Giordan, 1995). This socio-constructivist model assumes that learners build knowledge from their own lives, and learn through their mental conceptions that depend on their social and biological experiences, and their dispositions. Learning is a highly active mental process that operates in an integrative mode in the conflict between what a learner has in his/her mind and what (s)he can identify and understand from his/her environment. When a learner develops a new model, all his/her mental models must be reorganized based on an interaction between the pre-existing conceptions and new information from environmental sources (Giordan, 2000). Health education requires the teacher to take the pupils' conceptions into account and to help them construct new and more relevant ones. Moreover, the child's environment must be taken into account in the programme as children's conceptions are not only based on what they learned at school, but also on all the other aspects of a child's life (Downie, Tannahill, & Tannahill, 1996).

The present collaborative research attempted to identify and study the initial conceptions of 9 and 10 year-old pupils relating to aids and to examine the impact of an early educational programme on regular teacher's activities and interventions of health educators. Some of the initial results of the study have been already reported in a French journal for teachers (Berger & al., 2003).

## **Methods**

Most evaluations of health education programs are usually quasi-experimental designs, but to study health education other designs seem more appropriate (Victoria et al., 2004). In our context, using the controlled randomized design as a method for assessing the effects of the implementation of a programme would be really difficult. The impact of the intervention on the children's social environment means that attempting to use a control group would be delusive, and that randomization would be really difficult (Tones & Tilford, 2001). This relates directly to the complex nature of causal chains in public health interventions and education. Although such an approach has its limits, several authors concluded that they are in favor of a collaborative research design aiming at determining exactly what content and what tools would be most suitable (Darroch, & Silverman, 1989; Heymans, 1993). Associating all agents in the design and implementing the programme based on collaborative research design, makes it possible to make the interactions between researcher and agents more visible and transparent (Martinand, 2003; Merini, 2005). These would be otherwise masked and confounding factors.

The data for the present communication concern one side of the collaborative research. On one hand, an account of the general course of the study is provided but not presented and, on the other hand, the results from two questionnaires (pre- and post-questionnaire) that were used to collect information on pupils' representations are compared and analyzed.

## **Programme**

The research programme was developed by the Auvergne I.U.F.M. (Teachers' Training Institute), the I.N.R.P. (National Institute for Pedagogical Research) and the School of Medicine at the University of St Etienne, in partnership with the local School Health Services. The research design was regularly approved and evaluated by a pilot committee, which defined its ethical framework on the basis of the texts published by the French Society of Public Health. This was composed of parents' associations, Regional Health Authorities (DDASS), the School of Medicine, the Training Institute primary teachers, the heads of the schools concerned, and the technical advisers of school health services. The implementation of the project in each school involved its approval by the school council, a meeting with the parents, the training of those involved, and the action in the classroom.

Figure 1. Presentation of the Research Process.

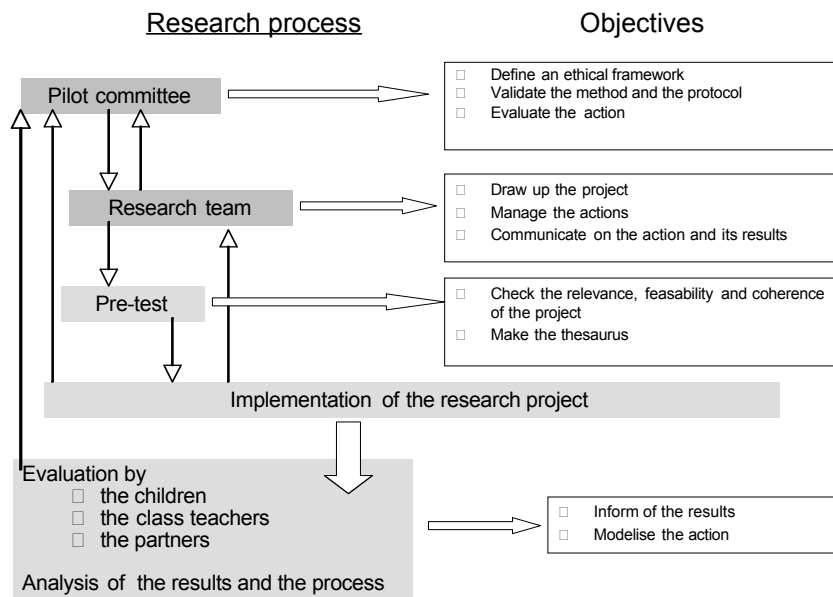


Figure 1 shows the design of the collaborative research. It was founded on six principles:

1. A complementarity of regular teacher's activities and interventions of health educators.
2. A thorough preparation for the context of the project, which associated the families, teachers, and school health services in a comprehensive approach. The partners were closely involved in the design of the study (questionnaire, interventions in the classrooms, relationship with the population).
3. The inclusion of all the classes of the same level in a school.
4. The choice of working with groups of children (no more than 15).
5. The decision to put children in groups according to gender (separating girls from boys).
6. A participatory design with games and tools that were designed targeting a high rate of participation.

The programme was developed on the basis of previous studies, (see Kirby, 2002 and UNAIDS, 1997). It was first piloted in a school during the school year pre ceding the study. The team that worked at each site was composed of six people (three per single-sex half group). Two persons from the research team, two representatives of school health services (a nurse and a doctor), and two observers who were to evaluate the teaching project and the way it was implemented.

Evaluation of the process was carried out using the following indicators:

- For the pilot committee, the number of meetings that were held was compared with the scheduling and the number of participants in each category (parents, teachers, doctors, and nurses). There were three interviews with all the members of the pilot committee, one before the project, one between the two sessions, and one after the results of the project had been made available.
- For the school health services, an individual and anonymous questionnaire was used. It dealt with the form of the action, its pedagogical value, and the analysis of the elements benefiting health education in schools. Fourteen school nurses and 14 school doctors were interviewed.
- For the school staff, the same type of individual and anonymous questionnaire was used. All the teachers and heads of schools involved in the programme (28) were interviewed.
- The participation of the parents was measured for every meeting, and analyzed in relation to the age group of the pupils and to the socio-economic status of the schools. Twenty interviews were carried out with parents from 4 categories of schools.
- Each session was evaluated by an outside observer, using a grid including items relating to the way the session went, the interactions between adults and children, the involvement of the children, and the amount of time used by them to speak.

## Population

The study was performed in the south east of France (the regions of the Loire and Haute Loire). It concerned pupils in “Cours moyen première année” (CM1) et “Cours moyen deuxième année” (CM2), which correspond to Key Stage 2. The sample was composed of 10 schools and 18 classes. Schools corresponding to the main types of school in the country were selected (small size / large size; rural / urban; privileged / under-privileged). The research team asked for the teachers’ cooperation. All the classes that were asked volunteered and took part in the project. The overall results of the investigation concern 353 children. Among the participating children, 54% were girls and 46% were boys, while 31% and 69% of them came from CM1 and CM2, respectively. The total sample can be divided into 4 sub-groups depending on the social environment of the school (INSEE 2003), on the basis of the head of the family’s profession. Population A (14%) was severely under-privileged (coming from schools classified as “educational priority zones”). Population B (31%) was relatively under-privileged. Population C (30%) was quite privileged, and D (25%) was highly privileged. This classification brought out variations in the number of children per family. For Population A, there was an average of more than 4 children, for B and C, there was an average of 1.7, and for D, an average 1.5 of children per family. The children from Population A were the only ones to have parents with a significant age difference. The father was on average 10 years older than the mother, whereas, in the other sub-categories, the father was on average no more than 3.5 years older than the mother. However, the average age of the mothers in the four sub-populations was the same (35 years). The children classified in A were generally older than those in the other sub-populations and faced more difficulties at school.

## Questionnaire

Due to the age of the pupils, it was not possible to use either the same questionnaire for adolescents and adults, or a multiple choice questionnaire to determine, as it was done with adolescents, the way the children represented modes of infection. Indeed, unfamiliar words, coming from adult or adolescent vocabulary about sexuality, inhibited communication in young children (WHO, 1999). However, we designed a new questionnaire based on the ones existing, but the vocabulary was modified based on the results obtained in the pilot study. Thus, in spite of the fact that it made the questions harder to analyze, we used many open questions, sometimes along with closed questions. Using only closed questions would not have enabled us to grasp the complexity of the conceptions of AIDS in young children. The validation of the questionnaire (understanding of the questions, coherence between writing questionnaire, and interview) was carried out at the end of the pilot study with a sample of children, who filled in the questionnaire and had an interview thereafter. The questionnaire had 22 questions and tackled 7 aspects:

- Initial conceptions of the HIV pandemic.
- An assessment of communication about AIDS.
- Knowledge about AIDS
- Modes of infection and protection.
- Determining how close the subject feels the epidemic to be.
- An evaluation of the representations of the possibilities of living with an affected person.
- An evaluation of social and individual conceptions of solidarity towards affected people.

The same questionnaire was used for both the pilot and the main intervention (series 1 and 2).

For the analysis of our pilot investigation, we started by devising a thesaurus. Each answer was put in a lexical category and coded. This made it possible to take subtle differences into account. The total number of words was 255, and the number of items we added to the first version of the thesaurus after our processing was low (< 10%). These precautions were taken in order to standardize the data acquired from the questionnaires and reduce any distortion in interpretation.

## Teaching Approach

We initially attempted to measure the impact of an early preventive action on children’s representations. The protocol was composed of two interventions in the course of the school year, one at the beginning and one at the end, at least six months later. Between the two interventions, the regular teachers worked on health education with the pupils (“normal” biology course including sexuality education). The two sessions were designed with the same pedagogical structure, which had two requirements, that is, to collect useful evidence from the questionnaires, and to put the children in a position where they were actors in their own learning process. The two sessions were

structured as follows: A short presentation of the team and the framework, a question-writing time, a presentation about HIV/AIDS, work in small single-sex groups on the answers to the questions asked without the teachers, a game (a card-game for the first, and role-playing for the second), and, finally, the collective writing of a text for the teacher and the families.

### *Presenting the Questionnaire*

The questionnaire was intended to deal with children's initial conceptions and it was anonymous. After the pre-test, it appeared to be necessary, in order to attain this goal, to break away from the school environment and the behavior it induces, especially in relation to writing. So, in the instructions for the procedure, we stressed that neither spelling nor the quality of the writing were important. What we were interested in was what the children thought, and in expressing their ideas in words. There was no question of making things hard for the children by asking them to write, but we just wanted to get their answers, which we could analyze and then link up with conceptions. We also explained that we would not give any further explanations about the meaning of the questions, as, we were afraid that in doing so, we could give ideas related to the answers. In order for all the children to be able to fill in the questionnaire as best as they could, we chose a collective approach. Each question was read out aloud and timed. Thus, we were able to include all the questionnaires in the analysis process, even those from children with serious literacy problems.

### *Information Provided*

This presentation was intended to provide precise and complex scientific information, and to give unity to sketchy and fragmentary conceptions, re-placing them in a context, and bringing out the link between the illness, the people, forms of behavior, and oneself.

### *The Children's Questions*

After children had filled in the questionnaire, they were invited to ask any questions they wanted to freely and anonymously, so that the educators could answer them in the second part of the session. Another form had been prepared for this and annexed to the questionnaire. Our aim here was to make the children put their questions in written form before the informational presentation, as well as to give us a representative body of questions, and to define these precisely before providing answers.

While the children were at break, their questions were written out again, with no modification whatsoever. After break, the children were put in single-sex groups in separate rooms, so as to make it easier for them to communicate, and to reduce the difficulties associated with talking about genitality and private concerns, which, in a mixed group, greatly disturb children's expression. Their regular teachers were not present for the same reasons. The health educator read out the question and asked the group to respond; only taking part to give more information to substantiate an answer, to get the children talking again, or to regulate the exchanges and make sure that everyone participated. An answer was given for every question as long as it had been asked by the children. Our ethical approach was to use only the vocabulary from the presentation or that used by the children, excluding any words or expressions coming from adolescent or adult vocabulary, particularly in the field related to the management of sexuality. This was essential as we had realized that unfamiliar words coming from adult or adolescent vocabulary about sexuality inhibited communication and thwarted our objectives. However, by using in our answers exactly the same expressions and words that the children used to their, sometimes, very direct questions about sexual practices, we could show the children that any subject can be tackled. The educator's role was mainly to get the discussion going, to modify, or to substantiate the representations by clarifying points, and, if necessary, to offer extra help in completing fragmentary or sketchy knowledge.

### *Teaching Tools*

The card game in the first session:

The card game was devised for this experiment and for this particular group. It was based on the approach developed for adolescents and on the results of the pilot study. It included situations in daily life concerning both close relationships with affected people, and more distant situations; so that the children could express their certainties and doubts, and the rumors they had heard. The rules were simple. Each child was given some cards. He read out what was written on the card, showed it to the group, and put it down on one of three cards which

indicated no risk, I do not know, or high risk. The child explained his choice and then asked the group to say what they thought. This approach enabled us to involve all the children, even the shyest, and gave them room for expressing themselves.

Role-playing game in the second session:

The aim of this activity was to get the pupils to talk about HIV/AIDS using a different point of view from their own. They had to take the role of parents, teachers, and children in a concrete situation. Through this, we intended to put the children in a situation where they could express, and become aware of their own representations of the pandemic, the risk of infection, and the ways to protect themselves. This projected identification had a powerful emotional component.

#### ***Final written work:***

The children dictated to the educator an account of what they had done, or of the ideas and things which they felt to be important, and which they, therefore, wanted to share with their families and class teacher. The advantage this strategy had over an individual account was that it did not put the children in a difficult school situation by asking them to write. It also made it possible to summarize what was essential.

## **Results**

### Statistical Analysis

The questionnaires were processed by the statistics department at the St Etienne School of Medicine, according to the thesaurus drawn up, when we did the pre-test. Epi info 5.01 and SPSS was used. Statistical significance was estimated at  $p < 0.05$ . When the size of samples was small, the adjusted  $\chi^2$  (Yates method) was used and, if the size of one of the samples was beneath 5, we kept the results given by Fisher's test. The analysis was only univariate. The data described here focus on a comparative study of the results of the two questionnaires. However, the programme was also assessed by the pilot committee, the school medical staff, the teachers and the parents.

### Analysis of the Questionnaires

The pupils had to fill the questionnaire before session 1 and before session 2. For the closed questions, the results are expressed as percentages of the total number of questionnaires taken into account in the analysis. For open-ended questions, the responses are put together in different items and are expressed as percentages of the total number of questionnaires including an answer to the concerned question. For multiple-choice questions, the total percentage could exceed 100, because children were allowed to give more than one answer. The analysis of the first questionnaire gives an overview of the initial representations of the pupils. The comparison between pre- and post-questionnaires guided us to identify where a modification of representations was observed. The analysis was performed taking into account five points: (a) knowledge about AIDS, (b) communication about AIDS, (c) knowledge about the disease, (d) knowledge about modes of infection and protection, and (e) relationships with affected people (the analysis of the other parts of the questionnaire are not shown in this article).

#### ***Knowledge about AIDS***

The analysis of the first questionnaire (pre-test) indicated that more than 92% of the children had information about AIDS, while, six months later, this percent age increased to 98% for the second questionnaire. The main source of information was television (88%) followed by the family (25%). However, these results (Question 2) were inconsistent with the results from another question (Question 4), where more than 65% of the children stated that they had talked about AIDS with their families. The only source of information which changed significantly between the two questionnaires was the school ( $p < 10^{-3}$ ). Children mainly associated AIDS with words suggesting, Illness, Death, and Sexuality. They also mentioned, to a lesser extent, condoms, blood as a vector for infection, drug-taking, and finally prevention, and solidarity. The intervention did not trigger off any substantial change in initial associations with Illness/Death/Sex, but it nevertheless allowed most children, who had not talked of the subject, to be involved in discussions about AIDS. Three-quarters of those who did not mention anything initially, they actually spoke up after the intervention. Thus, the highly privileged group D referred initially to sex and sexuality more than the severely underprivileged group A ( $p < 10^{-3}$ ). But, this difference was much smaller at



the end of the session ( $p=0.05$ ).

### Communication about AIDS

Figure 2 (next page) shows the differential influence of socioeconomic status on the impact of communication about AIDS with adults (Have you ever talked about AIDS with adults?) and in the family (Have you talked about AIDS in your family?). If the increase in communication with adults concerned the 4 groups, it was limited to the underprivileged, privileged and highly privileged groups for communication inside the family. Results are expressed as percentages of the total number of questionnaires including an answer to the question. Pupils communicated about AIDS with adults, with friends and at school. Fifty one percent of the children have talked about AIDS with adults before the intervention. At the end, 76 % of them have talked about the subject with adults, either before the first session or between the two. The intervention did not bring any significant increase in communication within the family in the severely underprivileged group ( $p=0.349\%$ ), unlike in the other groups, where there was a significant increase with 74%, 79% and 85%, for groups B, C and D with  $p=0.01$ ,  $p=0.01$ , and  $p=0.001$ , indicated that communication between the pupils was also enhanced. (Clarify the meaning)

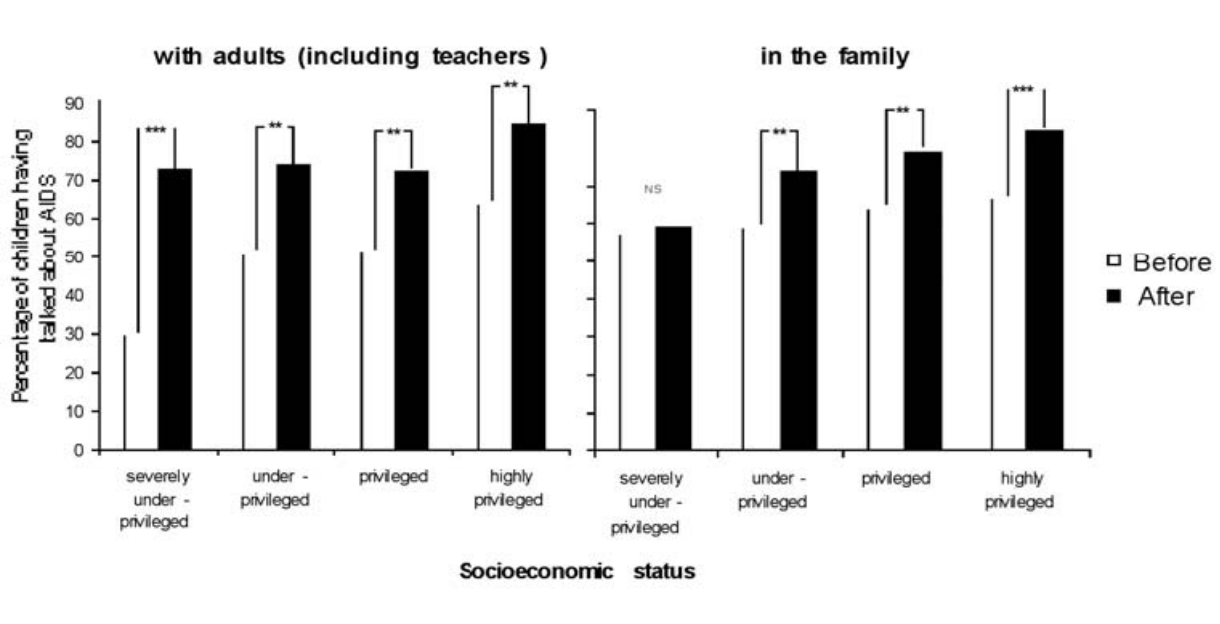


Figure 2. Influence of Socioeconomic Status on the Impact of the Intervention on Communication about AIDS. (\* $p < 0.05$  \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ ).

### Knowledge about the Disease

Before the intervention, more than half of the children associated AIDS with a fatal illness. On a scale ranging from 0 to 10, the children rated the dangerousness of AIDS at more than 8. Population A alone stands out by assessing its gravity at less than 8 ( $p=0.007$ ). The illness which is symbolically associated with AIDS is cancer.

Infectious illnesses are not often quoted, and only 5% of the children mention Hepatitis B. After the intervention, we found that references to infectious diseases dropped considerably, and associations with childhood illnesses disappeared. Two thirds of the children stated that they knew what a virus is, and could give a relevant explanation, with a definition based on one of three 'concepts': a microbe, an illness, or a vector of an illness. However, only a third knew what HIV positive means.

### Modes of Infection and Protection

Before the intervention, 88% of the children associated AIDS with a transmissible disease, and 97% after the intervention. The change was slight but significant.

In the pre-test, 74% of the children answered the question “What gives you AIDS ?” and in the post-test 89%. For the children, AIDS is transmitted by vectors: secretions (sperm), sex, drugs, and the HIV virus; and by behavior: sexuality, drug addiction, and medical practices related to the handling of blood, such as, trans fusion and giving blood. Drug addiction was scarcely mentioned, and references to syringes or exchanging syringes were very uncommon. Similarly, references to materno-foetal transmission, and to incorrect vectors, such as, saliva, mosquitoes, daily actions, morality, or God, were almost non-existent. The lexical field used was fairly limited, but it was wider in the second session. The question was put in such a way as to give the children the possibility of replying by designating supposedly high-risk groups (homosexuals, prostitutes, drug-addicts, dirty people, and others). Children did not consider that people identified as ‘deviant’ were responsible for beginning the infection. As far as modes of infection are concerned, after the intervention there was a modification in the trend concerning the answers about vectors of infection, and those about behavior. Representations definitely became clearer. Before the sessions, more than half the children explained that contamination came from vectors: sex (1/2) and drugs (3/4), but after the session, they referred to “dangerous” behavior (90% sexuality and 50% also mentioned drug addiction). Preventive action modified representations concerning modes of infection ( $p=0.001$ ). However, this reversal was less obvious for the very underprivileged social categories ( $p=0.03$ ).

In order to know whether an individual may have been infected, more than half the children suggested active solutions, such as, having a test, or going to see a doctor. Fifteen percent suggested passive solutions, waiting for the symptoms to appear, or waiting till you feel ill. The girls suggested fewer active solutions than the boys ( $p=0.013$ ), and the severely underprivileged children fewer than the highly privileged ( $p=0.049$ ). After the intervention, reference to detection increased considerably ( $p=0.002$ ), and there was less talk of adopting a passive stance or waiting for symptoms to appear ( $p=0.016$ ).

Prior to the intervention, 68 % of the children suggested the condom as a way to be protected, and this percentage increases to 91% afterwards. The intervention mainly gave rise to a considerable increase in references to condoms, protection, and avoidance. There was no statistically significant difference related to age, sex, or social status.

### ***Relationship with Affected People***

One in two children had heard of someone who had or has had AIDS, both before and after the intervention. Only one in ten has heard of it through a channel other than television. Before the intervention, 64% of the children thought it was dangerous to live with an HIV positive person. Twenty-nine percent continued to think so, even afterwards, but there was a significant change in the way infected people are seen and in the perception of the absence of risk of infection in every day life.

## **Discussion**

The aim of our study was to identify the initial conceptions of pupils on AIDS/HIV and to analyze the impact of an educational programme based on regular teacher’s activities and interventions of health educators on these conceptions, on communication about AIDS/HIV, and on the way in which infected people are seen. The main features of our study were its target (young pupils aged 9 and 10), the close partnership between teachers and health educators, the involvement of parents, and the fact that it was based on a learner-centered model (the allosteric model (Giordan, 1995)). First, we are going to discuss the relevance of such a research design and, secondly, we will analyze the pupils’ initial representations on AIDS/HIV and the impact of the program. Finally, the issue of communication about AIDS in the family and with peers will be addressed.

The main characteristic of collaborative research is the close involvement of the target population in the development and management of the program, or, in other words, the closeness between researchers and actors (Martinand, 2003; Merini, 2005). It also aims at an improvement of practices here and now. Our study shows the interest of such a design in AIDS/HIV prevention. Indeed, the participation of actors (teachers, parents, doctors, nurses etc.) in the programme was high and sustained throughout the two years. The intervention also took place in a coherent way in the educational environment of the pupils. In addition, the design guided us to take into account the ethical issues linked to a preventive intervention (respect for people, cultures, family upbringing etc.) Nevertheless, we must also underline the limits of such a design. It was time consuming and the involvement of the severely under-privileged group was lower than that of the other groups.

As described in previous studies (e.g., Anochie & Ikpeme, 2003), the analysis of the initial questionnaires indicated that 9- and 10-year-old children did have conceptions of the HIV pandemic, the people affected, and the modes of infection and protection, but they had incomplete information on the subject. More than half associated AIDS with a fatal illness as serious as, or more serious than cancer, transmitted by 'sex,' and 'caught' especially by adolescents and adults. The illness can be avoided by putting on a condom (68 %), and detected by 'tests' or going to 'see a doctor' (80%). The content of their scientific statements was still at times completely or partially incomprehensible, as they could not fit them into a more general conceptual framework of knowledge, which would allow overall understanding (Kirby & al., 1994; Kirby, 1995; UNAIDS 1997). It can be noted that the highly privileged group D referred to sex and sexuality more than the severely underprivileged group A. It was also evident that the severely underprivileged children generally used a much more limited lexical field than the others. This observation was evident in the questionnaire as well as in the analysis of the transcripts of work in sub-groups. This lexical limitation seemed to have interfered with establishing complex representations, and these pupils could not avoid a reductive over-simplification.

At the end of the session, more children answered most of the open questions, and did so using more words. The lexical field concerning biomedical knowledge was of higher quality. As far as modes of infection are concerned, we could see a reversal in the trend concerning the answers about vectors of infection, and those about behavior. Before the sessions, more than half the children explained that contamination came from vectors, such as sex or drugs, but, after the session, they mainly referred to dangerous behavior (sexuality, drug-addiction). As for protection, the study indicated the impact of the prevention programme. At the end of the sessions, only 8 children answered that you cannot avoid catching AIDS. There was a 150 % increase in the number of children stating that "the condom protects you from HIV infection." Three times more children spoke about protective behavior. These data have to be taken carefully into account, because it is well known that there is no direct link between knowledge and behaviors (e.g., UNAIDS, 1997).

In addition to the influence of socioeconomic status on children's conceptions, we observed an influence of age and gender. The representations of the 10 year-olds were more relevant than the 9- year-olds,' who are still quite childish. Researchers working on representations in children of different ages also made a similar observation (BMA, 1997; UNAIDS 1997; Brown 1990). However, there is little difference between girls and boys (du Guerny & Sjoberg, 1993; Guthrie & al. 1996; Prah Rugger, 2004; UNAIDS, 2004).

The study also investigated communication about AIDS. People with whom pupils speak about AIDS were mainly their families and peers. Nevertheless, in the second question, 1 %- 4 % of them stated that they had never heard their friends talking about AIDS. In a study performed with primary school children (11-years old), Anochie and Ikpeme (2003) had also shown that friends were not an important source of information for pupils (4 %). It is not easy to interpret this statement, as, in question 3, 44% of the same children stated that they have talked about AIDS with other children. Maybe this is a sign of a distortion caused by a devaluing of this source of information in favor of sources, which they interpreted as more knowledgeable. It is highly likely that the children had heard more about AIDS through the media than from their friends, which caused them to underestimate the importance of the information they got from their peers.

Moreover, the children discounted this information as not being serious and, therefore, not worth mentioning, in comparison with information given by experts on the TV, 'which tells the truth.' This point also proved to be valid with the analysis of the work done in the sub-groups of the study.

About 62% of the children have talked about AIDS in their families before the intervention whatever their age, sex, or social origin. In the second series, 76 % of them have talked about the subject with their families, either before the first session or between the two. But our intervention did not bring any significant increase in communication within the family in the severely underprivileged group. These data show how hard it is to get a family to talk about AIDS, particularly for the severely underprivileged, and raises the question of family communication in the field of health education. It is likely that the intervention triggered discussion in families where there was a readiness for this. Our analysis shows that more than 90% of the families of the underprivileged group were of foreign origin (North African and Turkish). Talking about sexuality, especially with boys, in a cultural framework that was profoundly steeped in tradition, meant adopting a new Western-style cultural position. So, it was difficult to talk about such a private subject in the family. The priority was not denying one's origins, and preserving an identity, so as not to be swallowed up by integration, which was experienced as culturally destructive. So, no standard model of intervention could be put forward, the cultural dimension was a significant variable in

actions and their impact (Rosenthal, 1990; Tones & Tilford, 2001; WHO 1997, 2004a, 2004b). The whole community must really be involved when the intervention occurs in a multicultural environment.

The cross analysis of the questions showed that in the situations described, where the question of the integration of an HIV positive person was raised, the attitude of children from families where AIDS was discussed was no different from that of children from backgrounds where it was not. So, it would seem that the family message did not focus on the integration of infected persons. Nor was it a message of exclusion. It was likely that the parents' message did not concern infected people. The reality of the infected persons remained largely virtual. Information mainly came from the mass media and television, and contact with sufferers in their daily lives was rare.

## Conclusion

This study shows an evolution in the conceptions of pupils about HIV/AIDS. The intervention led them to build new conceptions that take more objective facts into account. These results are interesting but have to be discussed with humility, as it is well known that there is no one to one link between knowledge and behavior. The mere provision of knowledge is not enough if the aim is a relevant scientific education, but the educational process here includes helping children "to clarify their values in relation with themselves health, health-influence in behaviors" (Downie et al., 1996). In addition, such an intervention makes it possible to talk much more about a much broader spectrum of themes related to health. In working on HIV/AIDS prevention and sexuality education, numerous other aspects of science education are tackled, and mainly the status of science in relation to the everyday life (nature of science and scientific knowledge, application of science concepts, values that underlie science etc.) By offering an HIV/AIDS education programme, it is possible to promote a comprehensive health approach (St Leger & Nutbeam, 1999), only if the whole educational environment is involved, the intervention is really learner-centred, the programme is sufficiently open and does not aim at enforcing some form of behaviors, and the ethical framework is clearly defined. Such an approach, to be effective, must take into account the complexity of health, and the factors which influence it, but also actual science education theory and practice. This last point is decisive as one of the most important difficulties in implementing relevant programs is, in addition to taking into account cultural and social diversity, the involvement of teachers and school staff (Ayo-Yusuf, 2001; Han & Weiss, 2005).

## Acknowledgments

Authors thank Dr. Rémi Collet for his contribution to the research.

## References

- ABRIC, J-C. (1997). *Pratiques sociales et représentations* (2<sup>nd</sup> edition). PUF. Paris.
- ANOCHIE, I., & IKPEME, E. (2003). AIDS awareness and knowledge among primary school children in Port Harcourt metropolis. *Niger Journal of Medicine*, 2003 (1), 27-31.
- AYO-YUSUF, I., NAIDOO, S., CHIKTE, U. M. (2001). The role of primary school teachers in HIV prevention in South Africa. *SAD*, (12), 596-598.
- BERGER, D., COLLET, R., LAQUET-RIFFAUD, A., & JOURDAN, D. (2003). Quelles représentations les enfants ont-ils du SIDA? Contribution d'une recherche-action en éducation pour la santé auprès de classes de CM1 et CM2. *En question*.48. 1 29.
- BMA Foundation for AIDS. (1997) *Using effectiveness research to guide the development of school sex education*. London: British Medical Association.
- DARROCH, J., & SILVERMAN, J. (1989). What public school teachers teach about preventing pregnancy, A.I.D.S. and S.T.D. *Family Planning Perspective*, (21)2, 65 73.
- DOWNIE, R. S., TANNAHILL, C., & TANNAHILL, A. (2004). *Health promotion: Models and values* (2nd edition). Oxford: Oxford Press.
- DUGUERNY, J, & SJÖBERG, E. (1993) Inter-relationship between gender relations and the HIV/AIDS epidemic: Some possible considerations for policies and programmes. *AIDS*, 7, 1027-34.
- FARR, R. (1997). Les représentations sociales. In *Psychologie sociale*. S. Moscovici. (dir.) PUF Editor Paris.
- FASSLER, D., MCQUEEN, K., DUCAN, P., & COPELAND, L. (1990). Children's perceptions of A.I.D.S. *J. Am. Acad. Child adolesc. Psychiatry*. (29)3, 459-462.
- FERRON, C., FEARD, S., BON, N., SPYCKERELLE, Y. & DESCHAMPSJ-P. (1989). L'enfant et le SIDA, connaissance et représentation, *revue française de pédiatrie* (XXV), 195-209.

- GIORDAN, A. (1995). New models for the learning process: Beyond constructivism. *Prospects*(XXV) 1.
- GIORDAN, A. (2000) Health Education, Recent and Future Trends. *Mem Inst Oswaldo Cruz.* (95), suppl. I: 53-58.
- GUTHRIE, B., WALLACE, J., DOERR, K., JANZ, N., SCHOTTENFELD, D., & SELIG, S. (1996). Girl Talk: Development of an intervention for prevention of HIV/AIDS and other sexually transmitted diseases in adolescent females. *Public Health Nursing*(13), 318-30.
- HAN, S. & WEISS, B. (2005) Sustainability of teacher implementation of school based mental health programs. *J Abnorm Child Psychol.* (33)6. 665-79.
- INSEE (2004). Nomenclatures et codes. Les nomenclatures des professions et catégories socioprofessionnelles; Liste des catégories socioprofessionnelles agrégées 2003. La documentation Française. Paris.
- JODELET, D. (1991). *Les représentations sociales.* Paris: PUF Editor.
- JOURDAN, D., PIEC, I., AUBLET-CUVELIER, B., BERGER, D., LEJEUNE, M. L., LAQUET RIFFAUD, A., GENEIX, C. & GLANDDIER, P. Y. (2002). Education à la santé à l'école: pratiques et représentations des enseignants du primaire. *Santé Publique*, 14, 403-423
- KELLY, J.(1995). Advances in HIV/AIDS education and prevention. *Family Relations.* 44, 345-52.
- KIRBY, D., SHORT, L., COLLINS, J., RUGG, D., KOLBE, L., & HOWARD, M, (1994). School-based programs to reduce sexual risk behaviors: A review of effectiveness. *Public Health Reports*, 109, 339-60.
- KIRBY, D. (1995) A review of educational programs designed to reduce sexual risk-taking behaviors among school-aged youth in the United States. ETR Associates. Santa Cruz.
- KIRBY, D. (2002). Effective approaches to reducing adolescent unprotected sex, pregnancy, and childbearing. *J. Sex. Res.* 39(1), 51-7.
- MARTINAND, J.L., (2003). Les savoirs entre pratique, formation et recherche. *Recherche et Formation*(40).
- MERINI, C. (2005). Travail conjoint et professionnalité enseignante Rapport d'étude IA 92- UIMM Mai 2005, ADASE, Paris.
- MEN (Ministère de l'éducation nationale) (2002) BO hors série n°1 du 14 février 2002
- MEN (Ministère de l'éducation nationale) (2003) L'éducation à la sexualité dans les écoles, les collèges et les lycées BO n °27 du 17 février 2003
- PRAH RUGER, J. (2004) Combating HIV/AIDS in developing countries *BMJ* (121) 329;121-122.
- ROSENTHAL, D., MOORE, S. & BRUMEN, I. (1990) Ethnic group differences in adolescents. *Australian Journal of Social Issues*, 25, 220-39.
- SCHAALMA, H., KOK, G.. & PETERS, L. (1993). Determinants of consistent condom use by adolescents: The impact of experience of sexual intercourse. *Health Education Research*, 8, 255-69.
- SCHONFELDD. J., JOHNSONS. R., PERRINE. C., O'HAREL. L. & CICCETTI D. V. (1993). Understanding of A.I.D.S. by elementary school children – A developmental survey, *Pediatrics.* (92)3, 389-395.
- SLY, D. F., EBERSTEINI. W., QUADANOD., & KISTNERJ. A. (1992). Young children's awareness, knowledge & beliefs about A.I.D.S.: observations from a pretest, A.I.D.S. education & prevention. 4(3), 227-239.
- TONES, K. & TILFORD, S. (2001). *Health Promotion effectiveness, efficiency and equity* (third edition). Cheltenham: Nelson Thornes Editor.
- UNAIDS (1997). Influence de l'éducation en matière de VIH et de santé sexuelle sur le comportement sexuel des jeunes: un bilan actualisé. Geneva.
- UNAIDS (2004). *AIDS and girls education.* Geneva
- VICTORIA, C. G., HABICHT, J.P. & BRYCE, J.(2004). Evidence-based public health moving beyond randomized trials. *Am. J. Public Health.* (94) 400-405.
- WHO. (1999), Preventing HIV/AIDS/STI and related discrimination an important responsibility of health promoting schools. WHO information series on school health. WHO Editor Geneva.
- WHO. (2004a). Guide to Monitoring and Evaluating National HIV/AIDS Prevention Programmes for Young People - Addendum to the UNAIDS "National AIDS Programmes: A Guide to Monitoring and Evaluation". Geneva.
- WHO. (2004b). Participatory Learning Activities from the EI/WHO Training and Resources Manual on School Health and HIV and AIDS Prevention. Geneva.
- WHO. (1997). *Promoting health trough school.* Geneva



# SOCIAL AND EDUCATIONAL EXCLUSION/ INCLUSION OF TURKISH IMMIGRANT YOUTH IN CANADA

Dilek Kayaalp

## 1. Research Context and Statement of the Problem

This study seeks to explore the experiences of social, cultural and educational inclusion/exclusion of Turkish immigrant youth in Vancouver, B.C, Canada. In this work, I view social and educational exclusion from the perspective of, and in relation to, other forms of inequality, such as racism, economic retrenchment and other forms of cultural exclusion. As research has shown (Wacquant, 1993; Kaya, 2005), the exclusion of young people from educational institutions can lead to wider forms of social alienation from social institutions (e.g., the labour market) and the broader society at large. Much of this relates to the wider politics of nation-states, associated immigration policies and the larger questions of rights for young people who are not deemed “official” citizens. The social exclusion of youth from the boundaries of the modern nation-state and the associated loss for them of the “right to have rights” is therefore not only tied to the history of nation-state building (Arendt, 1951) but also to the process of identity-formation and feelings of belonging. This situation is made worse for immigrant youth, whose original identification with a nation-state of origin becomes a challenge to the definitions of their citizenship and sense of belonging, security and rights in a new nation-state. In other words, diasporic identities of immigrant youth are sometimes considered to be threats to the ideals of the nation-state and its homogenising logic (Caglar, 1997). Turkish youth have long been a mobile group who are seen as members of the diaspora and who must struggle with the bigger questions of “who they are” under the dynamics of mobility, immigration, and change.

While initial assessments of this diasporic configuration in Europe have begun to expose issues about Turkish immigrants’ social and educational exclusion in host countries, very little sociological and educational research has investigated Turkish youth immigrants’ experiences of exclusion/inclusion in Canada- despite the growing Turkish population in metropolitan areas like Toronto, Montreal and Vancouver. According to Ataca and Berry (2002), “The general pattern of Turkish immigration to Canada has been such that it reached its peak before World War I, stopped until after World War II, and peaked during the late 1960s, again in the early 1980s, it has been increasing rapidly during the last few years (p.16).” Immigrant youth from Turkey offer a unique opportunity to illuminate how fragmented, complex, hybrid identities (i.e., Kurdish/Laz/Circassian/Turkish or European/Mediterranean/Middle-Eastern or secular/religious/modern/traditional) in one’s home country are transformed into a “diasporic hybrid identity” in Canada. This inquiry offers an untapped opportunity to explore the diverse experiences of Turkish immigrant youth in multicultural Canada, which differs in significant ways from European countries (e.g., Germany) with regard to its historical immigration policies, social and educational practices.

In response to this research gap, the current project investigates the experiences and perceptions of Turkish female and male immigrant youth in relation to social and educational exclusion in Vancouver, Canada. The literature here is sparse, but there have been enough studies on the immigrant experience to suggest that Turkish youth may also face considerable social and educational exclusion in Canada, a situation arising from immigration laws, government policy, and popular prejudices which have been inherited from a colonial past.

## 2. Research Aims and Questions

This study seeks to achieve four aims. First, it will provide an educational and social profile of a sample of 30 immigrant Turkish youth living in Vancouver, Canada. Second, this research aims to showcase how Turkish youth immigrants negotiate the process of exclusion in a new national culture, particularly in urban centers. Finally, I seek to uncover young people’s multiple attachments, and sense of in-betweenness; “the process of fragmentation” based on the hybrid and diasporic identities stemming from pre and post-migration histories as well as their conflicts within their families. The research questions I pose are as follows:

- (i) How do Turkish immigrant youth describe their schooling and social experiences in Canada?
- (ii) What are the cultural strategies that first and second-generation immigrant youth use to negotiate social integration in Canada?

(iii) How do young people's multiple attachments and identities play out in Canada?

### **3. Theoretical Framework**

For the interpretation of social and educational realities and of the experiences of exclusion of Turkish immigrant youth, my research draws particularly upon the theories of Hannah Arendt, Pierre Bourdieu and Stuart Hall. The Arendtian notions of the "right to have rights," and "statelessness," Bourdieu's concepts of "social space," "symbolic violence" and "official language", and Hall's concept of "state's hegemony" and "new ethnicities" (diasporic and hybrid identities) are necessary theoretical tools to examine the relationship between the exclusion of Turkish immigrant youth from the educational market, public space and their "statelessness" in nation-states (Arendt, 1951; Bourdieu, 1991; Hall, 1984). These combined theoretical approaches provide both sociological and educational explanations about the part played by state institutions (e.g., education) in the reproduction of social inequality and the marginalization of immigrant groups (e.g., ethnic origin, language, class position, religious affiliation and gender) in particular national and regional contexts. They also provide a framework for understanding the spatial organization of educational and social exclusion as it pertains to immigrant Turkish youth in Canada. Cross-national studies of educational attainment, immigration and their relation to immigrant youth's socio-economic status, their social and educational exclusion and inclusion (Angin, 2003; Kaya, 2005) are also particularly helpful in exposing and accounting for any potential links between nation-state formation and the social and educational exclusion/inclusion of immigrant youth.

### **4. Methodology**

This project uses qualitative methodology. The data will be drawn by semi-structured interviews, participant observation in various community and formal institutional settings, and document analysis. In-depth semi-structured interviews will be conducted with approximately 15 female and male Turkish immigrant youth (aged 15-25) to gain a full understanding of the educational and social profile of Turkish immigrant youth. A special emphasis will be placed on first and second generation Turkish immigrant youth who are living in Vancouver, Canada, a city with a significant Turkish population and history of Turkish immigration. Attention will be paid to young people's feelings of belonging, attachments, and their experiences, perceptions of inclusion/exclusion in Canada. Interview questions will be clustered around four themes of: 1) sense of belonging 2) experience of social and educational inclusion and exclusion, and finally 3) multiple identities and attachments. To complement interview data, I will conduct participant observation in different settings where immigrant youth are present. The idea is to engage in the web of the young people's everyday lives, observe them within their own realm, capture the complexity of social relations embedded in their daily experiences. In addition, I plan to analyze secondary data related to Turkish immigrant youth including community organization materials, websites, event posters, fiction and nonfiction materials.

### **5. Discussion**

Current literature on the social and educational exclusion of immigrant youth fails to address the situation of Turkish youth in Canada. Turkish immigrant youth, as immigrants considered to be "from somewhere in the Middle East" and "Muslims," probably face social, cultural and educational obstacles, although their situation has yet to be examined in depth. Studies about immigrant youth tend to avoid addressing issues of the nation-state and its exclusionary discourses. Therefore, I argue that the host country's immigration policies needs further scrutiny if we are to understand and respond to the plight of Turkish immigrant youth. Similarly, the interplay between immigrant youth's pre-migration history such as their class origins and involvement in ideological conflicts and their post-migration history should be examined to explore the multiple marginalities of immigrant youth (e.g., their in-betweenness and the conflict between them, their families and the mainstream) and their identity constructions and transformations.

### **5. Anticipated Contributions**

This empirical research analyzes the diverse experiences of an understudied population, Turkish immigrant youth, in multicultural Canada, which differs in significant ways from European or Asian immigration into Canada. This examination is therefore vital for our understanding on the conditions of social integration for one of the most marginalized immigrant minority groups in Canada. At a theoretical level, it will contribute to the international debate about youth, ethnicity and immigration and clarify the ways in which education may create both opportunities and obstacles for disadvantaged immigrant youth, particularly those young people coming from drastically different demographic/geographical locations as compared to urban inner city Canada.



## References

- Angin, Z. (2003). *Diasporas of difference: Turkish communities in Germany, Canada and the U.S.* Unpublished doctoral dissertation, Colorado State University.
- Arendt, H. (1951). *The origins of totalitarianism*. New York: Harcourt.
- Ataca, B., & Berry, J. W. (2002). Psychological, socio-cultural, and marital adaptation of Turkish immigrant couples in Canada. *International Journal of Psychology*, 37, 13-26.
- Bourdieu, P. (1991). *Language and symbolic power*. Cambridge: Harvard University Press.
- Caglar, A. (1997). Hyphenated identities and the limits of culture. In P. Werbner, & T. Modood (Eds.), *The politics of multiculturalism in the New Europe: Racism, identity and community* (pp. 169-186). New York: Columbia University Press.
- Kaya, A. (2005). Poverty and Muslim atheists in France. *Eurozine*, 1-12. Retrieved January 28, 2008, from [www.eurozine.com](http://www.eurozine.com)
- Hall, S. (1984). The state in question. In G. McLennan, D. Held, S. Hall (Eds.), *The idea of the modern state*. Oxford: Open University Press.
- Wacquant, L.J.D. (1993). The return of the repressed urban violence, 'race', and dualization in three advanced societies. *Russellsage Foundation*, 1-14.



# EXPLORING GENDERED STEREOTYPES ON SCIENCE TELEVISION WITH CHILDREN AND YOUNG PEOPLE: TOWARDS A CLASSROOM APPLICATION

Elizabeth Whitelegg  
The Open University

Richard Holliman  
The Open University

Jennifer Carr  
The Open University

## Abstract

*The Invisible Witnesses project ([www.open.ac.uk/invisible-witnesses](http://www.open.ac.uk/invisible-witnesses)) worked with 62 young people (girls and boys) aged 8 to 15 years in out-of-school settings to investigate their interpretation of representations of Science, Technology, Engineering and Mathematics (STEM) on UK television. Using a video library of 374 hours of TV programme extracts assembled for the project, the researchers firstly analysed the STEM content of these programmes and subsequently how young people conceptualised images of STEM produced by broadcasters. Through a series of activities designed to draw on the participants' media literacy skills, the project explored how images of STEM and TV programmes about STEM could be made more engaging for children and young people. ]*

## Introduction

The participation of young people, particularly girls, in STEM has been of concern for several decades. An extensive research review (Murphy and Whitelegg, 2006), reported at ESERA 05 (Whitelegg et al., 2007), revealed a complex, interacting web of factors that influences the participation of girls, and some boys, in physics and in science more generally. Two key factors revealed by this review are the development of young people's self concept and self efficacy in science. Recognising that young people's self efficacy and self concept are not developed solely within the school environment, the 'Invisible Witnesses' project focused on another potential sphere of influence, that of children's television. Surveys that seek to explore public attitudes to science (see for example Research Councils UK/ DIUS, 2008) have highlighted that television programmes continue to be an important source of information about science-based issues. The study did not aim to investigate how TV programmes could influence CYP's science content knowledge, but to contribute to an understanding of how the image of STEM that pervades popular culture outside school can affect CYP's willingness to engage with these subjects..

## **Rationale**

The project, which was conducted over 3 years, addressed the following three research questions:

1. How much STEM is represented on UK terrestrial TV; how is it distributed between the five channels; and what times of day is it broadcast?
2. Which genre/type of programme represents the most STEM; what is the gender distribution among scientists/experts/those in authority; how many women/men are represented; and how many words are spoken by women and men in these programmes on UK terrestrial TV?
3. What are children and young people's (CYP) current images of STEM; how are these affected by the images of STEM shown on TV.

These research questions were addressed in the first phase of the project. A second phase emerged during the course of the project that engaged CYP as participant researchers by employing and further developing their media literacy skills to enable them to devise a television series about STEM for an audience of their choice. This work aimed to help CYP to understand the role of stereotypes in representations of STEM in the media to enable them to deconstruct such stereotypes and move beyond the simplistic representations of scientists as 'mad, bad and dangerous and dangerous to know' (Frayling, 2005).

## **Methods**

The TV programmes sampled were chosen from TV listings over 2 distinct weeks – the first in October 2005 and the second in March 2006. All programmes that were described as having any STEM content or context were recorded, including all news programmes. This resulted in recordings of 600 programmes. This sample was reduced to 374 hours of TV programme extracts containing STEM content or contexts which was analysed using quantitative and qualitative content analysis methodologies (see Silverman, 1993) to produce a video library for the project. This video library of extracts provided baseline data of the representations of STEM and STEM practitioners available to children and young people on UK TV. The analysis of the extracts divided these into four types: educational; pre-school; news and current affairs; and cartoons and animations.

The content analysis was followed by a reception study with 62 children and young people (37 girls and 25 boys) aged 8 to 15 years. The CYP were chosen from those who answered a call to participate in the study and from a local primary (5-11 years) school. A key premise that has underpinned the project is that children and young people are not simply passive receivers of media messages, but active viewers and interpreters of media representations, also potential participants/contributors to certain forms of popular media (e.g. programme websites). Indeed, we have argued that this process of interpretation plays an important role in the ways in which children and young people actively construct their sense of self-concept and their identities (see Whitelegg et al., 2007; Carr et al., 2008, 2009).

The methods used within the studies, therefore, were designed to engage with, and capitalise on, the participants' media literacy skills. In brief, the methods used in the reception studies included (i) An initial questionnaire to ascertain the participants' existing perceptions of STEM and STEM professionals (adapted from Sjøberg, 2002), TV viewing habits and Internet use; (ii) implementation of the Draw-A-Scientist activity, DAS (adapted from Chambers 1983); (iii) reflective writing on the participant's involvement in STEM in the future; (iv) worksheets containing activities using short video extracts taken from our video library; (v) storyboard activities where the participants created STEM-related TV series; and (vi) evaluation activities. The worksheets and the storyboard activities were undertaken in small groups of between 3-5 participants, whilst the other activities were done individually. The reception study was undertaken on three separate occasions, in two different locations. Initially, two researchers obtained access to a primary classroom and conducted the study in school time with the support of the class teacher. The remaining two occasions took place out-of-school in the children and young people's school holidays on the researchers' university campus. .

## Results

The results of the content analysis showed that educational programming formed the largest proportion of programmes for children and young people (41%). For each of the four types of the TV programmes containing STEM that were analysed, there were more words spoken by males than females. This provided evidence that males were more visible and more active in STEM-related TV content than females in these genres. A sub-set of the TV extracts was analysed in detail to examine the content of the words spoken to further determine the images of STEM and STEM practitioners that were being communicated by the characters' actions and talk. Some of these extracts were then analysed by participants as part of the reception study. The young people identified stereotypical representations of STEM and gender, and whilst they recognised that these stereotypes were often used to provide useful 'short-cuts' for programme-makers in terms of establishing the roles of characters within the plot, they also highlighted the possible negative impact of these stereotypes and questioned the over-simplistic use of stereotypes. The analysis carried out by the young people suggests that programme-makers should recognise the significance of contextual information and should not under-estimate young people's abilities to interpret quite nuanced aspects of storylines if they are presented to them in a way that they find engaging.

The questionnaire and DAS tests were administered to provide baseline data about our sample of children and young people to ensure that we did not have an unusual cohort. The results from these studies were compared with surveys of much larger studies (Sjøberg, 2002; Steinke et al., 2007). The questionnaire revealed that older children generally had some understanding of who scientists and engineers were, but younger children had difficulty recognising STEM professionals. Many of our participants were enthusiastic about being involved in STEM careers in the future but often had unrealistically optimistic expectations about the ages they would attain positions of responsibility, high salaries and working conditions, although they recognised that being a scientist or engineer would involve hard work. The questionnaires also revealed that the children and young people saw job satisfaction as important for their future careers. The analysis of the DAS test revealed 55 (89%) of the images drawn were identified as drawings of male scientists. 7 (11%) images were of female scientists and these were all drawn by the younger girls. The test also revealed that some girls appear to be more aware than some boys of different images of scientists, but this appears to decline with age. Contrary to other research there was no evidence that a repeated application of the DAS test produced more drawings of women scientists.

In designing STEM-related TV series the young people demonstrated a sophisticated understanding of genre and of strategies deployed by programme-makers to engage potential viewers. They emphasised the importance of programmes being both entertaining and educational, but stressed that the entertainment element of the programmes should not lead to a 'dumbing down' of the STEM-related content. A further key aspect of the format of the programmes was that they should enable the audience to engage actively with the STEM-related aspects of the programme, often through activities on programme-related websites. The participants demonstrated the ability to conceptualise an audience, rather than just designing programmes that they themselves might find appealing, and when designing programmes aimed at younger age-groups they emphasised the importance of encouraging children to engage with, and learn about, STEM from a very young age.

## Conclusions and Implications

There is clear evidence of gendered representations of STEM in our sample such that the stereotypical male scientist retains a strong presence in TV programmes for children and young people in the UK. New images of STEM and those involved in STEM are emerging, with cartoons and science fiction programmes in particular providing opportunities for programme makers to create new images of STEM, including positive images of women in STEM roles. More authentic and diverse images of expert women STEM professionals on TV are needed, however, and when women do appear as experts on the programmes it is important that they are identified as such.

Results from the evaluation of the storyboarding activities showed that children and young people in this study were able and enthusiastic to use STEM in developing ideas for TV programmes. An explicit focus on media literacy skills provides opportunities for developing teaching activities around STEM and also provides a useful vehicle to enable young people to think more reflectively about what they could do in later life.

## References

- Carr, J., Whitelegg, E., Holliman, R., Scanlon, E. and Hodgson, B. (2009). *(In)visible Witnesses: Drawing on young peoples' media literacy skills to explore representations of science, technology, engineering and mathematics*. Research Report. Bradford, UK, United Kingdom Resource Centre for Women in Science Engineering and Technology (UKRC).
- Carr, J., Whitelegg, E., Holliman, R., Scanlon, E. and Hodgson, B. (2009). Investigating gendered representations of scientists, technologists, engineers and mathematicians on UK children's television. *Investigating Science Communication in the Information Age*. Holliman, R., Whitelegg, E., Scanlon, E., Smidt, S. and Thomas, J. (Eds.) Oxford, Oxford University Press.
- Chambers, D. (1983). 'Stereotypic images of the scientist: the draw a scientist test.' *Science Education* **67**: 255 - 265.
- Frayling, C. (2005). *Mad, Bad and Dangerous? The Scientist and the Cinema*. London, Reaktion Books.
- Murphy, P. and Whitelegg, E. (2006). *Girls in the Physics Classroom: A review of the research on the participation of girls in physics*. London, Institute of Physics.
- Research Councils UK/ Department for Innovation, Universities and Skills (2008) *Public Attitudes to Science: 2008*, London, HMSO.
- Silverman, D. (1993). *Interpreting Qualitative Data: Methods for analysing talk, text and interaction*. London, Sage.
- Sjøberg, S. (2000). *Science for the children? Report from the SAS-project, a cross-cultural study of factors of relevance for the teaching and learning of science and technology*. Oslo, University of Oslo.
- Steinke, J., Knight Lapinski, M., Crocker, N., Zietsman-Thomas, A., Williams, Y., Higdon Evergreen, S. and Kuchibhotla, S. (2007). 'Assessing media influences on middle school-aged children's perceptions of women in science using the Draw-A-Scientist Test (DAST).' *Science Communication* **29**(1): 35 - 64.
- Whitelegg, E., Holliman, R., Carr, J., Scanlon, E. and Hodgson, B. (2008). *(In)visible Witnesses: Investigating gendered representations of scientists, technologists, engineers and mathematicians on UK children's television*. Research Report. Bradford, UK, United Kingdom Resource Centre for Women in Science, Engineering and Technology (UKRC).
- Whitelegg, E., Murphy, P. and Hart, C. (2007). 'Girls and Physics: Dilemmas and Tensions' *Contributions from Science Education Research*. Pinto, R. and C, D. (Eds.) Dordrecht, The Netherlands, Springer: 27-36.

# INTRODUCING THE NATURE OF SCHOOL SCIENCE (NOSS)

## Using Wittgenstein's language game concept to analyse meaning making in school science

Mattias Lundin  
University of Kalmar

### Abstract

*This paper focuses on how students and teachers address features of science in school science practice in lower secondary school. The point of departure is that if a school subject content is treated as relevant, it is likely to promote the involvement of the students. The concept nature of science (NOS) could be part of science education and perhaps enhance the relevance of a school science activity. The excerpts found in this text are based on video observations in two schools. The classes were not chosen for any particular reason, except that the teachers and their students agreed to be visited during their lessons. The analysis is based on the idea that school science involves different ways of meaning making and these are referred to as different language games. The analysis points out that school science involves features that are not related to science itself, for example, students' learning as well as their safety. The science classroom is consequently not an example of a pure science language game but should be interpreted as a school science language game where students' learning is a major purpose. Features of a school science language game that do not relate to the NOS, but, to students' learning, I designate nature of school science (NOSS) (Cf. Lundin, 2008). NOSS is not applicable in professional science practices. In a school science language game, the teacher needs to consider the students' learning, their safety (cf. Lundin & Lindahl, 2005), and to ensure that the lesson is carried out in its allotted time etc. Such considerations are core elements in the NOSS. It is suggested that students' discrimination of features referring to the NOSS and the NOS could facilitate classroom communication.*

### Introduction

In this paper I address school science practice in lower secondary school. The purpose is to show features of school science practice in which the scientific relevance is brought up. The scientific relevance is dealt with here because if students treat the school subject as highly relevant it is likely to encourage their involvement. Furthermore, the nature of science (NOS) is often discussed in science education, and included in the concept is the idea that the NOS should be part of classroom activity, either explicitly or implicitly. The research question is formulated as follows:

How do students and teachers address features of science in school science practice?

To answer the question I will use the ideas of Wittgenstein. First, I focus on Wickman and Östman's, as well as my own, interpretation of the later Wittgenstein's later writings. Second, I present two excerpts from science classroom practice to which I apply theory. The concept NOS is addressed in relation to the second excerpt. To conclude the text, I suggest that the concept NOSS should be used to explain the priorities and questions regarding school science features that the participants emphasised.

The language game concept as a theoretical starting point

School science involves different ways of meaning making. Teachers and students can, for example, refer to nature phenomena by using a selection of scientific words or by using everyday ones. For example, Szybek (2002) describes how students both communicate on an everyday and a science stage of events as they make meaning of a problem in two different ways. In the present text such different ways of meaning making and acting are referred to as *language games* (Wittgenstein, 1953, §7). Language games are legitimate in relation to the purposes of their particular setting. That is, a language game is here seen as a "whole, consisting of language and the actions into

which it is woven...” (Wittgenstein, 1953 §7). When we participate in a scientific language game, we not only learn to give scientific meaning to words but also how to be involved in a scientific activity (Östman & Roberts, 1994). The language game concept involves the norms and rules (expressed and tacit) that can be interpreted in an activity such as school science. You learn a language game by observing and participating in it in the same way that you might learn to play a party game by observing and participating in it. It is only possible to identify a language game because we agree on how language is used, and as we do that, the language game emerges. The rules of a language game are not pre-defined, but have to be found in the participants’ actions. Meaning of words come with the use of them and there is no agreement made beforehand about how words should be used: “A meaning of a word is a kind of employment of it. For it is what we learn when the word is incorporated in our language” (Wittgenstein, 1969, § 61). The rule of a language game does not give rise to particular actions; a rule is a construction *after* the event. The idea that meaning making is an employment of words implies that different ways of meaning making are possible. A word can, as any physical form of a tool, be used for different purposes. For example, a screwdriver can be used for screwing or to widen a loose joint. It could also be useful to use the screwdriver as a blackboard pointer in the classroom. Similarly, words can be used for various purposes.

Although, the meaning of a particular word can be different in different language games, language games are not distinct units. There are similarities between different language games, regarding, for example what is meaningful to talk about and how meaning is made. Similarities facilitate our possibilities to go from one language game to another. However, it is not possible to define similarities between language games beforehand and similarities are characterized as family resemblances. Wittgenstein (1953, § 67) explains *family resemblances* as similarities that are shared between family members, but every resemblance is not shared between all members of the family. That is, words can be used in similar ways in different language games but there is not necessarily a core resemblance between all uses. Family resemblances regarding how meaning is made of words in different language games facilitate the work of joining a language game that is new to us.

The language game makes it possible to make meaning of actions (moves or utterances). Some things that we say even become evident directly. According to Wickman and Östman (2002) such immediately intelligible utterances *stand fast* in a conversation. What stands fast in a language game does not need any further explanation to be understood. That is, we have to start trusting in our interpretation of other people’s utterances at some point (Wittgenstein, 1969 § 150) and everything cannot be doubted if we intend to go on with our conversations. The communicative items that stand fast are important as communication is only possible if meanings of words are intelligible to the participants. Furthermore, if nothing stood fast there would not be any kind of starting point in conversations:

“If you are not certain of any fact, you cannot be certain of the meaning of your words either. If you tried to doubt everything you would not get as far as doubting anything. The game of doubting itself presupposes certainty” (Wittgenstein, 1969, § 114-115).

Consequently, in any conversation utterances that stand fast are possible to identify. As a conversation goes on we encounter new items, such as words or things. Some of the items that we encounter do not stand fast, and then, some kind of comment will be needed to fill the *gap* that was encountered with that item. When studying a conversation we may notice how relations are established between items that stand fast and these encountered gaps. When we add a comment in a conversation the comment fills a gap. Gaps are possible to notice by their consequences (that is, when they are filled). Wickman and Östman (2002) build on these ideas in their approach to analysing conversational change. Their analytic approach is based on an establishment of relations to items that stand fast. They describe the approach as

“...on the one hand describing what is standing fast in discourse (the already shared meaning) and on the other hand by describing how participants establish new relations in terms of similarities and differences to what is standing fast in an encounter (new shared meaning)” (ibid., p. 5).

We can see that a gap has been encountered when a relation is established. Relations can either be *differences* or *similarities*. A ‘difference’ can imply a contrast that discriminates the related items. A ‘similarity’ on the other hand constitutes an analogy between the related items. In a conversation, an increasing number of relations are established which makes up a conversational change. Such a change can, for example, be seen as an increasing



number of items in a conversation becoming immediately intelligible to the participants. The gradual change is one way to operationalize language games. In this text I will give two examples that illustrate what can hinder such a gradual change.

## Methods

The excerpts found in this text are made using video observations in two schools. The first excerpt originates from a physics class which was learning about batteries. These students were 13 years of age. The second excerpt originates from a biology class with 15-year-old students studying the human body. The classes were not chosen for any particular reason, other than that the teachers and their students agreed to be visited during their lessons. Both classes were observed during every lesson on that theme. All participants were informed about the research project, their anonymity and their option to decline to participate. In the excerpts single parentheses are used to comment on what was done while the utterance was made. For further information about the instrument and the classroom work I refer to Lundin (2007).

## Results

### Analysis of the first excerpt

The example below shows how a teacher introduces laboratory work to students. It is likely that the student had previously heard of sal ammoniac, since there is a Swedish name of the substance (salmiak).

- Teacher: Okay, eh this is called a tray, it is not very interesting but eh a small beaker that you can have a fluid in, for example water (shows a tray). We are going to have something else in it.
- Student: Soap?
- Teacher: Tada (shows a bottle with a fluid in it), sal ammoniac, it is called (opens the bottle slowly).
- Student: It tastes good...
- Teacher: It is like this, one thing to keep in mind if you get it on your clothes, it will cause stains and I believe it is not particularly corrosive but try to avoid getting it on your fingers and, and wash your hands after your laboratory work please (pours the fluid into the tray)
- Student: Is it dangerous?
- Teacher: No, not dangerous but you should always be careful with these kind of things I believe.
- Student: Can you drink ... ?
- Teacher: No, you shouldn't do that, so... (puts the cork onto the bottle)  
(Lundin & Lindahl, 2005)

The phrase "It tastes good" seemed to stand fast (Wickman & Östman, 2002) in the language game because the teacher went on explaining how you should be careful when using the fluid, without anybody asking or commenting on the utterance. However, in the teacher's next turn the fluid is described as something to avoid having contact with. A gap can be seen as the student asked for guidance by asking if the fluid is dangerous. The gap appears not to be filled because the teacher said that they should be careful. However, it can hardly taste good at the same time as they should be careful with it. Accordingly, the student's new question seems to concern the suggested caution in handling the fluid associated with its good taste. The teacher repeated that they should not drink the fluid. The gap was still lingering and there was no relation established between "It tastes good" and the utterance, implying that you should not drink it. The conversation can be interpreted as showing how a shift from a *science language game* is avoided, maybe because science praxis is not to eat or drink in the laboratory at the same time as the student suggests that the fluid tastes good. The suggestion of an intake of the substance is interpreted as a part of an *everyday language game*. It is possible that the student had had a pastille with the same name as the substance (salmiak). An important observation in the previous excerpt is the lingering gap. To utter that the substance is edible to a limited extent, as in the pastilles, seems not to have been an option. The everyday relevance of the substance was not picked up as a topic.

### Authenticity of school science

I will here use Brown, Collins and Duguid (1989) to introduce the next excerpt. They describe school as a *hybrid culture*, since it is framed by one culture and attributed to another. That is, school can be regarded as involving the use of its own language game, although school activities are sometimes attributed to other language games. For example, writing and producing a school newspaper would be an activity embedded in a hybrid culture, because it consists of an activity that has been transferred to the classroom and a context which is transmuted to a school culture, with newspaper making seen as an *authentic* culture. By comparison pre-modern societies involve learning from participating in the culture that is to be mastered (e.g. a shoemaker's apprentice). However, activities outside school are not always models for in-school activities although they might look alike (Carlgren, 1999). For example, although making a school newspaper involves similar actions to newspaper making, a distinguishing and crucial feature of school is the learning purposes. In other words, one reason for making a school newspaper is the students' learning, which is not a basic reason for making a commercial paper. When focussing on learning purposes, school needs to be considered an authentic culture (Carlgren, 1999). Thus, writing a school newspaper would be an authentic school activity based on learning purposes. Hogan (2000) distinguishes knowledge that deals with professional science processes (*distal* knowledge) from knowledge that deals with a person's own science knowledge (*proximal* knowledge). In Hogan's terminology, knowledge about an authentic culture (e.g. newspaper making) can be described as distal, whereas experiences embedded in a school activity (e.g. experience of writing texts for a school paper) can be described as a student's proximal knowledge.

### The Nature of Science

In order to discriminate science features in the second excerpt I introduce the NOS. Khishfe and Abd-El-Khalick (2002) describe the NOS in four statements that they claim are not controversial. These statements emphasise the characteristics of scientific knowledge: <sup>1</sup>Scientific knowledge is tentative and subject to change. <sup>2</sup>Scientific knowledge is based on empirical observations. <sup>3</sup>Scientific knowledge is a product of human creativity. <sup>4</sup>When science knowledge is acquired a distinction is made between observation and inference. In contrast to the language game concept, which is a base for analysis, the NOS is a possible content in science education. The NOS can either be taught implicitly, by participation in science activities or explicitly by direct instruction. According to Khishfe and Abd-El-Khalick (2002) students benefit from the latter alternative because the NOS is not necessarily easily discerned in an activity. In the previous excerpt, the teacher seems to avoid a shift to an everyday language game, which implies a lingering gap between "It tastes good" and the utterance implying that you should not drink sal ammoniac. It can be argued that the students could have been allowed to taste. Maybe, the teacher could have filled the gap by including a comment on a hypothetical intake of the substance. However, the teacher prioritized the *science language game*, and a possibility for students to learn the NOS implicitly (by experiencing no eating in the laboratory).

### Analysis of the second excerpt

The following excerpt shows how Mark questioned the relevance of the chosen procedure for examining the blood group. The excerpt is chosen to show how meaning can be made of school science procedures and that the procedures do not always fit well with the concept NOS.

- Mark: The hospital doesn't do it this way, with this kind of...  
Teacher: They can do, but they have certainly automatically but, basically the same procedure.  
Mark: Wasn't it kind of, put the blood into computers?  
Teacher: I cannot confidently answer that. Nevertheless it has formerly been done this way, but there certainly is some machine that manages all that (murmuring). How many of you want to check blood group (students raise their hands)?  
Bryan: Yes me too (show of hands). (Lundin, 2008)

The teacher explained the procedure at the same time as Mark questioned whether it corresponds to blood testing procedures in professional practices. Mark questioned the procedure, claiming that hospitals examine blood groups in a different way - that is, he questioned the authenticity of the method. Although Mark pointed out

differences, the teacher never explained them. The question of authenticity did not seem to be part of the language game. The teacher's comment was that the classroom procedure was basically the same procedure as an automated healthcare procedure. The teacher related the suggested laboratory work to antecedent procedures rather than a contemporary view of science work and NOS.

The situation when Mark questioned the authenticity of the procedure is an occasion for learning what counts as a relevant topic in school science (i.e. the practical epistemology, cf. Lidar *et al*, 2006). However, even if students learnt that the authenticity was not an issue, they hardly learnt about the reasons why. Similarly, Delamont *et al* (1988) show how science is sometimes introduced as self-justifying and self-evident. The results herein identify the possibility that the emphasis on procedures might appear superfluous to students. For example, when comparing professional practices (of science) with school science, the procedures of school science might appear to be purposeless because they do not resemble professional approaches. Relating the school procedure to a possible science procedure by expressing a core similarity might have solved this issue. A comment on the response for the choice of procedure could have drawn attention from the idea of school practice being built on the NOS only. The comparison with professional practices (of science) that Mark made draws attention to the irrelevance of chosen school procedures. School science may then appear to be purposeless to students, for example, if students expect school science procedures to be equivalent to those of professional practices. Mark's comments can be interpreted in that way and indeed the authenticity of their procedure can be questioned. According to the Swedish Work Environment Authority, blood testing is not an appropriate school activity and safety is one reason for their statement. (AFS 2005:1).

## Conclusions and Implications

In school science many things have to be accounted for, some of which are not related to science practices. Such things are, for example, related to learning. The science classroom is not an example of a pure science language game, but should be interpreted as a *school science language game* where students' learning is a major purpose. To introduce NOS to students is only one of many purposes in school science. NOS can be central under some circumstances and set aside in other situations. In either case, understanding of NOS is accompanied by learning a practical epistemology (cf. Wickman, 2004; Lidar *et al*, 2006), which for example points out what is worth talking about. Features of classroom activities that do not relate to the NOS, but to students' science learning, I designate *nature of school science* (NOSS) (Cf. Lundin, 2008). NOSS is not applicable in professional science practices (where NOS is prevalent). In a school science language game the teacher has, for example, to consider the students' learning, their safety (cf. Lundin & Lindahl, 2005), as well as to ensure that the lesson is carried out in its allotted time, and so on. Such considerations are key elements in the NOSS. It is suggested here that students' discrimination of features referring to the NOSS as well as to the NOS would facilitate classroom communication. I suggest the NOSS is needed as a contrast when the NOS is taught by explicit instruction, as Khishfe and Abd-El-Khalick (2002) argue. If students knew how to discriminate NOSS and NOS it would imply that they had prerequisites for relating classroom features, based on a science language game, to the NOS. Similarly, they would be able to relate science educational issues to the NOSS. Then, the avoided everyday use of the sal ammoniac substance could have been explained. Also, the learning purposes of blood group testing could have made the school procedure relevant, not because of an exact match with professional practices but because of its learning possibilities. This interpretation supports the notion of school as an authentic culture (cf. Carlgren, 1999): making school science an authentic practice rather than a hybrid culture of science (cf. Brown *et al*, 1989). In situations where distal knowledge (Hogan, 2000) is learnt only the NOS is relevant because distal knowledge implies learning by instruction about a science practice outside school. However, proximal knowledge is learnt in school situations that can be described in terms of NOS as well as NOSS.

In this text I have shown how the language game concept can be used to point out different rationales and purposes in school science, and how different meanings can be made of procedures. For a teacher that only uses a science language game (e.g. in the laboratory), it might seem unwise to explain how, for example, sal ammoniac is

used in pastilles. However, as everyday language game questions are asked, it seems valuable not only to emphasise features of science and the NOS but also features of school science. These, additional features become visible and purposeful when addressing the concept of NOSS, as the basis of *school* science activities. For example, the procedures when determining blood groups in school are not fully understandable if addressed only to the activities of professional healthcare and science practices. The NOSS emphasises rationales that are suitable for learning purposes, for example. That is, procedures in school science experiments are not justified mainly because of the need for exact results or by claims of authenticity in relation to professional science practices, but by their role in the school science language game. I suggest that future research tries to gain a deeper understanding of the special prerequisites of the school science language game that relate to the NOSS. I also suggest a wider definition of the NOS in order to include not only the characteristics of scientific knowledge but also the characteristics of, for example, scientific *activities*.

## Acknowledgement

This paper was made possible thanks to ‘The Board of Teacher Education and Educational Research’ at the University of Kalmar, Sweden.

## References

- Brown, J. S., Collins, A. & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, 18, p. 32 - 42.
- Carlgrén, I. (1999). Pedagogy and teachers’ work. *Nordisk pedagogik*, 19(4), p. 223-234.
- Delamont, S. Beynon, J. & Atkinson, P. (1988). In the beginning was the Bunsen: the foundations of secondary school science. *Qualitative studies in education*, 1 (4), p. 315-328.
- Hogan, K. (2000). Exploring a Process View of Students’ Knowledge about the Nature of Science. *Science Education* 84, p. 51-70.
- Khishfe, R. & Abd-El-Khalick, F. (2002). Influence of Explicit and Reflective versus Implicit Inquiry-Oriented Instruction on Sixth Graders’ Views of Nature of Science. *Journal of research in science teaching*, 39(7), p. 551-578.
- Lidar, M., Lundqvist, E. & Östman, L. (2006). Teaching and learning in the science classroom. *Science Education*, 90, p. 148 – 163.
- Lundin, M. (2007). *Students’ participation in the realization of school science activities*. Norrköping: Linköping university.
- Lundin, M. (2008). Meaning making of precision and procedures in school science. *Canadian Journal of Science Mathematics and Technology Education*, 8(1), p. 25 – 34.
- Lundin, M. & Lindahl, M. (2005). Experiences and their role in science education. *Journal of Baltic Science Education*, 1(7), p. 31 – 39.
- Swedish work environment authority (2005:1). *Mikrobiologiska arbetsmiljörisiker – smitta, toxinpåverkan, överkänslighet*. Solna: Arbetsmiljöverket.
- Szybek, P. (2002). Science Education –An Event Staged on Two Stages Simultaneously. *Science & Education*, (11), p. 525 - 555.
- Wickman, P. - O. (2004). The practical epistemologies of the classroom: A study of laboratory work. *Science education*, 88, p. 325-344.
- Wickman, P.- O. & Östman, L. (2002). Learning as Discourse change: A Sociocultural Mechanism. *Science Education*, (86), p. 601–623.
- Wittgenstein, L. (1953). *Philosophical investigations*. Oxford: Basil Blackwell.
- Wittgenstein, L. (1969). *On certainty*. Malden: Blackwell.
- Östman, L. & Roberts, D. A. (1994). Toward understanding the production of meaning in science education. Introduction to the theme. *Nordisk pedagogik*, 1, p. 2 - 9.

# QUALITATIVELY DETERMINING PHYSICS TEACHER CANDIDATES' SELF-EFFICACIES AND ATTITUDES TOWARDS PROBLEM SOLVING

Serap Çalışkan  
Dokuz Eylül Üniversitesi

Gamze Sezgin Selçuk  
Dokuz Eylül Üniversitesi

Hilal Aktamış  
Adnan Menderes Üniversitesi

## Abstract

*A successful problem solver's self-efficacy and attitude towards problem solving are also very important as much as self-efficacy and attitude towards physics course which are widely-encountered in the field literature. In the light of this information, the aim of this research is to determine the physics teacher candidates' self-efficacies, and attitudes towards problem solving by means of the structured interviews as different from the other researches done, and to determine qualitatively the relation of their self-efficacies, and attitudes with academic achievement, gender, and grade levels. Seven teacher candidates have been selected from each grade level, namely first, second, third, fourth and fifth from Physics Education Department, Dokuz Eylül University, İzmir. The data of the research had been collected by constructive interviews each lasting about 50 minutes. During the interview a form developed by the researchers named "Assessment Form of Self-Efficacy and Attitude towards Problem Solving" (AFSATPS) is used. Findings of the study indicate that there were meaningful relations between the teacher candidates' academic achievements, gender, grade levels, and their problem solving attitude and self-efficacy.*

## Introduction

One of the most important aim of the modern education is to educate individuals who are overcoming the problems which they encountered in their daily lives and social lives on their own, in other words, individuals who can easily solve the problems which they encountered. Problem solving is usually defined as formulating new answers, going beyond the simple application of previously learned rules to create a solution (Woolfolk, 1993).

Two fundamental purposes of physics offered as a compulsory course in many academic programs (chemistry, biology, engineering, etc.) are to teach the fundamental concepts and principles to students, and help them gain a general physics culture and to help students develop positive attitudes and interests towards physics. Problem solving which is the integral part of also physics training as well as the other disciplines (Toluk and Olkun, 2002), and problem solving skill in physics constitute the fundamental source of the physics knowledge (Serway, Beichner and Jewett, 1999). In this context, as well as the importance of the level of the cognitive behaviours, the methods followed (strategies), and the knowledges gained in the problem solving skill; a successful problem solver's self-efficacy and attitude towards problem solving are also very important as much as self-efficacy and attitude towards course which are widely-encountered in the field literature. Moreover, at a research done related to attitude towards physics problem solving, it was determined that the attitude towards physics problem solving is directly related to the physics course academic achievement (Çalışkan, Selçuk, Şahin, and Erol, 2009); and it was emphasized

that high self-efficacy provides the students to endeavour more and deeply in problem solving process, and they believed that they could assuredly solve the problem (Jonassen, 2000).

Literature reviews in Turkey (Çalışkan, et al, 2009; Gök and Sılay, 2008) and other countries (Higgins, 1997; Marx and Cummings, 2007; Whitaker, 1982) revealed that there were limited numbers of researches on attitudes towards physics problem solving. In addition to this, it can be said that in Turkey and other countries scarcely none research related to determining self-efficacy towards physics course had been done (Selçuk, Çalışkan, and Erol, 2008; Shaw, 2004; Zhu, 2007); and unfortunately no research related to especially directly determining self-efficacy towards physics problems had been encountered in field literature review. At the researches done in the field literature, the students' self-efficacies and attitudes were almost always measured by means of Likert type scales (for example: Baldwin, May, and Burns, 1999; Çalışkan, Selçuk, and Erol, 2007; Çalışkan, et al, 2009; Nuhoğlu and Yalçın, 2004; Selçuk, 2004). At this research, differently, instead of the scale, the students were asked structured questions to perform qualitative analysis. It is believed that, in physics where problem solving is very important and is used frequently, investigating future physics teachers' attitudes and self-efficacies towards physics problem solving would provide significant contributions to physics education literature.

In the light of this information, the aim of this research is to determine the physics teacher candidates' self-efficacies, and attitudes towards problem solving by means of the structured interviews as different from the other researches done. Here the aim is to determine the teacher candidate's self-efficacy, and the attitude towards physics problem solving by using his/her own expressions specifying the causes and methods; and to determine qualitatively the relation of their self-efficacies, and attitudes with academic achievement, gender, and grade levels. For this purpose, the following questions were asked at the research:

- 1) How are the physics teacher candidates' attitudes towards problem solving?
- 2) How are the physics teacher candidates' self-efficacies towards problem solving?
- 3) How is the relation of the physics teacher candidates' attitudes towards problem solving with their academic achievements, genders, and grade levels?
- 4) How is the relation of the physics teacher candidates' self-efficacies towards problem solving with their academic achievements, genders, and grade levels?

## **Methods**

### **Subjects**

Selected 35 physics teacher candidates constitute the subject of the research. Seven teacher candidates have been selected from each grade level, namely first, second, third, fourth and fifth from Physics Education Department, Dokuz Eylül University, Izmir. 22 of the teacher candidates are female, and 13 of them are male.

At this research, the students who have 3.00 or above grade point averages were determined as highly achiever, the students who have grade point averages between 2.9-2.0 were determined as middle achiever, and the students who have 1.9 or below grade point averages were determined as lowly achiever according to the 4.00 grade point system regarding the Instruction and Exam Application Rules of University. In this context, 15 of the subjects who participated into this research were determined as highly achiever, and 10 of them were determined as middle achiever, and 10 of them were determined as unsuccessful (lowly achiever). 3 highly achiever, 2 middle achiever, and 2 lowly achiever teachers participated from each grade level.

### **Data Collection Tool**

The data of the research had been collected by constructive interviews each lasting about 50 minutes. During the interview a form developed by the researchers named "Assessment Form of Self-Efficacy and Attitude towards Problem Solving" (AFSATPS) is used. The form contains three mechanics problems, and five open-ended questions related to determining the attitude, and seven open-ended questions related to determining the self-

efficacy. The form which is used at the research was used with its final form after the necessary corrections had been done by consulting to three experts, and five teacher candidates.

### Procedure

The data of the research was collected by the researcher by means of the structured interviews lasting 50 minutes done with seven teacher candidates from each grade level. During the three-month period, approximately four teacher candidates from each grade level per week were interviewed with individually. At the beginning of the interview, it was expressed to the teacher candidate that the aim was not to determine his/her physics achievement or problem solving achievement, but to reveal how an attitude he/she has while solving a physics problem and his/her self-confidence level. And then, these three questions were submitted to the teacher candidates by the researcher, and they were wanted to try to solve the problems on the empty papers which were given to them. The interviews were started with the teacher candidates after they finished the problem solving. The researcher expressed to the teacher candidates that the answers given by them should have been written by themselves. During the interview, five questions prepared to determine the problem solving attitude such as how they felt generally about solving such mechanics problems, and the importance which they gave to the physics problems, and then seven questions related to determining the problem solving self-efficacy were asked respectively, and the answers given were recorded in written. And then the meeting is finished.

### Data Analysis Techniques

This is a qualitative study. For this study, structured interviews were used. At the research, the written expressions of the teacher candidates and 35 pieces of AFSATPS containing the solutions of the problems were individually read, and the interviews were transcribed verbatim from the ASFATPS. Transcripts of the student teachers' interviews were examined independently by two members of research group, looking for both similarities and differences among them, selecting significant statements and comparing these statements in order to find the case of variation and thus grouping them accordingly. Two researchers had defined 9 common categories for 12 questions unanimously after investigating the questions and given answers. While representing the research results, some student quotes which would be the characteristic samples for the definitions at these categories were given. In the quotes "I" means Interviewer and "S" means Student. In addition "n" means frequency. In addition, frequency (n) and percentage (%) of the student responses were presented.

## Results

1. The answers given to 5 questions asked to determine the problem solving attitudes of 35 physics teacher candidates to answer the following sub-problem of "How are the physics teacher candidates' attitudes towards problem solving?" were investigated generally in the following categories of "liking, being afraid of, being interested in, finding useful, and giving importance to".

#### *Category 1: Liking*

**I:** Do you like to solve physics problems? Why?/ How?

**S:** *I like very much when I achieved to solve at my well-known subjects. They are like puzzles, and I find problem solving enjoyable. By the way, they make me think quantitatively and analytically.*

**S':** *They are only necessary for me, because I am a physics teacher candidate. I generally dislike them since they are very difficult and complex.*

At this category, most attention grabbing expressions of the teacher candidates who like or dislike solving physics problems were given as example. During the analysis of data, the following finding had been obtained that

the number of the teacher candidates who like to solve physics problems (n=23, 65.7 %) are much more than the number of the teacher candidates who dislike to solve physics problems (n=12, 34.3 %).

*Category 2: Being Afraid of*

**I:** Are you afraid of solving physics problems? Why?/ How?

**S:** *I am not afraid of it if I thought that I have the sufficient knowledge about the subject of the problem.*

**S':** *I am afraid of not abling to apply / fictionalize the solution. Sometimes, they can contain more than one subject.*

At this category, the number of the teacher candidates who think that s(he) could assuredly solve the physics problems anyway, and who expressed that s(he) was not afraid of it unless it is very difficult is almost all of the subjects (n=32, 91%). It has been seen that there are a few numbers of teacher candidates who are afraid of while applying and fictionalizing the solution of the physics problems (n=3, 9%).

*Category 3: Being interested in*

**I:** Could you please define your interest level of solving physics problems? Could you please explain the reasons and ways?

**S:** *Physics is very much related to the daily life. In this context, I am very interested in especially the ones which are related to the daily life.*

**S':** *I am not interested in the physics problems. Because I think that I always have knowledge deficiencies.*

**S'':** *According to me, the problems are aimless, and they don't contain any daily life applications. I am not interested in it at all. I am interested in it just at the examination periods.*

At this category, n=15 (42.8%) of the physics teacher candidates expressed that they have very low interest in solving problems because of the following reasons such as knowledge deficiencies, being afraid of not abling to solve problem, and their beliefs about the problems being aimless; whereas n=20 (57.2 %) of them expressed that they established a relation between the problems and the daily life, and they are especially interested in physics problems since they are physics teacher candidates.

*Category 4: Finding Useful*

**I:** Do you believe that solving physics problems is useful for you until now from the secondary school? Why?/ How?

**S:** *My problem solving skill improves. It helps me understand and comment the events which I observed in my daily life better. For example I always put the hot tea pot onto wooden mat instead of marble. I calculate the power which iron consumed.*

**S':** *I feel that my mind improves. I think that it has a great contribution on me to think logically.*

**S'':** *It is not useful in real daily life. It only provides to get high scores at exams. Or it can be useful to comprehend the subjects. Except that it is not useful. Everything is like root learning.*

At this category, when the teacher candidates' opinions are examined, it is seen that again the majority of them "n=28" (80%) emphasized that solving physics problems is very useful, and effective in daily life, and in the events such as improving the logical thinking in the course of time. Here, the following data is a remarkable finding such that the teacher candidates who expressed that they are not interested in physics problems also believe that solving physics problems is useful. And a few teacher candidates "n=7" (20%) expressed that the problems are rote-



learning based knowledges, and they are only useful for passing the course, or passing the exams rather than a physical contribution, and have no benefit except those.

*Category 5: Giving Importance to*

At this category, the teacher candidates who expressed that they are not interested in solving problems or do not find it useful also agree that solving physics problems is important. Almost all of the teacher candidates who participated into the research n=32 (91%) emphasized the importance of the physics problems. Only a few numbers of teacher candidates n=3 (9%) expressed that physics problems and solving them are not important.

**I:** “Do you consider the physics problems as important? Why?”

**S:** “*Physics explains our lives, in other words, it is interrelated to the life. Physics is the most important component of all equipments that we use in our lives, and in recent technology. So, the physics problems are very important*”.

**S’:** “*Physics problems do not contain significant current issues. They can be important for the exams or for the professional life. And except these, they do not have any benefits*”.

2. In order to get an answer to the sub-problem of “How are the physics teacher candidates’ self-efficacies towards problem solving?”, it was categorized from the expressions of the teacher candidates related to their self-efficacies towards problem solving and their opinions as “finding themselves adequate in problem solving, determining the points where they are inadequate, the belief on solving the difficult problem correctly, the belief whether being better than his/her friends or not, and the belief on teaching ability to a student who reads at a lower level grade”.

*Category 1: Being adequate and inadequate in problem solving*

At this category, n=17 (48.6%) of the physics teacher candidates find themselves inadequate since they don’t have full confidence in their problem solving knowledges, and since they forgot the formulas, and because of some deficiencies such as not knowing the details related to the subject of the problem. Whereas n=18 (51.4 %) teacher candidates expressed that they have good command of physics subjects sufficiently, and they will assuredly find a solution for the problem by remembering the subject anyway, in this context they find themselves adequate for solving problems.

**I:** How adequate / inadequate do you find yourself in physics problems solving? Could you please express your deficiencies and weaknesses?

**S:** *I feel myself adequate in solving the physics problems. Because I am also successful at the course. I think that I can understand the problems well, and I can comment well.*

**S’:** *I find myself inadequate in solving problems. I think that it causes from unit conversion, lack of some subjects, and not solving example problems.*

*Category 2: Solving the difficult problem correctly*

At this category, n=16 (45.7 %) of the physics teacher candidates expressed that they could not be sure about the solution of a difficult physics problem generally, and they always referred to key containing the right answers, and since the physics problems are too detailed, somethings might be missed at the solution, and so that they believed that they could make mistakes unwittingly. However n=19 (54.3 %) of the physics teacher candidates expressed that even though the physics problem is too difficult, they believed that they could certainly solve the problem correctly by investigating and concentrating on it, or by using the trial-and-error method, or if they could not find any reasonable result, they could find their mistakes after checking the solution of the problem.

I: Can you assure the accuracy of a physics problem that you solved? Do you believe that you can solve a difficult physics problem correctly? Why? How?

S: *If I solved a problem, I am sure that it is correct. Even though it is difficult, I certainly reach to the correct solution by trial-and-error method.*

S': *I can not be sure completely in solving problem. Even if I solved it, I still refer to the answer key.*

*Category 3: Being better than his/her friends or not*

When the answers of the teacher candidates related to finding themselves better than their friends in solving the physics problems are examined, it is seen that the numbers of the teacher candidates who find themselves better “n=16 (45.7 %)” and the ones who do not find better “n=19 (54.3 %)” are almost the same.

I: Do you believe that you are better than your friends in solving the physics problems? Why? How?

S: *I am more hardworking than my friends, and I believe that I have a well improved physical logic .*

S': *I feel that my friends are more capable than me in physics.*

*Category 4: Teaching ability*

Most of the teacher candidates (n=30, 85.7 %) strongly believe that they can lecture the subjects to a student who reads at secondary school well. This is an expected finding at the research. It is thought that it is a native behaviour for the teacher candidates who read at Education faculty to like teaching and lecturing. However, a few numbers of teacher candidates n=5 (14.3 %) expressed that they can teach physics to the students who are reading at lower levels and help them to solve problems, and they also expressed that they believed that they have knowledge deficiencies.

I: How well do you believe that you can teach solving physics problems to a student who reads at secondary school ?

S: *I teach it by summarizing the subjects related to the problem, and giving the most important points, and correlating it with daily life.*

S': *If the grade level is high (such as 11th grade), it would be very difficult. I have too much knowledge deficiencies .*

3. In order to answer the sub-problem of “How is the relation of the physics teacher candidates’ attitudes towards problem solving with their academic achievements, genders, and grade levels?”, the frequencies belonging to the teacher candidates and their striking sample expressions related to the attitude are given regarding three dependent variables.

*\*Relation with academic achievement and attitude:*

*For Category 1:* n=12 of totally n=15 highly achiever teacher candidates; n=7 of totally n=10 middle achiever teacher candidates; and n=4 of totally n=10 lowly achiever teacher candidates like to solve physics problems.

*For Category 2:* n=14 of totally n=15 highly achiever teacher candidates; n=9 of totally n=10 middle achiever teacher candidates; and similarly n=9 of totally n=10 lowly achiever teacher candidates are not afraid of solving physics problems, and think that they can ultimately solve them.

*For Category 3:* n=9 of totally n=15 highly achiever teacher candidates; n=5 of totally n=10 middle achiever teacher candidates; and n=6 of totally n=10 lowly achiever teacher candidates are interested in solving physics problems.

*For Category 4:* n=12 of totally n=15 highly achiever teacher candidates; n=9 of totally n=10 middle achiever teacher candidates; and n=7 of totally n=10 lowly achiever teacher candidates believe that solving physics problems is useful.

*For Category 5:* n=14 of totally n=15 highly achiever teacher candidates; n=8 of totally n=10 middle achiever teacher candidates; and all of totally n=10 lowly achiever teacher candidates believe that physics problems are important.

From these data, it can be concluded that more successful teacher candidates have more positive attitudes towards problem solving.

*\*Relation with gender and attitude:*

*For Category 1:* n=19 of totally n=22 female teacher candidates; and n=4 of totally n=13 male teacher candidates like to solve physics problems.

*For Category 2:* n=21 of totally n=22 female teacher candidates; and n=11 of totally n=13 male teacher candidates express that they have less fear on solving physics problems.

*For Category 3:* n=14 of totally n=22 female teacher candidates; and n=6 of totally n=13 male teacher candidates are interested in solving physics problems.

*For Category 4:* n=20 of totally n=22 female teacher candidates; and n=8 of totally n=13 male teacher candidates believe that solving physics problems is useful.

*For Category 5:* All of totally n=22 female teacher candidates; and n=10 of totally n=13 male teacher candidates believe that physics problems are important.

When these data are investigated, especially Category 1 is examined, it can be concluded that generally female teacher candidates' attitudes towards solving physics problems are more positive than the males'.

*\*Relation with grade levels and attitude:*

*For Category 1:* Whereas n=3 of totally n=7 1<sup>st</sup> grade teacher candidates; and n=4 of each 2<sup>nd</sup> and 3<sup>rd</sup> grade teacher candidates like to solve physics problems; almost all (n=6 for each) of the 4<sup>th</sup> and 5<sup>th</sup> grade teacher candidates express that they like to solve physics problems very much.

*For Category 2:* Among the teacher candidates, n=1 of totally n=3 teacher candidates who are afraid of solving physics problems are reading at 1<sup>st</sup> grade, and the other n=2 of them are reading at 2<sup>nd</sup> grade. And when the teacher candidates' expressions belonging to this category are examined according to the grade level, then it is seen that it is remarkable to have hardly any expressions containing a fear on problems at 4<sup>th</sup> and 5<sup>th</sup> grade levels.

*For Category 3:* Whereas it was determined that at 1<sup>st</sup> grade n=3, at 2<sup>nd</sup> grade n=5, and at 3<sup>rd</sup> grade n=4 teacher candidates have no interest on solving physics problems; only n=2 teacher candidates who are reading at 4<sup>th</sup> grade, and n=1 teacher candidates who are reading at 5<sup>th</sup> grade expressed that they have no interest on solving physics problems.

*For Category 4:* At 1<sup>st</sup> grade n=4, at 2<sup>nd</sup> grade all, at 3<sup>rd</sup> grade n=6, at 4<sup>th</sup> grade n=5, and at 5<sup>th</sup> grade n=6 of teacher candidates believe that solving physics problems is useful.

*For Category 5:* At the category of giving importance to, n=1 of teacher candidates who are reading at 1<sup>st</sup> grade, and n=2 of teacher candidates who are reading at 3<sup>rd</sup> grade expressed that solving physics problems can be important only for the professional life, and except that, they are not important in daily life.

When these data are investigated, especially Category 1, 2, and 3 are examined, it can be concluded that generally physics problems solving attitudes of teacher candidates who are reading at higher grade level are more positive than the teacher candidates who are reading at lower grade level.

4. In order to answer the sub-problem of “How is the relation of the physics teacher candidates’ self-efficacies towards problem solving with their academic achievements, genders, and grade levels?” the frequencies belonging to the teacher candidates and their striking sample expressions related to the self-efficacy are given regarding three dependent variables.

*\*Relation with academic achievement and self-efficacy:*

*For Category 1:* n=10 of totally n=15 highly achiever teacher candidates; n=5 of totally n=10 middle achiever teacher candidates; and n=3 of totally n=10 lowly achiever teacher candidates find themselves adequate in solving physics problems.

*For Category 2:* n=10 of totally n=15 highly achiever teacher candidates; n=6 of totally n=10 middle achiever teacher candidates; and n=3 of totally n=10 lowly achiever teacher candidates are sure about the accuracy of the physics problem that they solved, and even though the problem is difficult, they believe that they certainly reach to the correct solution by trial-and-error method or by investigating.

*For Category 3:* n=7 of totally n=15 highly achiever teacher candidates; n=7 of totally n=10 middle achiever teacher candidates; and n=2 of totally n=10 lowly achiever teacher candidates believe that they are better problem solvers than their friends in solving the physics problems.

*For Category 4:* n=15 of totally n=15 highly achiever teacher candidates; n=9 of totally n=10 middle achiever teacher candidates; and n=6 of totally n=10 lowly achiever teacher candidates assuredly believe that they can teach physics and solving problems well to a student who reads at lower level than themselves.

From these data, especially from Category 1 and 2, it can be expressed that there is a positive relation between the physics teacher candidates’ self-efficacies towards solving problems and their academic achievements.

*\*Relation with gender and self-efficacy:*

*For Category 1:* n=8 of totally n=22 female teacher candidates; and n=10 of totally n=13 male teacher candidates find themselves adequate in solving physics problems.

*For Category 2:* n=11 of totally n=22 female teacher candidates; and n=8 of totally n=13 male teacher candidates expressed that while solving physics problems, even though the problem is difficult, they believe that they can certainly solve it, and they are always sure about reaching to the correct solution.

*For Category 3:* n=12 of totally n=22 female teacher candidates; and n=4 of totally n=13 male teacher candidates believe that they are better than their friends in solving the physics problems.

*For Category 4:* n=17 of totally n=22 female teacher candidates; and all of totally n=13 male teacher candidates assuredly believe that they can teach physics and solving problems well to a student who reads at lower grade than themselves.

When these data are investigated, especially Category 1 and 4 are examined, it can be concluded that generally male teacher candidates’ self-efficacies towards solving physics problems are more positive than the females’.

*\*Relation with grade levels and self-efficacy:*

*For Category 1:* Whereas n=4 of 1<sup>st</sup>, 2<sup>nd</sup>, and 3<sup>rd</sup> grade teacher candidates, and n=3 of 4<sup>th</sup> grade teacher candidates find themselves inadequate in solving problems; n=2 of 5<sup>th</sup> grade teacher candidates find themselves inadequate in solving physics problems.

*For Category 2:* Whereas n=6 of totally n=7 1<sup>st</sup> grade teacher candidates, and n=3 of 2<sup>nd</sup>, 3<sup>rd</sup>, and 4<sup>th</sup> grade teacher candidates expressed that they are not sure about the accuracy of the problems that they solved; only n=1 of 5<sup>th</sup> grade teacher candidates expressed that s(he) can not assure the accuracy of the problem that s(he) solved and believed that s(he) may not solve when s(he) encountered a difficult problem.

*For Category 3:* At 1<sup>st</sup> grade n=4, at 2<sup>nd</sup> grade n=3, and at 3<sup>rd</sup>, 4<sup>th</sup>, and 5<sup>th</sup> grade n=4 of teacher candidates find themselves worse than their friends in solving physics problems. From this, it is seen that there is no remarkable difference between the teacher candidates' self-efficacies according to their grade levels at this category.

*For Category 4:* At 1<sup>st</sup> grade n=5, at 2<sup>nd</sup>, 3<sup>rd</sup>, and 4<sup>th</sup> grade n=6, and at 5<sup>th</sup> grade all (n=7) of teacher candidates assuredly believe that they can teach solving physics problems well to the students who read at lower level than themselves.

When these data are investigated, especially Category 2, and 4 are examined, it can be commented that generally physics problems solving self-efficacies of teacher candidates who are reading at higher grade level are higher than the teacher candidates who are reading at lower grade level.

## Conclusions and Implications

At the research, it was determined from the expressions of the physics teacher candidates related to their attitudes towards problem solving that their attitudes were positive in middle level in general and in the dimensions of "liking, being afraid of, being interested in, finding useful, and giving importance to" for five questions.

It was determined from the expressions of the teacher candidates related to their self-efficacies towards problem solving and their opinions categorized as "finding themselves adequate in problem solving, determining the points where they are inadequate, the belief on solving the difficult problem correctly, the belief whether being better than his/her friends or not, and the belief on teaching ability to a student who reads at a lower level grade" which seven questions contain that they generally find themselves adequate in problem solving, and their self-efficacy beliefs were in a good level.

It was understood from the categorized common opinions obtained by the interviews that there was a positive relationship between the physics teacher candidates' attitudes towards problem solving and their academic achievements, and female teacher candidates' attitudes were better, and the more the grade level, the more positive the attitudes of the teacher candidates towards problem solving.

It was understood from the categorized common opinions obtained by the interviews that there was a positive relationship between the physics teacher candidates' self-efficacies towards problem solving and their academic achievements, in other words, a teacher candidate who has a high academic achievement find himself/herself quite adequate in problem solving, and male teacher candidates' self-efficacies were better, and the more the grade level, the more positive the self-efficacies of the teacher candidates towards problem solving.

It can be said that this research has the feature of being the first in qualitatively introducing the self-efficacy and attitude towards solving problems which is an important factor in physics. Moreover, it is thought that this research would provide new contributions in the field literature in terms of investigating the importance of problem solving and its relations with two important variables such as self-efficacy and attitude towards solving problems in physics education field literature. In this context, it is thought that more researches related to the subject investigating the relation of problem solving with different variables (e.g. motivation, satisfaction) in detail in different educational levels should be done.

## References

- Çalışkan, S., Selçuk, G. S. & Erol, M. (2007). *Development of physics self-efficacy scale*. Sixth International Conference of the Balkan Physical Union, AIP Conference Proceedings, 899, 483-484.
- ÇALIŞKAN, S., SELÇUK, G. S., ŞAHİN, M. & EROL, M. (2009). PHYSICS STUDENT TEACHERS' ATTITUDES TOWARDS PROBLEM SOLVING: EFFECTS OF GENDER, ACHIEVEMENT, AND GRADE LEVEL. BALKAN PHYSICS LETTERS, 15 (1), 151078.
- Gök, T. & Sılay, İ. (2008). Fizik eğitiminde işbirlikli öğrenme gruplarında problem çözme stratejileri öğretiminin problem çözmeye yönelik tutum üzerindeki etkileri, *Journal of Theory and Practice in Education*, 4 (2), 253-266.
- Higgins, K. M. (1997). The effect of year-long instruction in mathematical problem solving on middle-school students' attitudes, beliefs, and abilities. *Journal of Experimental Education*, 66 (1).
- Jonassen, D.H. (2000). Toward a design theory of problem solving. *Educational Technology: Research & Development*, 48(4), 63-85.
- Marx, J. & Cummings, K. (2007). What factors really influence shifts in students' attitudes and expectations in an introductory physics course?. AIP Conference Proceedings, CP883, 101-104.
- Nuhoğlu, H. & Yalçın, N. (2004). Fizik laboratuvarına yönelik bir tutum ölçeğinin geliştirilmesi ve öğretmen adaylarının fizik laboratuvarına yönelik tutumlarının değerlendirilmesi. *Kuşehir Eğitim Fakültesi Dergisi*, 5 (2).
- Selçuk, G. S. (2004). "Strateji öğretiminin fizik başarısı, tutum, başarı güdüsü üzerindeki etkileri ve strateji kullanımı", Ph.D. Thesis, Dokuz Eylül University the Institute of Educational Sciences.
- Selçuk, G. S., Çalışkan, S. & Erol, M. (2008). Physics self-efficacy beliefs of student teachers: The relationships with gender and achievement perception, *Balkan Physics Letters (Special Issue)*, 648-651.
- Shaw, K. A. (2004). The development of a physics self-efficacy instrument for use in the introductory classroom, *AIP Conference Proceedings*, 720 (1), 137-140.
- Toluk, Z. & Olkun, S. (2002). Türkiye'de matematik eğitiminde problem çözme: ilköğretim 1.-5. sınıflar matematik ders kitapları. *Kuram ve Uygulamada Eğitim Bilimleri*, 2 (2), 567-581.
- Whitaker, D. R. (1982). Mathematical problem solving performance as related to student and teacher attitudes. *School Science and Mathematics*, 82 (3), 217-224.
- Woolfolk, A. E. (1993). *Educational psychology (5th ed.)*. Boston: Allyn & Bacon.
- Zhu, Z., (2007). Learning content, physics self-efficacy, and female students' physics course taking, *International Education Journal*, 8 (2), 204-212.

# A COMPARATIVE STUDY ON UNIVERSITY STUDENTS' ATTITUDES TOWARD A CONTROVERSIAL ISSUE: BIOTECHNOLOGY

Mehmet Erdogan  
Akdeniz University

Murat Ozel  
Gazi University

Saouma BouJaoude  
American University of Beirut

Pavol Prokop  
Trnava University

Muhammet Usak  
Dumlupınar University

Vincentas Lamanauskas  
Siauliai University

William Toli  
Masinde Muliro University of Science and Technology

## Abstract

*The purpose of the study was to investigate university students' attitudes toward the various applications of biotechnology in five countries. 150 Kenyan students, 80 Lebanese students, 283 Lithuanian students, 209 Slovakian students and 190 Turkish students voluntarily participated in the study. The cross-cultural data was gathered through the use of Biotechnology Attitude Questionnaire (BAQ) including 28 items on a five point Likert scale. The results revealed that students' attitudes differed by country, gender and study area; however, not for all dimensions of BAQ. The degree of Kenyan university students' attitudes toward consuming and purchasing GM products was highest, but their concern of ethics in genetic modification and their beliefs in the ecological impact of genetic engineering were observed to be relatively low. Male students seemed to be more accepting of consuming GM products of using of genetic engineering in human medicine but also stronger believers in the ecological impact of genetic engineering.*

## Introduction

Science educators have recognized the importance of scientific literacy in science education and emphasized that one of the essential elements of science education is scientific literacy (Goodrum, Hackling, & Rennie, 2001; Holbrook & Rannikmae, 2009). Depending on this emphasis, preparing scientifically literate citizenry is emphasized in many documents in the USA (American Association for the Advancement of Science [AAAS], 1993; National

Research Council [NRC], 1996) and worldwide (e.g. BouJaoude, 2002; Jenkins, 1990; Liu, 2009). Mainly, it concerns one's being "learned" or "knowledgeable" about the science content, and being able to critique scientific debates (Coll, Lay, & Taylor, 2008). One of the typical examples of these scientific debates is biotechnology representing a new and rapidly evolving area of scientifically and technological innovation (Sturgis, Cooper, & Fife-Schaw, 2005). With scientific and technological innovations, the impact of biotechnologies on peoples' everyday lives continuously increases and peoples begin to face with products genetically modified products in their daily lives. Despite positive effects of those innovations, several people are concerned about the ethical issue and level of acceptable risk of biotechnology applications (Bailey & Lappé, 2002). However, research is scarce on peoples' thinking about and acceptance of various applications of biotechnology in daily life. Research on students' attitudes toward biotechnology and its applications in many countries such as Australia, Brazil, Germany, Slovakian, Spain, United Kingdom and Turkey was mainly conducted with high school students (i.e. Chen & Raffan, 1999; Dawson & Schibeci, 2003; Gunter, Kinderlerer, & Beyleveld, 1998; Klop & Severiens, 2007; Lock & Miles, 1993; Massarani & Moreira, 2005; Özel, Erdogan, Uşak, & Prokop, 2009; Saez, Niño, & Carretero, 2008). We need research on university students' attitudes toward various applications of biotechnology in order to serve broader perspective on to what degree biotechnology applications accepted by different groups (i.e. rejection and/or acceptance GM foods, genetic engineering) This aspect of research will provide science educators and policy makers with valuable information about the thinking and positions regarding these applications prevalent among university students who are the engineers, scientists, teachers, and policy makers of future. Moreover, since the controversy regarding applications of biotechnology is a global issue, including participants from different countries provides a wider international view about acceptance of biotechnology in various cultures, contexts and educational settings especially that the selected countries are diverse with regard to economic, social and educational traditions. This study thus aimed to investigate university students' attitudes toward various applications of biotechnology in five countries.

## Literature Review

The topic of biotechnology is usually introduced in high school and university biology courses in many parts of the world, including Australia, Brazil, Germany, Slovakian, Spain, United Kingdom and Turkey. Most of these studies investigating students' attitudes toward biotechnology and its various applications have focused on the context of high school students. For example, Lock and Miles (1993) first investigated the views of 14- to 16-year-old students in the UK in order to determine their knowledge and attitude regarding biotechnology. They found that students had a broad approval of biotechnology and genetic engineering applied to plants and microbes but not to animals. Lock, Miles, and Hughes (1995) investigated 188 high school students' attitudes toward biotechnology and their findings demonstrated that there was general approval of using genetic engineering when dealing with plants and micro-organisms, but this approval diminished when animals and humans were involved. Another study in the UK was carried out by Gunter and Kinderlerer (1998) examined the understanding and opinion towards biotechnology of 48 teenagers, with regard to food production. Their findings showed that teenagers considered genetic engineering of plants to be more acceptable than genetic engineering of food crops and animals. Chen and Raffan (1999), in a study comparing attitudes of high school students in Taiwan and the UK, reported that students were in favor of genetic engineering applied to plants, but not to animals, and that participants did not approve of animal gene transfers into plants. Dawson and Schibeci (2003), in Western Australian, investigated the attitudes of 1116 15-16 years-old high school students toward biotechnology processes. Their results showed that students held a wide range of beliefs about the acceptable use of biotechnology, and also a majority of students (90%) approved of the use of micro-organisms for specific gene technology processes. However, their acceptance of the use of organisms in biotechnology decreased from 71–82% for plants to 42-45% for humans and to 34–40% for animals. Similarly, Cavanagh, Hood and Wilkinson (2005) reported that a significant proportion of the students were concerned about the use and/or safety of biotechnology. In Brazil, Massarani & Moreira (2005) investigated high school students' attitudes toward modern genetics and biotechnology. The researchers reported that most of the students thought that some applications originating from genetics were useful and should be encouraged, but their support varied, depending on the specific application considered. Klop and Severiens (2007) investigated the



attitudes of Dutch secondary school students upward the modern biotechnology and found that participants' attitudes ascribed to four groups of attitudes toward biotechnology. These four groups were labeled as "confident supporter" (22%), "not sure" (42%), "concerned sceptic" (18%), and "not for me" (17%). Dawson (2007) carried out a study with 465 Western Australian high school students whose ages ranged from 12 to 17 on their understanding and attitudes toward biotechnology processes. Results showed that a majority of students approved of the use of biotechnology processes involving microorganisms, plants and humans; but, disapproved of the use of animals in biotechnology. She also reported that while most students approved of prenatal genetic testing for genetic diseases and the cloning of endangered species, they disapproved of human cloning. In a recent study, Saez et al. (2008) investigated first-year secondary school biology students' views of biotechnology in Spain. They reported students' supports to biotechnology applications for living organisms according to the degree of kinship with humans. Usefulness in students mind is one of the values considered best when supporting to the biotechnology applications, with a certain ambiguity when distinguishing between process and product. In the other study, Kidman (2009) aimed to describe Australian students' attitudes toward biotechnology. His results revealed that students have positive attitudes toward studying biotechnology issues. More recently, Özel, Erdogan, Usak, and Prokop (2009) investigated high school students' knowledge and attitudes regarding biotechnology and its various applications in Turkey. Their findings showed that students' attitudes toward various applications of biotechnology were moderate level but their attitudes toward genetic modification in animals and public awareness of genetically modified organisms were rather negative. As note in results of abovementioned research, in brief, results of those have summarized that students' attitudes vary depending on various applications of biotechnology.

The rest of research studies which investigated students' attitudes toward biotechnology and its applications focused on the sample of pre-service teachers. For instance, Prokop, Leskova, Kubiato, and Diran (2007) conducted a study among Slovakian university students on students' knowledge and attitudes toward modern biotechnology. Their findings indicated that generally the most negative attitudes were found in items related to control of genetic engineering, which probably resulted in reluctance against shopping of genetic modification (GM) products. A recent study by Lamanauskas and Makarskaite-Petkeviciene (2008) that assessed Lithuanian university students' attitudes toward biotechnology showed that their students frequently contradicted one another applications of biotechnology. Recently, Usak, Erdogan, Prokop and Ozel (2009) who assessed Turkish high school and university students' knowledge and attitudes toward biotechnology reported university students' more positive attitudes toward biotechnology than high school students. Their results also indicated that although students' appreciation of (agricultural) biotechnology was relatively positive, attitudes toward shopping genetically modified products were therefore negative.

## **Rationale and Purposes of Study**

Even though applications of biotechnology have become more prominent, visible and controversial, the number of studies aiming to investigate public acceptance of these applications in every-day life is relatively very small. The fact that applications are controversial has prompted government agencies to develop regulations and policy regarding these applications. Investigating people's rejection and/or acceptance of GM foods, genetic engineering, and other applications of biotechnology will provide policy making with valuable information about citizen's thinking about and positions regarding these applications. Moreover, since the controversy regarding applications of biotechnology is a global issue, including participants from different countries will provide a wider international view about people's acceptance of biotechnology in various cultures and contexts. The main purpose of the study was to investigate university students' attitudes toward the various applications of biotechnology. In addition, this research showed that subject area specialization, gender and age were three variables which contributed to the variation in students' attitudes toward biotechnology. In most cases, research showed that those who took biology and biotechnology classes were more likely to show favorable attitudes toward biotechnology (Lock et al., 1995; Hill, Stanisstreet, Boyes, & O'Sullivan, 1998; Chen & Raffan, 1999; Gunter et al., 1998). As far as the male-female difference was concerned, male students were found to have more positive attitudes toward

biotechnology applications than females (Lock & Miles, 1993; Lock et al., 1995; Prokop et al., 2007; Usak, Erdogan, Prokop, & Ozel, 2009). Finally, younger students had less favorable positions toward than older ones (Dawson, 2007; Gunter et al., 1998; Hill, Stannistreet, O’Sullivan, & Boyes, 1999). The following research questions were addressed in the study;

1. To what extent do university students accept various applications of biotechnology?
2. Does university students’ acceptance of biotechnology differ by country, gender and major (subject area studied)?

## Method

### *Participants*

A total number of 912 university students from five countries: Kenya (n=150), Lebanon (n=80), Lithuania (n=283), Slovakia (n=209) and Turkey (n=190), constituted the sample of the study. Table 1 presents a description of the sample by country, gender, major and grade level. Of the participants, 596 were female and 316 were male, while 502 students already took biology and biology related classes during their university education. These students were from biology and related majors. The remaining students (N=410) did not take biology classes during their university education and they were from humanities and social science majors. As shown in Table 1, because of the humanities department in the selected university in Lebanon was not volunteering to be a part of this study, no Lebanese students from humanities department were included in the study.

**Table 1. Demographics data of study participants (frequency)**

	Kenya (n=150)	Lebanon (n=80)	Lithuania (n=283)	Slovakia (n=209)	Turkey (n=190)	Total (n=912)
<i>Gender</i>						
Female	65	40	222	164	105	596
Male	85	40	61	45	85	316
<i>Grade</i>						
Freshmen	60	--	115	149	2	326
Sophomore	--	71	69	45	36	221
Junior	90	9	73	--	63	235
Senior	--	--	26	15	89	130
<i>Subject area</i>						
Major*	85	80	134	89	114	502
Non-major**	65	--	149	120	76	410

\* Biology and related science majors \*\* Humanities and social science majors

Science (i.e. biology, science education) and humanities (i.e. social sciences) departments in the selected universities were visited and invited by researcher in each country to participate in the study. Students’ voluntariness to participate in the study was set as the selection criteria.

*Instrument*

The Biotechnology Attitude Questionnaire (BAQ) developed by Erdogan, Ozel, Usak and Prokop (2009) was used to collect data in the study. The BAQ is a 28 item on a 5-Point Likert-type (strongly agree, agree, I do not know, disagree and strongly disagree) questionnaire. BAQ consists of 7 sub-scales that address various applications of biotechnology. More detailed information about factor names, number of items and reliability of each sub-scale in BAQ are presented in Table 2. Cronbach's alpha reliability of entire instrument was found .82. The BAQ includes both positive and negative items. The scores of the negative items in the questionnaire were reversed during coding. In Lebanon, Lithuania, and Kenya were used the English versions of the questionnaire. In Slovakian and Turkey, country specific language version of language of questionnaire (i.e. Slovakian in Slovakia and Turkish in Turkey) was translated by researcher in that country. Then translated version of questionnaire in those countries was independently translated by two researchers who were bilingual and had specific knowledge of biotechnology. These translated questionnaires were reviewed by a third researcher to identify differences between the translations. Furthermore, the Turkish items were back translated and were found to match the original items.

**Table 2. Number of items in each sub-scale and reliability of each sub-scale**

Sub-scales	Number of items	Reliability ( $\alpha$ )
Consumption of GM products	4	.80
GM in agro industry	5	.66
Public awareness of GMO	3	.56
Shopping of GM products	6	.79
Ethics of genetic modifications	3	.61
Ecological impact of genetic engineering	4	.61
Use of genetic engineering in human medicine	3	.62

*Data Collection and Analysis*

The questionnaire was administered by researcher in each country in the classroom environment as a part of their class time in spring semester of 2007-2008 academic year. For data input, a common excel file including five demographic items along with the Likert-type items was prepared and sent to the researchers in each country who entered the data collected in their own countries. Then, the five data sets were combined into one data set. Initially, data cleaning procedures were performed to examine possible outliers and missing data within the data set. Later, descriptive and inferential statistics were conducted for addressing to the research questions. For the first research question, the mean, frequency and percentage of each individual item in BAQ was computed. For the second research question, 2(gender) x 5(country) MANOVA and 2(major) X 5(country) MANOVA were conducted in order to examine both individual and interaction effects of each independent variable on university students' acceptance of various applications of biotechnology.

**Results**

Mean scores obtained from each sub-scale of the Biotechnology Attitude Questionnaire across country are given in Table 3. MANOVA outputs revealed that the main affects of *country* [Pillai's Trace = .333, F (28, 3596) = 11.672,  $p < .001$ , partial  $\eta^2 = .083$ ] and *gender* [Pillai's Trace = .062, F (7, 896) = 8.516,  $p < .001$ , partial  $\eta^2 = .062$ ] and interaction effect of *country-major* [Pillai's Trace = .059, F (21, 2697) = 2.584,  $p < .001$ ,  $\eta^2 = .020$ ] on students' overall attitudes toward the various applications of biotechnology were observed to be significant. Considering the individual scores for each country, Kenyan university students showed the highest degree for the acceptance of consuming GM products whereas those from Turkey showed the lowest degree of acceptance of consuming such products. Moreover, Lebanese and Kenyan university students' attitudes toward purchasing GM products were significantly higher than Lithuanian, Slovakian and Turkish students' attitudes. With regard to genetically modified

in agro industry, Lebanese and Turkish students' attitudes were significantly higher than other students' attitudes. Turkish and Kenyan students believed in the sufficiency of current governmental regulations to protect the public from risks associated with genetically engineering foods (GEFs). But, most of them believed that the public has not been sufficiently informed about risks associated with consuming GEFs. With regard to students attitudes toward ethics of genetic modifications and ecological impact of genetic engineering of biotechnology were found to be negative. Students thought that some applications of biotechnology were be able to cause negative effects on human and nature. Furthermore, attitudes regarding the use of genetic engineering in human were to be positive in all countries. From this result, it could be concluded that students support some applications of biotechnology if they have been seen a profit for human being and nature.

**Table 3. Total raw scores obtained from each sub-scale across country**

Dependent variables	Max./Min.	Lebanon	Lithuania	Slovakia	Turkey	Kenya
<i>Attitudes toward:</i>						
Consumption of GM products	0 – 20	11.69	9.28	10.78	8.83	12.73
GM in agro industry	0 – 25	19.43	17.38	16.92	19.20	19.12
Public awareness of GMO	0 – 15	8.5	8.70	8.31	8.72	8.75
Shopping for GM products	0 – 30	16.45	14.28	14.94	13.25	15.44
Ethics of genetic modifications	0 – 15	10.16	8.21	8.23	7.77	9.12
Ecological impact of genetic engineering	0 – 20	11.16	10.10	11.44	9.24	11.92
Use of genetic engineering in human medicine	0 – 15	12.23	10.36	10.81	10.82	10.42

Although male university students' acceptance of purchasing and consuming GM products was higher than that of females, they also seemed to be more concerned about the ethical issues related to biotechnology applications and the ecological impact of genetic engineering. Biology majors in Turkey and Kenya showed higher acceptance of consuming GM products. On the other hand, humanity and social studies major students in Lithuania showed higher acceptance of consuming and purchasing GM products. For those who took biology related classes, Lebanese students ( $M=16.45$ ) scored significantly higher than the four other groups of students. Furthermore, male students, and Lebanese and Kenyan students seemed to be more concerned with the ethical dimension of genetic modification. Kenyan and Slovakian students were more concerned about the ecological impact of genetic Engineering. Significant differences were observed between male and female students for only the Lithuanian sample in favor of males. Of the students who majored in science, Kenyan ( $M=11.87$ ), Lebanese ( $M=11.16$ ) and Slovakian ( $M=11.38$ ) students showed significantly higher attitudes than Turkish ( $M=9.71$ ) and Lithuanian ( $M=9.24$ ) ones. Of the students who majored in humanities or social sciences Kenyan ( $M=12.0$ ), Slovakian ( $M=11.00$ ) and Lithuanian ( $M=10.38$ ) students' attitudes were higher than Turkish ( $M=8.68$ ) students. Regarding

genetic engineering in human medicine, Lebanese and male students were more supportive in using genetic engineering in human medicine.

## Discussion

Analysis of the comparative data collected from the university students from Kenya, Lithuania, Lebanon, Slovakia and Turkey suggested different levels of acceptance of various applications of biotechnology. For example, Lebanese and Kenyan students' attitudes in relation to consumption of GM products showed positive views than students in the other countries. As parallel to this finding, Lebanese and Kenyan university students' attitudes toward purchasing GM products were significantly higher than Lithuanian, Slovakian and Turkish students' attitudes. It is worth noting that these differences could be most likely due to differences in curriculum and distribution of genetically engineered products in each country in different way and level; an interpretation that is supported by the fact that female students and those who major in the humanities in this study were especially unwilling to purchase and eat GMPs. With regard to the use of genetically modified in agro industry, Lebanese and Turkish students' attitudes were significantly higher than other students' attitudes. Moreover, most students in five countries supported the use of genetic engineering for therapy of genetically determined diseases. This suggested that students accepted the practice of biotechnology mostly in the area of medicine. The positions of the students in this study were similar to those of the adults in Pardo Midden and Miller (2002) and Gaskell et al. (2003), and students in Massarani and Moreira (2005). These studies, however, indicated that a minority of students who supported the use of genetic engineering for therapy of genetically determined diseases perceived the risks of this application of biotechnology. Furthermore, most of students believed that the public was not sufficiently informed about risks associated with consuming GEFs. Prokop et al. (2007) and Lamanauskas and Makarskaite-Petkeviciene (2008) also reported similar results. This might have resulted from a combination of low level of awareness of the biotechnology practices and distrust in governmental regulations and control of GEFs. It is interesting to note that students in the five countries did not have more positive views regarding use of genetic engineering in human medicine. This finding is inconsistent with the findings of other studies undertaken by Dawson and Soames (2006), Massarani and Moreira (2005), Pardo et al., (2002), and Sorgo and Ambrozic-Dolinsek (2009).

Significant differences were observed between male and female students. This finding is consistent with the findings of previous research (Lock & Miles, 1993; Lock et al., 1995; Prokop et al., 2007; Usak et al., 2009). Also between those who took biology and related classes and those who did not take such classes were observed significant differences. Similar results also reported in the other studies (Lock et al., 1995; Hill et al., 1998; Chen & Raffan, 1999; Gunter et al., 1998). Several reasons could explain these differences among the students' responses. The reasons behind the differences in students' acceptance of biotechnology applications might be attributed to cultural diversity, social orientation, differences in university curriculum, background information about biotechnology and male-female tendencies.

As a consequence, differences in curriculum, teaching approaches and sequences in each country might be important factors in whether students learn the intended attitudes about biotechnology. More research on these areas is urgently needed. In addition, understanding how individuals think about biotechnology and the beliefs and values that underlie this thinking requires the use of qualitative as well as quantitative research methodologies. Finally, there is a need to widen the scope of research to investigate how all citizens think about such an important and still controversial socio-scientific subject.

## References

- American Association for the Advancement of Science [AAAS] (1993). *Benchmarks for science literacy: A project 2061 report*. New York: Oxford University Press.
- Bailey, M. B., & Lappé, M. (2002). *Engineering the Farm: Ethical and Social Aspects of Agricultural Biotechnology*, Island Press: Washington.
- BouJaoude, S. (2002). Balance of scientific literacy themes in science curricula: the case of Lebanon. *International Journal of Science Education*, 24(2), 139-156.
- Cavanagh, H., Hood, J., & Wilkinson, J. (2005). Riverina high school students' views of biotechnology. *Electronic Journal of Biotechnology*, 8(2), 121-127.
- Chen, S. Y., & Raffan, J. (1999). Biotechnology: student's knowledge and attitudes in the UK and Taiwan. *Journal of Biological Education*, 34(1), 17-23.
- Coll, R.K, Lay, M.C., & Taylor, N. (2008). Scientists and scientific thinking: understanding scientific thinking through an investigation of scientists views about superstitions and religious beliefs. *Eurasia Journal of Mathematics, Science and Technology Education*, 4(3), 197-214.
- Dawson, V., & Schibeci, R. (2003). Western Australian high school students' attitudes towards biotechnology processes. *Journal of Biological Education*, 38(1), 7-12.
- Dawson, C., & Soames, C. (2006). The effect of biotechnology education on Australian high school students' understandings and attitudes about biotechnology processes. *Research in Science & Technological Education*, 24(2), 183-198.
- Dawson, V. (2007). An exploration of high school (12–17 year old) students' understandings of and attitudes towards biotechnology processes. *Research in Science Education*, 37(1), 59-73.
- Erdogan, M., Ozel, M., Usak, M., & Prokop, P. (2009). Development and validation of an instrument to measure university students' biotechnology attitude. *Journal of Science Education and Technology*, 18(3), 255-264.
- Gaskell, G., Allum, N., Bauer, M., Durant, J., Allansdottir, A., Bonfadelli, H., Boy, D., de Cheveigné, S., Fjaestad, B., Gutteling, J.M., Hampel, J., Jelsoe, E., Correia Jesuino, J., Kohring, M., Kronberger, N., Midden, C., Hviid Nielsen, T., Przystalski, A., Rusanen, T., Sakellaris, G., Torgersen, H., Twardowski, T. and Wagner, W. (2000). Biotechnology and the European Public. *Nature Biotechnology*, 18, 935-938.
- Goodrum D, Hackling M, & Rennie, L. (2001). *The status and quality of teaching and learning of science in Australian schools*. Research report. Training and Youth Affairs. Retrieved October 14, 2008, from Web site: <http://www.dest.gov.au/NR/rdonlyres/5DF3591EDA7C-4CBD-A96C-CE404B552EB4/1546/sciencereport.pdf>.
- Gunter, B., Kinderlerer, J., & Beyleveld, D. (1998). Teenagers and biotechnology: A survey of understanding and opinion in Britain. *Studies in Science Education*, 32, 81-112.
- Hill, R., Stanisstreet, M., Boyes, E., & O'Sullivan, H. (1998). Reactions to the new technology: Students' ideas about genetically engineered foodstuffs. *Research in Science & Technological Education*, 16(2), 203-216.
- Hill, R., Stannistreet, M., O'Sullivan, H., & Boyes, E. (1999). Genetic engineering of animals for medical research: Students' views. *School Science Review*, 80, 23-30.
- Holbrook, J., & Rannikmae, M. (2009). The meaning of scientific literacy. *International Journal of Environmental & Science Education*, 4(3), 275-288.
- Jenkins, E. W. (1990). Scientific literacy and school science education. *School Science Review*, 71(256), 43-51.
- Kidmam, G. (2009). Attitudes and interests towards biotechnology: The mismatch between students and teachers. *Eurasia Journal of Mathematics, Science & Technology Education*, 5(2), 135-143.
- Klop, T., & Severiens, S. (2007). An exploration of attitudes towards modern biotechnology: A study among Dutch secondary school students. *International Journal of Science Education*, 29(5), 663-679.
- Lamanauskas, V., & Makarskaite-Petkeviciene, R. (2008). Lithuanian university students' knowledge of biotechnology and their attitudes to the taught subject. *Eurasia Journal of Mathematics, Science & Technology Education*, 4(3), 269-277.

- Liu, L. (2009). Beyond science literacy: Science and the public. *International Journal of Environmental & Science Education*, 4(3), 301-311.
- Lock, R. & Miles, C. (1993). Biotechnology and genetic engineering: students' knowledge and Attitudes. *Journal of Biological Education*, 27(4), 267-272.
- Lock, R., Miles, C., & Hughes, S. (1995). The influence of teaching on knowledge and attitudes in biotechnology and genetic engineering contexts: implications for teaching controversial issues and the public understanding of science. *School Science Review*, 76, 47-59.
- Massarani, L., & Moreira, I. C. (2005). Attitudes towards genetics: a case study among Brazilian high school students. *Public Understanding of Science*, 14, 201-212.
- National Research Council (1996). *National science education standards*. Washington, DC: National Academy Press.
- Özel, M., Erdogan, M., Uşak, M., & Prokop, P. (2009). High school students' knowledge and attitudes regarding biotechnology applications. *Educational Sciences: Theory & Practise*, 9(1), 321-328.
- Pardo, R., Midden, C., & Miller, J. D. (2002). Attitudes toward biotechnology in the European Union. *Journal of Biotechnology*, 98(1), 9-24.
- Prokop, P., Lešková, A., Kubiátko, M., & Diran, C. (2007). Slovakian students' knowledge of and attitudes toward biotechnology. *International Journal of Science Education*, 29(7), 895-907.
- Sáez, M. J., Niño, A. G., & Carretero, A. (2008). Matching society values: Students' views of biotechnology. *International Journal of Science Education*, 30(2), 167-183.
- Šorgo, A., & Ambrožič-Dolinšek, J. (2009). The relationship among knowledge of, attitudes toward and acceptance of genetically modified organisms (GMOs) among Slovenian teachers. *Electronic Journal of Biotechnology*, 12(3), 1-13.
- Sturgis, P., Cooper, H., & Fife-Schaw, C. (2005). Attitudes to biotechnology: estimating the opinions of a better informed public. *New Genetics and Society*, 24(1), 34-58.
- Usak, M., Erdogan, M., Prokop, P., & Ozel, M. (2009). High school and university students' knowledge and attitudes regarding biotechnology: A Turkish experience. *Biochemistry and Molecular Biology Education*, 37(2), 123-130.





# MOTIVATION OF COLOMBIAN STUDENTS WORKING WITH A GERMAN COMPUTER-BASED LEARNING ENVIRONMENT

Antonio Rueda

University of Education Heidelberg

Manuela Welzel-Breuer

University of Education Heidelberg

## Abstract

*Within the discourse of sharing instructional information among countries, basic research on possibilities and effects of implementing a learning environment of a certain “nationality” in another country, is needed. In a previous study, a computer-based learning environment concerning optical phenomena was developed for its use in German science classes at secondary school. It achieved gender-equitable promotion of motivation of students (Schnirch 2006). Does this German learning environment also reach a promotion of motivation in another country and culture? Approaching the answer of this question, a study with 285 students, grade 8 and 9, of four schools near Medellín (Colombia) has been conducted. After working with the learning environment, the students were asked to fill in a standardized questionnaire, which assesses different factors of motivation within the frame of the Self-Determination Theory of Motivation (Deci & Ryan 1985). Statistical analysis features that students have been highly motivated. Looking at the results more deeply, the formulation of items produced bias on the results. Nevertheless, a linear model validates the questionnaire and highlighted the importance of the value of the learning environment for Colombian students. Furthermore, a lower mean of perceived autonomy of students seems to shift motivation into the terrain of internalization.*

## Introduction

In 2003 the University of Education Heidelberg initiated a project to develop and evaluate a gender-equitable, computer-based learning environment, ExploMultimedial, containing multimedia elements and real experiments (Schnirch 2006). The learning environment was dedicated to optical phenomena, linking light phenomena and vision, for the lower secondary school. After its development, ExploMultimedial was used by several school classes, wherein students' motivation was investigated. Results showed gender-equitable promotion of interest and motivation of students while working with the learning environment. Due to this success, the material was translated into other languages. Then, the major question of the cultural dependency of learning environments arose, particularly considering the fast development of ICT and the importance of its adequate adoption in science classes. Using, as far as possible, the same instruments as in the German study it should be determined whether the participating in the study Colombian students were motivated working with the topics of ExploMultimedial.

The general aim of the current investigation is the approach to the factors that define the culture-dependency of a learning environment. For it, ExploMultimedial was directly adopted in science classes in a foreign country maintaining as far as possible the same conditions as in the German study. Existing connections to Colombia led the investigation to this country. Firstly, the research on Colombian school conditions and educational system was initiated from the distance, in Germany. The delay concerning the communication with potential cooperating schools in Colombia induced to organize a first research stay in November 2007 in Medellín. In this first stay contact with science teachers of four schools near Medellín was established. Furthermore, observations, interviews

of teachers and a written survey for students on their interest in science classes were conducted. Moreover, the equipment of computer labs was tested for implementation of the learning environment and the study, where some partially dated PCs were detected. After that, again in Germany, only minor changes were introduced in ExploMultimedial according to the findings of this first stay. Then, before the second stay in February-March 2008, dates and conditions for the implementation of ExploMultimedial were appointed with the cooperating teachers. During the second research stay in Colombia, the data acquisition in the four participating schools took a total time of one month, one week per school, where a written survey on motivation was conducted and the work with a unit of the learning environment of one pair of students per class was videotaped. Back in Germany, the written survey on motivation while working with ExploMultimedial was analyzed firstly. The results are presented in this paper. Video analysis of the videotapes yielded an overview of the activities of students during their work with the recorded unit of the learning environment. These three introduced factors (motivation, activity and learning of students) together with school and culture conditions have already been and will be investigated also in the German data, giving an appreciation of the use of ExploMultimedial in two different countries. In this contribution just one factor, exclusively the results related to the quantitative analysis of a survey on motivation will be presented.

## Rationale

### Theoretical frame of ExploMultimedial

The development of ExploMultimedial was grounded in “consequent constructivist” principles (von Aufschnaiter 2001), results of empirical gender studies and research on motivation (Krapp & Ryan 2002). It integrates real experiments and is designed to enhance active work in pairs. The sub-themes are structured in task-based and action-oriented (Hense, Mandl & Gräsel 2001) learning cycles based on Educational Reconstruction (Duit et al. 2005), in which previous knowledge of students, teaching practices and learning outcomes are joined each learning cycle. The result is a computer-based multimedia learning environment containing three main themes about optics that link physics and biology, and aiming a gender-equitable promotion of motivation (Häußler et al. 1998).

### The Self-Determination Theory of Motivation

Deci and Ryan (1985) declare that every form of human motivation goes back to the endeavour to fulfil basic and innate needs. To those basic needs, belong autonomy, competence feedback, and relatedness. By internalizing extrinsic motivation through self-determined motivation one can reach intrinsic motivation. This process is called internalization and refers to people’s “taking in” a value or regulation. As people internalise regulations and assimilate to the self, they experience greater autonomy in action. The extrinsic motivation is thereby divided in four different levels (see Table 1) of regulation that defined the process of internalization of a given activity towards intrinsic motivated behaviours.

**Table 1. Forms of extrinsically motivated behavior (from Deci, Ryan & Williams 1996, p. 168)**

Type of regulation	Degree of Self-Regulation	Description
External	Very low	Behavior controlled by demands or contingencies external to the person.
Introjected	Moderately Low	Behavior controlled by demands or contingencies inside the person such as self-esteem contingencies
Identified	Moderately High	Behavior chosen because the person identifies with the importance of the activity
Integrated	Very High	Behavior experienced as “wholly free” because the regulation has been integrated with the person’s sense of self

From this background following research question emerges: To what extent is motivation of Colombian students enhanced while working with ExploMultimedial in science classes?

---

## Method

### Participants

The implementation started in February 2008. 4 schools close to the city of Medellín took part in the investigation. Teachers and school-management provided a statement of requirements of the classes (8<sup>th</sup>-9<sup>th</sup> grades) participating in the study. After introducing the learning environment to teachers during approximately two hours, the work with students started (9 classes, 3 hours per class), supported by the researcher: 1 session in computer laboratories, 1 session of presentations of outcomes by students themselves. In each class 1 pair of students was videotaped while actively working with *ExploMultimedial*. In all 9 classes also the final presentations were videotaped. After that, all students filled in a questionnaire related to interest and motivation while interacting with the learning environment. The 9 participating classes are divided in 3 classes in the mono-educative school of Copacabana and 2 classes in each of the other 3 co-educative schools. A total of  $n = 284$  students (206 girls and 78 boys) completely filled in the questionnaire.

### Procedure

The questionnaire used was divided in three parts, (a) questions about the general interest in science classes (6 items) and working with classmates (5 items); (b) questions related to further use in school classes and design of the learning environment (2 items) and open questions that gathered general impressions of students (2 items); (c) a multidimensional measurement device that has been developed and evaluated at the University of Rochester (McAuley et al. 1989) intending to assess participants' experience related to a target activity in laboratory experiments. This paper is focused on results of (b) and (c).

The multidimensional measurement device, called "Intrinsic Motivation Inventory" <sup>1</sup> (IMI), contains a variable number of items according to the requirements, and comprehends seven subscales that rest upon the Self-Determination Theory of motivation (SDT). These subscales are *interest/enjoyment*, *perceived competence*, *perceived choice*, *social relatedness*, *value/usefulness*, *pressure/tension*, and *effort/importance*. The subscale *interest/enjoyment* per se represents a measurement of intrinsic motivation. *Perceived competence*, *perceived choice* and *social relatedness* are positive predictors of intrinsic motivation, particularly, considering that they correspond to the basic needs after the SDT. The remaining three subscales (*value/usefulness*, *pressure/tension*, and *effort/importance*) reveal the statement within internalization process, which is constituted by a continuum that links external and integrated behaviours towards an activity. The combination of the contribution of these three last factors establishes a certain degree of internalization.

In the previous study in Germany the IMI-questionnaire was already adopted and contained 41 items using a 5.likert-scale (from "strongly agree" to "strongly disagree"). Therein, the factor loading was proven by means of reliability analysis. Subscales were reliable and could be fitted to normal distributions. The Spanish version of the questionnaire was translated from the German one. The comprehensibility of the items was checked by experts.

### Measures

Basic quantitative analysis of the 41 items of the questionnaires has been carried out, which can be seen in Table 1. In the 5.likert-scale all means are above the midpoint (3). The variables *interest/enjoyment*, *social relatedness* and *effort/importance* show a notable low level of reliability.

---

<sup>1</sup> [http://www.psych.rochester.edu/SDT/measures/IMI\\_description.php](http://www.psych.rochester.edu/SDT/measures/IMI_description.php)

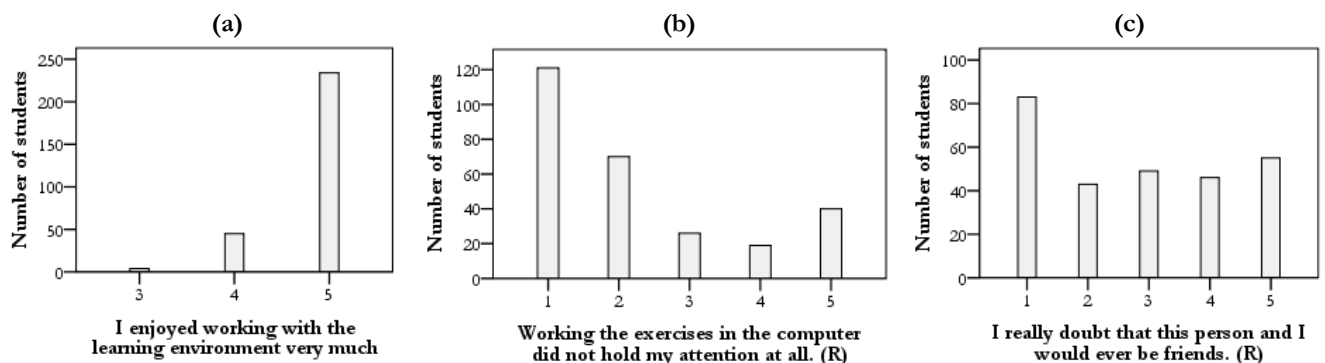
**Table 2. Initial properties of measurement instrument**

Subscale	#Items	$\alpha$	$M$	$SD$
Interest/enjoyment	7	.585	4.49	.42
Perceived competence	6	.628	4.36	.47
Perceived choice	7	.707	4.11	.69
Social relatedness	4	.263	4.17	.59
Value/usefulness	7	.734	4.69	.34
Pressure/tension	5	.633	1.94	.69
Effort/importance	5	.119	3,60	.55

Note. Descriptive analysis (n=284) and results of the reliability test (Cronbach's  $\alpha$ ) for the 7 subscales included in the questionnaire. Scales could range from 1 (strongly disagree) to 5 (strongly agree).

***In-depth analysis of subscales showing low reliability***

All items of the three problematic subscales have been separately analysed. At first glance, a remarkable difference between positive and negative worded items regarding their distribution has been detected. Figure 1 shows frequency diagrams of distributions of responses of (a) a positive worded item of the subscale *interest/enjoyment*; (b) a problematic item of the same subscale, which is negative worded; and (c) a negative worded item of the subscale *social relatedness*.



**Figure 1.** Frequency distributions of three items of the questionnaire (n=284); scales could range from 1 (strongly disagree) to 5 (strongly agree). (a) Common distribution of positive worded items – high skewness. (b) Negative worded item corresponding to subscale *interest/enjoyment* with aprox. 20% of negative responses. (c) Negative worded item corresponding to subscale *social relatedness* shows high deviation from normal distribution.

In Figure 1a can be appreciated that the distribution of the positive worded item presents high skewness, wherein a high number of students estimated the issue very positively. This trend is a common factor in all positive worded items of the translated IMI-questionnaire. In contrast, the agreement of students to the negative worded item of Figure 1b (almost 20%) is very high in comparison with the positive worded item (0%). This arisen fact and its consequences on the design of the questionnaire will be treated later on in more detail. Figure 1c shows an almost constant distribution of the responses to one item of the subscale *social relatedness*. The item is also negatively formulated, like Figure 1b, but here the whole spectrum of grades of agreement are more represented than in the other negative worded items. In the third problematic subscale, *effort/importance*, it emerged another kind of problem, namely a wrong translation of one item from German to Spanish. The deletion of these three items increases the values of alphas and means, what can be seen in Table 3.

Now, five of seven subscales pass over the value of .6 for Cronbach's alpha. This limit isn't high enough to presume good reliability within the subscales, but acceptable in psychological constructs (Kline 1999). Otherwise,

the alphas for *social relatedness* and *effort/important* don't reach the limit. Cortina (1993) demonstrated that reliability of subscales containing a small number of items show difficulties in achieving an acceptable value, due to the calculation formula.

**Table 3. Properties of measurement instrument. Correction of reliability**

Subscale	#Items	$\alpha$	<i>M</i>	<i>SD</i>
Interest/enjoyment	6/7	.621	4.61	.42
Perceived competence	6/6	.628	4.36	.47
Perceived choice	7/7	.707	4.11	.69
Social relatedness	3/4	.368	4.49	.56
Value/usefulness	7/7	.734	4.69	.34
Pressure/tension	5/5	.633	1.94	.69
Effort/importance	4/5	.419	4.00	.68

Looking for explanations for this outcome, it comes forward the wording of items, introduced before, that is, that distributions of negative worded items considerably differ from those of positive worded items. In order to examine these differences in the whole construct, factor analysis within each subscale has been conducted. It was not surprisingly to assert that the supposition of different trends in positive and negative worded items was confirmed. This actually is a known problem (Schmitt & Stults 1985) that however seems to be bigger since the responses to the positive worded items are very skewed to the positive extreme. Due to the fact that this difference affects further statistical analysis, a clearer examination of this issue will be presented in the next subsection.

Looking at further properties of the instrument, the means of *interest/enjoyment*, *social relatedness* and *effort/importance* also become higher when deleting problematic items. Therewith the value in all positive subscales achieves an overall agreement (mean > 4). The reversed scale *pressure/tension* also performed a positive average score, which is below the value of disagreement (mean < 2). The highest score corresponds to the variable *value/usefulness*, followed by *interest/enjoyment*, which feature the lower standard deviations, as well. These results represent at first glance a very high acceptance of the learning environment in the investigated school classes. The high mean of interest/enjoyment and value/usefulness lead to the statement, that students enjoyed the work with the learning environment, but that they find themselves within an internalization process. Normality of distributions has been checked by means of Kolmogorov-Smirnov-test. Results yield the inexistence of normal distribution in all subscales ( $p < .001$ ) due to the high skewness, i.e., the shift of responses to one extreme of the scales' range. In spite of that, means and standard deviations will be kept in the analysis, since they account for a better understanding of the results. Moreover, in case of correlations and estimation of differences non-parametric tests will be executed.

#### ***Positive versus negative worded items***

The problem of the difference of students' responses to differently worded items has been recognized during the reliability calculation of subscales and posterior factor analysis within them, which corroborated the hypothesis of discrepancy of distributions of those items. Schriesheim et al. (1991) described four types of item's wording: regular (R), e.g. "I am happy"; negated regular (NR), e.g. "I am not happy"; polar opposite (PO), e.g. "I am sad"; negated polar opposite (NPO), e.g. "I am not sad". He reported that correlations between regular and reverse coded negated regular are bigger than correlation between regular and reverse coded polar opposite. Regular and negated polar opposite correlated the lowest. After this categorization, the items of the complete translated IMI-questionnaire can be classified in: *interest/enjoyment*, 5R/1NR/1PO; *perceived competence*, 5R/1NR; *perceived choice*, 2R/3NR/2PO; *social relatedness*, 3R/1NR; *value/usefulness*, 7R; *pressure/tension*, 1R/1NPO/3PO; *effort/importance*, 3R/2NR. In this classification, it can be seen that subscales like *interest/enjoyment*, *perceived competence*, *value/usefulness* and *social relatedness* are predominantly positive worded. *Pressure/tension* just contains one regular worded item,

*effort/importance* is equilibrated after deleting one wrong translated regular item; and *perceived choice* contains mostly negative worded items. Exemplarily, three items of the subscale *interest/enjoyment* are presented in Table 4, at which mean, standard deviation and categorisation after Schriesheim (1991) are showed.

**Table 4. Descriptive statistics of one positive worded item and two kinds of negative worded items (n=284)**

Item	<i>M</i>	<i>SD</i>	Category
I would describe this task in the computer as very interesting.	4.68	.60	Regular
I thought the exercises on the computer were boring. (R)	4.25	1.16	Polar opposite
Working the exercises in the computer did not hold my attention at all. (R)	3.81	1.56	Negated regular

Table 4 evidences the differences, which are trend in the whole questionnaire. Contrariwise to Schriesheim (1991) the negated regular items correlate worse to the regular ones than the polar opposite. Apparently, students had more difficulties to show disagreement to negated regular items than to polar opposite items. The tendency in almost all subscales is that the higher the amount of regular items, the higher the means of subscales. Though, the rule is broken by *perceived competence*, whereas the mean is relatively low, considering that there is just one negated regular item. From this fact it can be concluded that students have sincerely responded the items, since they could vary from just answering the positive extreme of the scales, what differed in negative worded items. Due to this first diagnosis, the wording of subscales has to be kept in mind in the next analysis, since mainly positive worded subscales probably correlate better with those which are also positive. In order to know whether or not it is a cultural feature, these intermediary results have been compared to the results of the survey of the German study. Here the differences related to the wording were not as large as in the Colombian one are. A deeper look into the items shows that some negative worded German items have not been literally translated: Some negated regular items have been translated as polar opposite. This fact will hinder possible comparisons between both studies.

### ***Open question***

Students had the possibility to express with their own words what they liked and did not like during the work with the learning environment. The positive item (“I did like...”) has been answered by 233 of 284 students. In some of the utterances students wrote some reasons. These utterances have been categorized finding a total of 386 positive mentions. The negative item (“I did not like...”) has been filled by 45 students, giving a total of 48 categorized responses.

## **Results**

In this section further statistical analysis, done by means of SPSS 16.0, of the part of the questionnaire analogue to the IMI, and category analysis of the open questions are presented. Within, correlations of subscales show a primary comparison map among the factors that affect motivation of students towards the learning environment. Then, a linear regression has been calculated, which tries to corroborate the assumption that the subscale *interest/enjoyment* alone represents a measure of the grade of intrinsic motivation and is supported by the rest of subscales. An acceptable model that predicts *interest/enjoyment* based on a linear combination of the other subscales would confirm the outcomes of the survey. In addition, considering that the amounts of students varied in gender and location of their school, its significance and effects of these differences between girls and boys and among schools are described for the leading subscales. Finally, a categorical analysis of the open questions and its connection to the IMI-results and the learning environment is pointed out.

Descriptive correlations between subscales

Table 5 shows the result of the Spearman’s non-parametric test, which yield correlations among subscales of the IMI questionnaire. All correlations are significant ( $p < .01$ ) and in some cases they reach high levels. Here is remarkable that *interest/enjoyment* highly correlates with *value/usefulness*. The co-variance of *effort/importance* and *pressure/tension* is higher when comparing them to *perceived choice*.

**Table 5. Correlation among subscales. Non-parametrical Spearman’s  $\rho$**

Subscales	1	2	3	4	5	6	7
1 Interest/enjoyment	1,000						
2 Perceived competence	.591**	1.000					
3 Perceived choice	.610**	.570**	1.000				
4 Value/usefulness	.658**	.542**	.413**	1.000			
5 Social relatedness	.487**	.373**	.314**	.484**	1,000		
6 Pressure/tension	-.521**	-.525**	-.636**	-.338**	-.380**	1.000	
7 Effort/importance	.493**	.425**	.561**	.360**	.269**	-.424**	1.000

Note. \*\* Correlation is significant at the .01 level (2-tailed). The higher correlation values of each subscale are highlighted in grey

In Table 5 is easy to recognize two patterns, (a) *interest/enjoyment* being supported by *value/usefulness*, *perceived competence* and *social relatedness*; and (b) *perceived choice* supported by *pressure/tension* and *effort/importance*. Moreover, *perceived choice* also highly correlates with *interest/enjoyment*.

Linear regression

A multiple linear combination of several variables trying to predict the principal dependent variable *interest/enjoyment* can provide a more global appreciation of the results. Table 6 shows the executed two-steps linear regression. In the first step, the combination of the three variables corresponding to the basic needs described in the SDT is presented. In the first and second columns the coefficients of the linear combination (B) and their standard error (SE B) are displayed. The third column corresponds to the standardized coefficients ( $\beta$ ).

**Table 6. Regression results examining interactions between *interest/enjoyment* and the other variables**

	B	SE B	$\beta$
Step 1			
Constant	1.596	.175	
Perceived competence	.301	.043	.341***
Perceived choice	.231	.029	.382***
Social relatedness	.168	.032	.224***
Step 2			
Constant	.756	.264	
Perceived competence	.135	.043	.153**
Perceived choice	.135	.032	.223***
Social relatedness	.077	.031	.103*
Value/usefulness	.461	.056	.376***
Pressure/tension	-.060	.030	-.099*
Effort/Importance	.078	.027	.128**

Note.  $R^2 = .557$  for Step 1;  $\square R^2 = .100$  for Step 2 ( $p < .001$ ). \* $p < .05$ , \*\* $p < .01$  and \*\*\* $p < .001$ .

The value of  $R^2$  for the first step is acceptable, but in the second step it increases by .100. That is to say that the model with all subscales as variables (second step) explains 66% of the variance of *interest/enjoyment*, what is a good result. The column of standardized coefficients shows that the contribution of *perceived choice* to the model is slightly bigger than the other variables, and that all are significant. The second step points out *value/usefulness* and

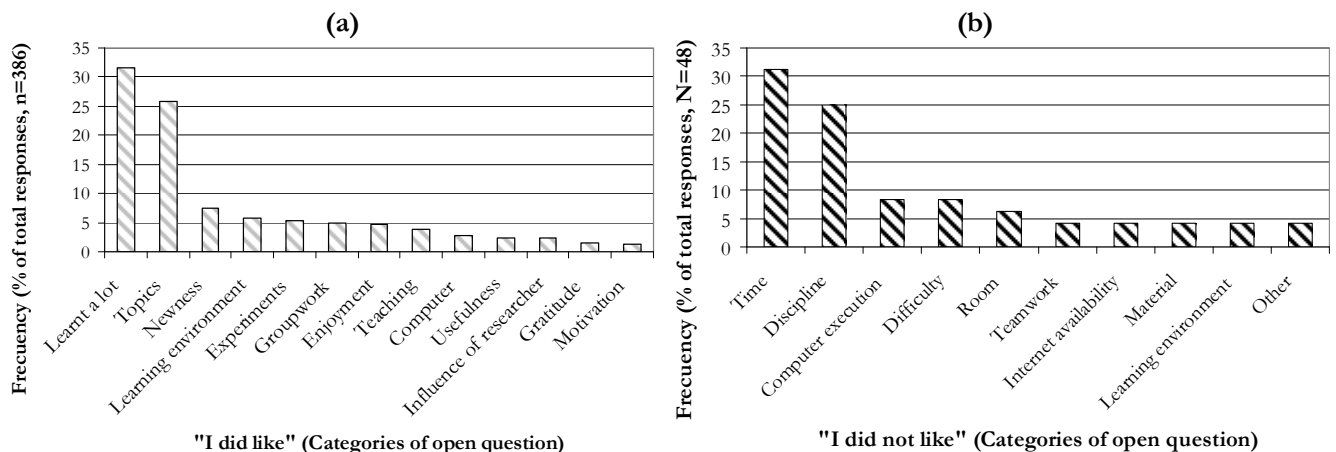
*perceived choice* as leading variables in the model. This result confirms the previously presented correlations between variables. Here, we see in addition, that although the wording of *interest/enjoyment* and *value/usefulness* differs from the wording of *perceived choice* (see section Method), value and perceived choice of students coexist predicting the level of interest and therewith their level of intrinsic motivation.

### Differences between girls and boys and among schools

Finalizing the part of analysis of IMI in this paper, a check of differences on gender (Mann-Whitney-test) and school conditions (Kruskal-Wallis-test) has been conducted. Differences concerning the interest and the value that the learning environment implied are not significant. Nevertheless, the strength of these tests' significances, i. e. the effect sizes, is small, what debilitates further conclusions based on these results.

### Open question

Students had the possibility of expressing what they personally liked (and did not like) during their work with the learning environment. Category analysis of the open questions was conducted and is presented in Figure 2.



**Figure 2. Categories (x-axis) vs. number of mentions (y-axis) founded in category analysis of the open questions. (a) "I did like...". (b) "I did not like..."**

On the one hand, in Figure 2a a general euphoric acceptance of the learning environment can be appreciated, due to the big amount of responses. The mentions partially reveal the reason for the skewness of the distributions and reflect the disciplined behavior observed during the implementation. 25% of students mentioned their interest in the topics treated, what supports the conceptual design of ExploMultimedial. 8% of students' mentions allude to the newness that it represented. Concrete elements of the learning environment and the learning environment itself do not get high scores, staying around 5% of the mentions. Although, only slightly more than 1 % of the students wrote down words of gratitude for the implementation in their class, this fact represents a keynote for the conclusions. On the other hand, the negative factors that students mentioned, shown in Figure 2b, are led by the lack of time and discipline. Apparently, they are not used to work within a less teacher-oriented setting, like this. The amount of negative responses represents little more than 10% of the positive mentions.

## Conclusions and Implications

In this paper, the repercussion of the wording of items on the investigated population has been demonstrated. A rather big difference between the mean of regular and negated regular items has been observed. This fact does not only depend on the peculiar distribution of responses of the negative worded items, but also on the highly skewed distributions of the positive worded items. Students showed a very unusual agreement with the positive worded items. Here the discipline observed in school classes shall be highlighted, wherefore students are accustomed to express acquiescence. Furthermore, they mentioned in the open item the newness of the learning



environment as third factor, they liked. Also gratitude to the researcher was emphatically named. Therewith, the objectivity of the measurement could be put into question. The videotapes show nonetheless that students seem to work naturally during the self-regulated phase (1 hour). The implementation was even so constituted by a presentation of results by the students, in which the researcher did take part, correcting some conceptual errors of the students. Hence, the deviation of normality in positive worded items could be explained on the one side by students' discipline, politeness and gratefulness, and, by the positive influence of the researcher on students' motivation. Then, concerning the negative worded item, two possible explanations emerge for the relatively undecided responses to them: (a) That students did not understand the questions; (b) that they are not used to express contrariness. These hypotheses need to be proven. Such an outcome has been obtained neither in the German study (Schnirch 2006), nor in other studies (McAuley et al. 1989, Tsigilis et al. 2003), in which acceptable reliability levels within subscales were yielded. Though, a direct comparison is not possible, since some items were not literally translated. In conclusion, reliability of subscales in the part of the questionnaire analogue to the Intrinsic Motivation Inventory could be affected by the wording of items, the newness and the presence of the researcher. That is why, in future research items have to be revised, and more time for data acquisition has to be planned, so that local teachers themselves adopt the learning environment. This last issue will be also remarked later on.

The high mean of *interest/enjoyment*, considering that this subscale alone was defined as measurement of intrinsic motivation, should state that students found the work with ExploMultimedial to be inherently interesting and enjoyable. A deeper view into the results infers that the high rate of *value/usefulness* of the learning environment and its correlation to *interest/enjoyment* seems to place students' motivation along the internalization process, i.e. between extrinsic and intrinsic motivation at the region of identified regulation. The variable *value/usefulness* also leads a statistical linear model that predicts with 66% of variance the variable *interest/enjoyment*. In other words, students enjoyed ExploMultimedial, felt confidence, and recognized the value of the learning environment but did not appreciate the concrete usefulness and importance for them, according to the low rate of *effort/importance* and little mentions in the open question. This fact can be due to an insufficient inclusion of the unit into the curriculum by teachers (Sierens, E. et al 2009). Thereby, and although students themselves declared the topics to be enjoyable, they did not realize the choice of attaining concrete goals that could be related to their science classes. In psychological terms, the students appreciated the task as important but not enough to be synthesized with other aspects of the self. The obtained high mean for *value/usefulness* is concordant with international surveys (Schreiner C. & Sjøberg S. 2007) on the value of science in school in developing countries in terms of interest. Moreover from the results of the open question it can be concluded that for students it seems to be very important to learn a lot (value), what is somehow represented through the ICT-based ExploMultimedial: new interesting topics taught by means of multimedia elements.

Also remarkable are the rather low means of *perceived choice*, *effort/importance* and *pressure/tension* and their respectively relationship, shown in analysis of covariance. Two hypotheses arise. Firstly, the partly out-dated equipment and less experimental material integrated in ExploMultimedial (that had to be brought from Germany) could decrease the perceived autonomy of students. Secondly, it has been observed during the stays in Colombia that the work in the visited classrooms is predominantly teacher-centered (introjected motivation), where obedience and discipline are common cultural features. This fact could explain that the learning environment supported more independence (Vansteenkiste, M. et al. 2005) than students are used to experience. This kind of newness could lead to anxiety and an associated pressure. It could undermine the individual interest and thwart the effort investment (Sheldon K.M. & Elliot A.J. 1998). The role of the teacher is therefore to introduce properly such a computer-based unit considering autonomy support of students (Chirkov, V. I. 2009).

The arguments exposed concerning the autonomy of students suggest the change of research focus from learning with ExploMultimedial to teaching with ExploMultimedial, moving from the product "learning environment" itself to the investigation of its use by native teachers. Oliveira et al. (2008) have also highlighted the process of adaptation of instruction material in their investigation. This way, the research project would also

enhance the sustainability of the use of the learning environment and the internalization of its background by teachers.

## References

- Chirkov, V. I. (2009). A cross-cultural analysis of autonomy in education: A self-determination theory perspective. *Theory and Research in Education*, 7, (pp. 253-262).
- Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behaviour*. New York: Plenum.
- Deci, E. L., & Ryan, R. M. (1996). Need satisfaction and the self-regulation of learning. *Learning and Individual Differences*, 8(3) (pp. 165-183).
- Duit, R., Gropengießer, H., & Kattmann U. (2005). Towards science education research that is relevant for improving practice: The model of educational reconstruction. in H.E. Fischer (ed), *Developing standards in research of science education* (pp. 1-9). London: Taylor & Francis.
- Häubler, P. & Hoffmann, L. (1998). Chancengleichheit für Mädchen im Physikunterricht – Ergebnisse eines erweiterten BLK-Modellversuchs. *Zeitschrift für Didaktik der Naturwissenschaften*, 4(1). (pp. 51-67).
- Hense, J., Mandl, H., Gräsel, C. (2001). Problemorientiertes Lernen. Warum der Unterricht mit neuen Medien mehr sein muss als Unterrichten mit neuen Medien. *Computer und Unterricht*, 44 (pp. 6-11).
- Krapp, A. & Ryan, R. M. (2002). Selbstwirksamkeit und Lernmotivation: Eine kritische Betrachtung der Theorie von Bandura aus der Sicht der Selbstbestimmungstheorie und Motivationsprozesse in Bildungsinstitutionen. *Zeitschrift für Pädagogik*, 44(54). Beiheft (pp. 54-82).
- Kline, P. (1999). *The Handbook of psychological testing* (2nd edition). London: Routledge.
- McAuley, E., Duncan, T., & Tammen, V. V. (1989). Psychometric properties of the Intrinsic Motivation Inventory in a competitive sport setting: A confirmatory factor analysis. *Research Quarterly for Exercise and Sport*, 60, (pp. 48-58).
- Oliveira, A. W., Colak H., & Akerson, V. A. (2008). “Who polluted the Potomac?” The translation and implementation of a US environmental story in Brazilian and Turkish classrooms. *Cultural Studies of Science Education*. 4(1) (pp. 89-132).
- Schnirch, A. (2006). *Gendergerechte Interessen- und Motivationsförderung im Kontext naturwissenschaftlicher Grundbildung. Konzeption, Entwicklung und Evaluation einer multimedial unterstützten Lernumgebung*. Heidelberg: Studien zum Physik- und Chemielernen, 54, Logos.
- Schreiner C. & Sjøberg S. (2007). Science education and youth's identity construction – two incompatible projects? In D. Corrigan, Dillon, J. & Gunstone, R. (Eds.), *The Re-emergence of Values in the Science Curriculum*. Sense Publishers: Rotterdam
- Schriesheim, C. A., Eisenbach, R. J., & Hill K. D. (1991) The Effect of Negation and Polar Opposite Item Reversals on Questionnaire Reliability and Validity: An Experimental Investigation. *Educational and Psychological Measurement*, 51 (pp. 67-78).
- Sheldon, K.M. & Elliot, A.J. (1998). Not all personal goals are personal: Comparing autonomous and controlling goals on effort and attainment. *Personality and Social Psychology Bulletin*, 24, 546-557.
- Sierens, E. et al (2009). The synergistic relationship of perceived autonomy support and structure in the prediction of self-regulated learning. *British Journal of Educational Psychology*, 79, 57-68.
- Tsigilis, N., & Theodosiou, A. (2003). Temporal stability of the Intrinsic Motivation Inventory. *Perceptual and Motor Skills*, 97, (pp. 271-280).
- Vansteenkiste, M., Zhou, M., Lens, W., & Soenens, B. (2005). Experiences of autonomy and control among chinese learners: Vitalizing or immobilizing?. *Journal of Educational Psychology*, 97, 468-483.
- Von Aufschnaiter, S. (2001). Wissensentwicklung und Lernen am Beispiel Physikunterricht. In J. Meixner and K. Müller (eds.), *Konstruktivistische Schulpraxis. Beispiele für den Unterricht* (pp. 249–271). Luchterhand, Neuwied: Kriftel.

## APPLICATION OF COMPUTER AIDED LEARNING ENVIRONMENTS IN SCHOOLS OF SIX EUROPEAN COUNTRIES

Manuela Welzel-Breuer  
University of Education Heidelberg

Sönke Graf  
University of Education Heidelberg

Eric Sanchez  
INRP

Valérie Fontanieu  
INRP

Helga Stadler  
University of Vienna

ZhelyazkaRaykova  
Plovdiv University

Roger Erb  
University of Education Schwaebisch Gmuend

Jari Lavonen  
Helsinki University

George Ioannidis  
Patras University

### Abstract

*The purpose of the EU funded project “the effective use of Computer Aided Teaching and learning materials in science teaching” is to create a teacher training course for science teachers that allows teachers to get acquainted with the latest research results in this field. Teachers who decide to take part in the course will get to choose between several modules available for them.*

*This paper describes the development and implementation of a questionnaire based survey, that aimed at finding out the*

- 1. Actual practice of working with CAT materials in schools,*
- 2. Teachers' needs concerning the use of CAT materials in science lessons,*
- 3. Experience with the use of CAT materials and with training courses,*
- 4. Infrastructural Conditions at schools in different European countries,*
- 5. Personal opinions towards use of CAT in class*
- 6. General Information on teachers and on schools*

*The survey had been consciously implemented before the project consortium decided on the specific course contents. A method specifically developed for this purpose, and also described in this paper, was implemented to use the survey's results as an additional means of reflection. This paper will also give an insight at selected results of this survey and discuss their probable consequences for the design of the teacher training course.*

## **Introduction**

Over the past years a tremendous development of the use of ICT (Information and Communication Technology) in everyday life has been observed. What is less well known is how this development affected the teaching and learning in European schools. An OECD survey in 2004 (OECD, 2004) found out that the use of ICT in education in most countries concentrates on sporadic information retrieval from the Internet. Only a minority of teachers regularly uses standard tool applications – Computer Aided Teaching and Learning Materials (CAT). The reasons were “difficulties in integrating CAT into classroom instruction problems in allocating computer time for classes, and a lack of ICT skills and knowledge of teachers” (Lavonen et al. 2006a). In addition, the teachers lack the structural as well as infrastructural support in finding the most effective ways of implementing ICT in their science classes (Barton & Haydn 2006; Lavonen et al. 2006a, b). We checked whether we have the same situation 4 years later. The survey on the actual “local culture”, with regard to the application of CAT environments in the different participating countries, provides fundamental data for our future course.

The draft version of the questionnaire and the appropriate coding scheme had been developed in English language and discussed with all partners at a common project meeting. The resulting version had been translated into the local languages by each country and then distributed to at least 50 science teachers of each country. The data are analyzed statistically and qualitatively in order to gain insights in the spectrum of conditions, needs and actual practices. The results of the survey also prove invaluable to form practical suggestions for the teachers participating in the course on how to handle ICT or CAT in-class.

## **Rationale**

Creating a teacher training course cannot be regarded as a one-way street – from theory to practice. The success and failure also depends on many different and complex contextual conditions to be taken into account (Kirkman 2000; Lavonen et al. 2006 a, b). Besides communicating latest results and findings of international research to teachers and helping them to find means of implementation, an international teacher training course has to address as well the different needs, requirements, competences and also hardships of the teachers (McFarlane & Sakellariou 2002) as it has to align itself with the diverse cultural habits and the different actual practices of the teachers. Also the different infrastructural premises of schools have to be taken into account while designing an international teacher training course. Thus it is evident that a substantial amount of data is needed ex ante in order to be able to start designing a training course. The pace that goes about with the development in the Information Technology and software industry is impressively high. As a result of this, all systems including the school systems connected to this development have to be seen as being in a constant state of flux. It is clear, that the data needed for a teacher training course in ICT itself have to be up to date, and the results of the survey play a vital role in the design of an international training course, which aims to serve the needs and capabilities of many European countries.

## **Methods**

The survey was organized in the form of a questionnaire offered to at least 50 teachers of each of the participating countries. Before distribution, the basic version of the questionnaire and the appropriate coding scheme had been developed in English language by one partner and had been discussed with all partners at an international meeting. The basic version was developed based on previous similar surveys, like OECD (2004) survey. During the discussion sessions, intercultural differences of item interpretation, school conditions and applicability of the questionnaire had been negotiated. The thorough discussions at this meeting were vital in order to get a comparable and valid questionnaire version. Also at this meeting, the items had been translated into the five (six) different languages. This translation process again provoked intensive discussions about theoretical and

empirical concepts, experiences, and approaches the different partners brought into the project. The result was an intercultural negotiated questionnaire, strengthened through communicative validation.

In order to reach the target group effectively within the different countries a special dissemination strategy was developed: We offered the questionnaire both, in a Portable Document Format (PDF) offline version and in a web based online version to teachers of all six countries. According to Bortz & Döring by using electronic questionnaires as compared to paper based versions "...particular falsification in the answers through the use of computer aided questionnaires or testing instruments are not to be expected." (Bortz & Döring, 2006, p. 254)<sup>1</sup>. Opting for an internet based distribution system had been done for several reasons:

- A) The teachers visiting our course are suspected of having an affinity or at least a tolerance for New Media – and thus were estimated to be likely answering electronic questionnaires.
- B) The distribution of electronic questionnaires proves to be rather cost effective, compared to paper based questionnaires.
- C) Electronic questionnaires allow dynamic programming, only showing relevant questions to the end user and thus providing as well a more guiding as well as a more time saving approach for the end user.

The survey on the actual "local culture" with regards to the application of CAT environments in the different participating countries provides fundamental data for our future course. The data are analyzed statistically and qualitatively in order to gain insights in the spectrum of conditions, needs and actual practices. The results of the survey also prove invaluable to form practical suggestions for the teachers participating in the course on how to handle ICT in-class.

The data serving as basis for our course design

In order to ensure, that the questionnaire had been designed and translated correctly it underwent several cycles of communicative validation as well as testing before it was distributed to the teachers in all countries. The first draft was distributed to all members of the consortium before the project meeting in Patras, Greece. In Patras the draft was presented and explained in detail. The members discussed the draft and suggested changes, which then were implemented. Afterwards the questionnaire was released to the members of the consortium for translation from English into each mother tongue. The translation were then used, to build several localized webpages using the software [LimeSurvey](#)<sup>2</sup> and also to build dynamic Portable Document Format (PDF)<sup>3</sup> documents using the Software [Adobe Lifecycle Designer ES 8.2](#)<sup>4</sup>. The localized versions were then checked and tested by CAT members and associated teachers from the different participating countries. In a last session they were adapted before they were publically released.

The dissemination process itself was organized by each consortium partner and thus the samples themselves due to different dissemination strategies proved too heterogeneous to be compared directly.<sup>5</sup>

---

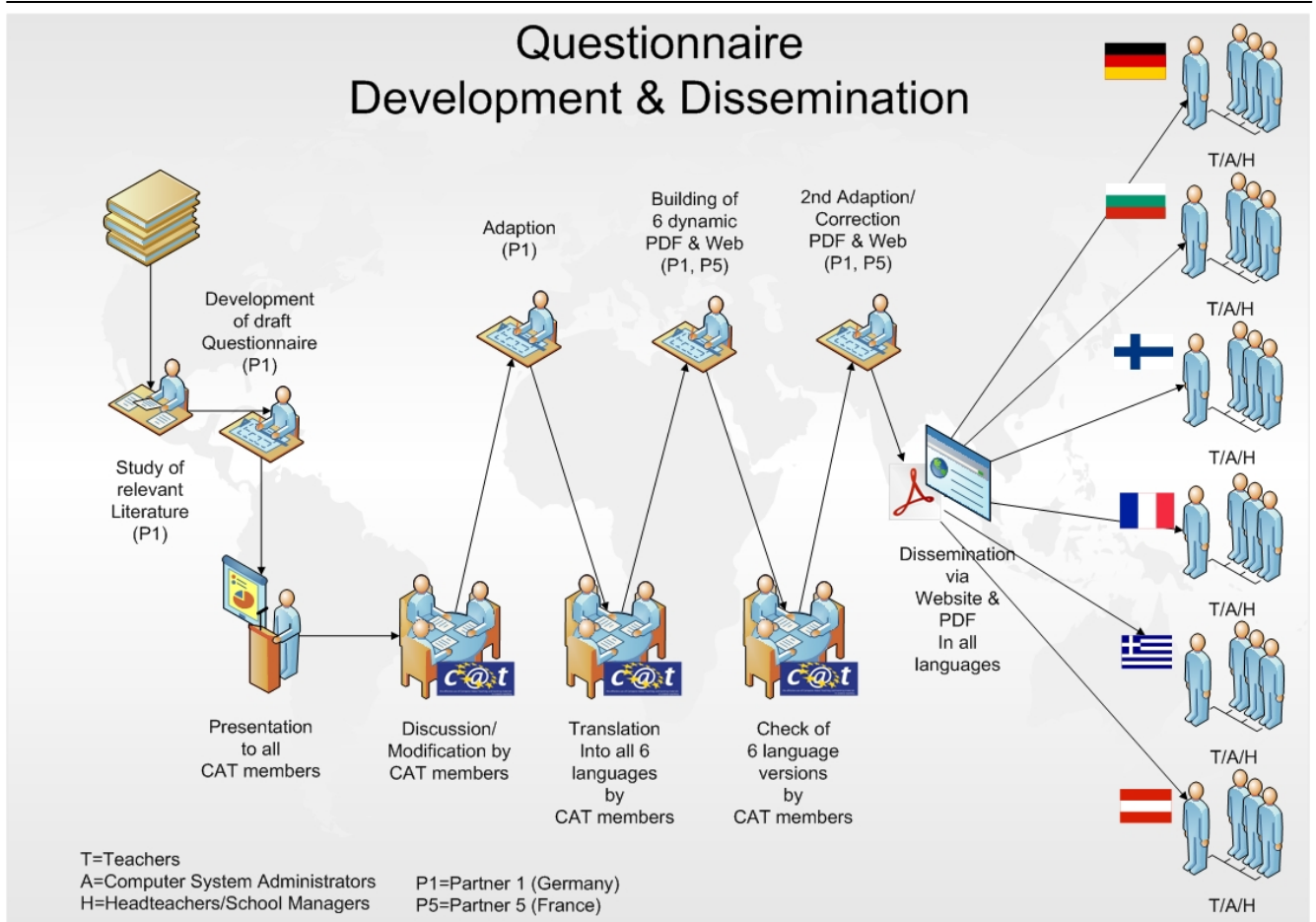
"Da mittlerweile sehr viele Menschen Erfahrungen im Umgang mit Computern sammeln konnten und zudem die Benutzerschnittstelle grafisch aufbereitet und sehr leicht bedienbar gestaltet werden kann, sind besondere Antwortverzerrungen durch eine computergestützte Fragebogen- oder Testadministration nicht zu befürchten." (Bortz & Döring, 2006, p. 254)

<sup>2</sup> <http://www.limesurvey.org/>

<sup>3</sup> The PDF questionnaires can be downloaded from: <http://cat.upatras.gr/research>

<sup>4</sup> [http://help.adobe.com/en\\_US/livecycle/8.2/lcdesigner\\_scripting\\_reference.pdf](http://help.adobe.com/en_US/livecycle/8.2/lcdesigner_scripting_reference.pdf)

<sup>5</sup> Our results are part of an extended brainstorming method developed to provide us with a spectrum of opinions serving as an element for reflection. The data were not intended for any other uses.

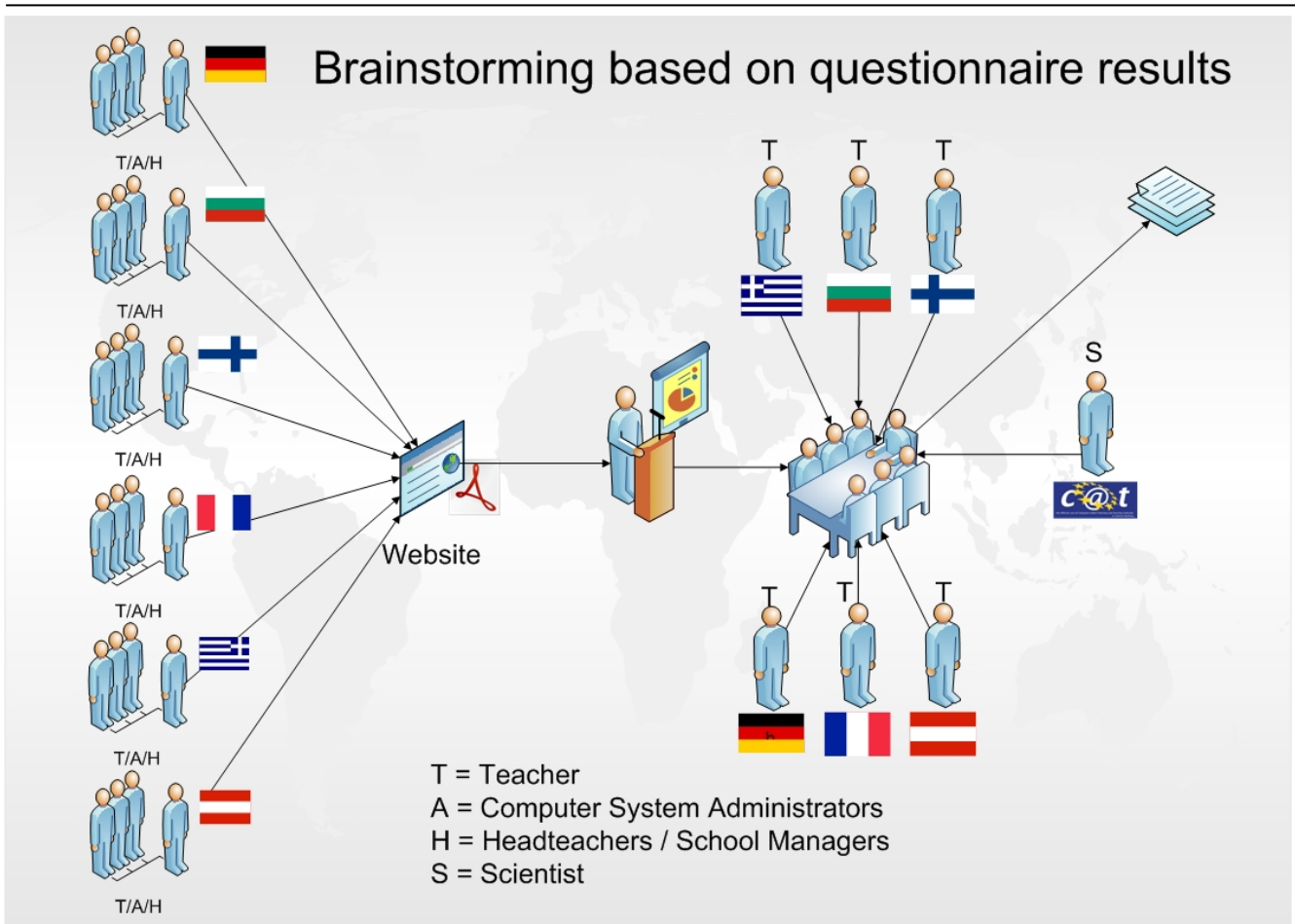


**Figure I Questionnaire Development and Dissemination**

Very important for the development was the revision provided by the teachers from the participating countries affiliated with our project. This cooperation combines the theoretical and empirical perspectives with the practical ones. Teachers thus have been actively involved in the survey construction, the survey application, and in the survey analyses. Taking into account their comments and suggestions we have the possibility of realizing a teacher training course which is closest to the needs of the European schools. As a summary, the construct and content validity of the questionnaire are high. This is because of the number of experts and target group teachers from all participating country participating in the iterative development process. The experts have published in the field and, consequently know the theories and concepts in the field.

A specific methodology which supports a transfer of theory into practice

After the first results had been collected and processed for presentation, they were presented at the 2<sup>nd</sup> project meeting in Plovdiv, Bulgaria to affiliated teachers as well as to the consortium's scientists for discussion and brainstorming. The teachers present gave their opinion concerning the correct interpretation of the data from the 854 teachers who answered our survey. By these means the consortium members received a sound standing view of the situation at the European schools in the participating countries.



**Figure 2 Brainstorming based on questionnaire results**

Acting the way described above, our results are not to be generalized yet, they apply specifically to the samples of the survey and they are gathered in order to serve as an element of reflection for the creation of our course. On the other hand the sample is presenting very much the potential teachers who could participate in the course. At least some ICT knowledge is needed by a teacher who will participate in a course concentrating on pedagogical issues of ICT use – not ICT itself. Therefore, it will be necessary to implement the survey results into our course design and then to evaluate the effectiveness of the training with respect to the aims stated above.

The question now is how we extracted results out of the answers to the questionnaire for the course design. For that again, we used a communication oriented approach of data analyses (see Figure II): All the qualitative data have been gathered within the different countries. The teachers answering to the questionnaire are members of the teacher training networks the scientists are working in. The answered questionnaires were sent anonymously to a web space offered by the French partner. The quantitative data were analyzed statistically by the French group. The qualitative data we got in six different languages, have been sent directly to our partners, were translated into English and sent to the German partner who was responsible for the survey. The German group undertook a first categorization and interpretation of the quantitative and qualitative data. During a meeting between the German and the French partner a first intercultural validation was realized. The results of this meeting were presented to the whole consortium and 3 teachers from each participating country (these teachers had answered the questionnaire, too). The discussion about the results and their interpretation lead us to useful hints concerning our future teacher training course.

## Results

### Quantitative Results

Our survey reached 887 people - 854 of them science teachers (96 %), 101 people were computer administrators (11%), 85 of them also science teachers. Our questionnaire was answered by 20 headteachers or schoolmanagers (2%). 2 people did not identify their position. As is observable from the data we mainly received answers from teachers (N=854). The nationalities were rather different in their returns:

Greek teachers	6%	n=55	(27 from primary schools)
German teachers	12%	n=103	
French teachers	59%	n=502	(due to centralized distribution)
Finish teachers	7%	n=60	
Bulgarian teachers	6%	n=55	(95% female)
Austrian teachers	9%	n=79	

Due to the heterogeneous samples our results are not to be generalized, they apply only to the samples of the survey. This however is in line with our strategy of using an input based on teaching practice for our course design.

We asked the teachers to give us an estimation of their Competences in using ICT by asking the following multiple choice question:

“I can use ICT...

- somehow myself but cannot guide my students to use it.”
- satisfactorily. I can guide my students to use a text processor, email.”
- well. In addition I can make webpages or use distance learning tools.”
- excellent. In addition to the previous levels I could help my colleagues.”

In our results we found that there were rather large differences between the sexes as there were large differences between the countries at least in the female population. Women in our samples estimate their self competence in ICT lower than men. Female teachers we asked in France, Germany or Greece rated their competences considerably lower than female teachers in the countries Austria, Bulgaria and Finland<sup>1</sup>. In Germany only 17,5% of the female sample population stated to be well or excellent amongst German men the same question was answered positively by 52,5%. In the French population 24 % of the females estimated themselves “well” or “excellent” while 57,7 % of the French men thought to be excellent. Compared to the Finnish results within our sample those percentages are astoundingly low. The Finnish sample showed a female population of 54,1 % answering the question with “well” or “excellent”, while the Finnish men had a 69,1% of teachers estimating themselves as being “well” or “excellent” in ICT matters.

In our results we also found evidence for a connection between the competence teachers feel and their use of ICT.

We also asked the teachers for a ranking of set items according to their preference for a course. To our surprise the ranking turned out to be pretty much alike over all participating countries:

1. Seeing best practice examples of implementation of computers inside the classroom

---

<sup>1</sup> It has to be stated, that these results are not representative and the samples are not comparable. However they help convey the possibility, that maybe (amongst women) very heterogeneous competence levels are to be expected.



2. Methods to effectively use the computer in class
3. Getting to know specific software and tools for implementation in class
4. Support for the choice of appropriate software for the use in science lessons
5. Learning how to use the computer for preparatory work outside the classroom

### Qualitative Results

In the following paragraph we present a few selected qualitative results. These results were obtained by means of categorization of the open answers given by some of the teachers. They concern the positive and encouraging aspects teachers realize (Figure 3), the negative or frustrating aspects while teaching with ICT (Figure 4), the teachers' ideas for a teacher training course (Figure 5), and the underrepresented aspects in courses the teachers attended (Figure 6).

The questions towards these results were the following:

**The experiences you have had with ICT in science classes so far are rather...**

1. "negative. Can you please jot down in a few words, why you think your experience has been negative so far?"
2. "frustrating. Can you please jot down in a few words, what about the use of ICT in science class has been especially frustrating for you?"
3. "positive. Can you please jot down in a few words, what have been positive moments that spring into your mind?"
4. "encouraging. Can you please jot down in a few words, what you remember as being especially encouraging?"

The questions for the categorizations in Figure 5 and 6 were the following

5. Here you can note down your own ideas of aspects you would like to see in a teacher training course:
6. Are there aspects YOU felt were underrepresented in your teacher training course. Can you briefly jot them down?

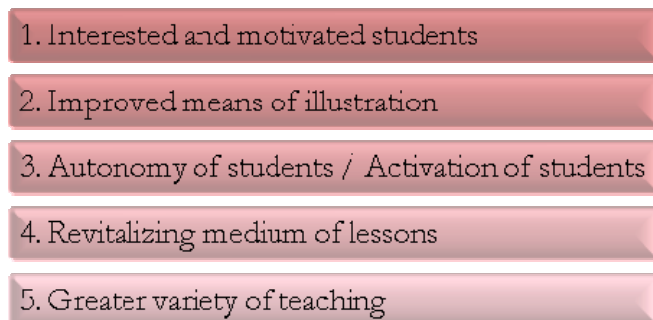


Figure 3. What has been regarded as positive or encouraged while teaching with ICT...?

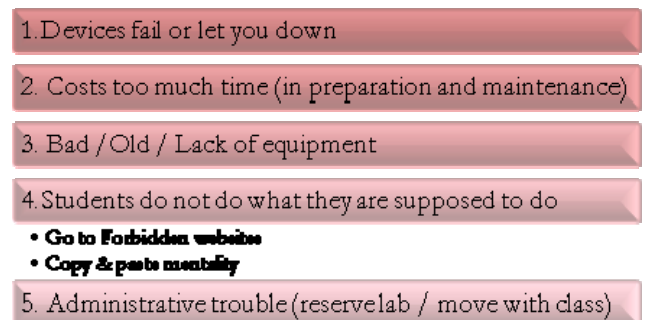


Figure 4. What has been negative or frustrating while teaching with ICT...?

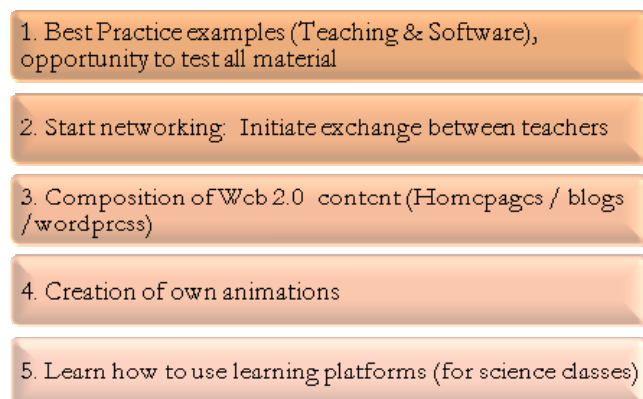


Figure 5. Teacher's ideas for a teacher training course



Figure 6. Underrepresented aspects in former courses attended by teachers

## **Conclusions and Implications**

### Quantitative results

Our data show that in general women in our samples estimated their self competence in ICT lower than men. That has to be taken into account, when organizing a training course and when offering materials. Three possibly coexisting factors could be the reason: lack of positive self reflection of women about their own technical competence, boast or overestimation of men, or a real difference in ICT competence between the sexes. The fact, that these results were repeatedly found in all countries for us is a strong indicator to pay special attention to the special needs of women and female students. The rather large differences that were found between the countries within the EU for us show the importance of combined actions, like collaborative teacher training courses allowing to learn from each other.

The ranking of predefined items gave us the incentive to check our course materials for their usability as both - closed as well as open questions in our questionnaire - show a strong preference for ready to use material that can be tested by teachers on site. Our course design will reflect that accordingly.

In our results we also found evidence for a connection between the competence teachers feel and their use of ICT. As a result our course needs to focus on confidence building as much as on competence building. In close collaboration with “our” partner teachers and our partners from the individual countries a look across the borders could help course participants to see concrete and new opportunities of ICT use in science classes, to adopt or develop new techniques themselves, to form partnerships, and to create virtual trading places for CAT environments. In addition to virtual and face-to-face collaboration, the teachers answering the survey appreciate contextuality in the training course. Therefore, we will offer “our” best practice examples from six different countries and at the same time we will give space and use open platforms to include more and better ones.

Finally we can state, that there is a connection between ICT competence and seeing the potential of ICT while using it for teaching and learning. The teacher training should try to increase ICT competence but also focus on directly showing the potential of ICT use in school. For that we will need a course design which organizes and guides a competence building process over a longer period of time. According to the teachers’ expectations, we will try to offer a course covering some months and reflecting upon the individual competence development. The idea of offering a module on action research methods fits perfectly to this approach.

### Qualitative Results

Looking at the results of the survey, we found teacher’s to be very interested in teacher training courses that reflect the real situations in school including problematic environments with malfunctioning hardware, network problems and missing software. There is a connection between the quality of hardware at school and the frequent use of ICT by teachers. The hardware situation in a school is an important and defining factor for teachers. The conditions show a wide variation between and within the different participating countries. The teachers in general feel not competent and confident enough to handle those situations on a hassling school day. If we could bring our teacher training course into schools, we could bring our expertise, ideas and knowledge into real life school conditions and at the same time grow more and more aware of the problems that teachers face every day, when working with CAT environments. Also this kind of teacher training setting allows for teachers to catch a glimpse of nearby schools that also are interested in the implementation of ICT within science lessons – this increases the chance of low-level networks and interschool partnerships.

### **Remark**

This project has been funded with support from the European Commission.

This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

### **References**

- Barton, R., & Haydn, T. (2006). Trainee teachers' view on what helps them to use information and communication technology effectively in their subject teaching. *Journal of Computer Assisted Learning*, S. 257-272.
- Bortz, J., & Döring, N. (2006). *Forschungsmethoden und Evaluation*. Ilmenau, Berlin: Springer.
- Kirkman, C. (2000). A model for the effective management of information and communication technology development in schools derived from six contrasting case studies. *Journal of Information Technology for Teacher Education*, 9, S. 37-52.
- Lavonen, J., Juuti, K., Aksela, M., & Meisalo, V. (2006a). A professional development project for improving the use of information and communication technologies in science teaching. *Technology, Pedagogy and Education* Vol. 15, No.2, pp. 159-174.
- Lavonen, J., Lattu, M., Juuti, K., & Meisalo, V. (2006b). Strategy-based development of teacher educators' ICT competence through a co-operative staff development project. *European Journal of Teacher Education*, 32(2), S. 221-232.
- McFarlane, A., & Sakellariou, S. (2002). The role of ICT in science education. *Cambridge Journal of Education* 32(2), S. 221-232.
- OECD. (2004). *Completing the foundation for lifelong learning: an OECD survey of upper secondary schools*. Paris: Studien Verlag.



## AN EXAMPLE SCIENCE EDUCATION ACTIVITY IN A MULTICULTURAL ENVIRONMENT

İsmail ÖNDER  
Sakarya University

Aysun Öztuna KAPLAN  
Sakarya University

Şenol BEŞOLUK  
Sakarya University

### Abstract

*In this study, an example activity developed in the workshops called “Science Education in Multicultural Environment” of the program “Integrative Teaching in Multicultural Environment” was presented. Workshops about varied subjects were carried out by participants representing four countries and participants developed teaching materials by getting benefit from elements special to their cultures in the ones related to science teaching. Two students from Belgium, 1 student from Denmark, 1 student from Latvia and 5 students from Turkey participated in the study and three Turkish academicians conducted the workshops. The outcomes of the study were evaluated by presenting them to all participants. The workshops were designed to help students learn instructional strategies and draw upon their prior learning experiences in order to apply effective multicultural education teaching activities. Emphasis is also placed on understanding the varied backgrounds and needs of students.*

### Introduction

Communication and transportation facilities increased and became easier, in addition to this factor, trade, business, education, immigration and war made the togetherness of people from different cultures indispensable. Because of this, many countries have started to live with the concept of multiculturalism. These multicultural environments created some special features. In addition to its negative effects and many difficulties, there are positive effects of multiculturalism on social life. Similar effects are also being observed in education process. Studies were conducted about curriculum development, teaching method, techniques and teaching materials in order to overcome the problems in the educational process of multicultural environments (Barton, 2000; Moore, 2006).

Multicultural education refers to equitable education for all students regardless of ethnic and cultural background, gender, race, color, religious affiliation or handicap, and implemented to enhance tolerance, respect, understanding, awareness and acceptance of self and others in the diversity of their cultures (Irwin, 1999).

Johnson et al. (2004) indicated that multicultural education is an educational approach that integrates four factors that encourage diversity and equality into a curriculum: the instruction of students from different backgrounds, the study of ethnic and other cultural groups, the development of critical thinking skills, and a focus on human relations. Therefore, the awareness of pre-service teachers on multicultural education should be increased and curriculum should be developed in this manner.

Pre-service teachers enter teacher education programs with beliefs based on experiences with diverse populations that have influenced their “ways of thinking about teaching learners who are diverse” (Milner & Smithey, 2003). However, pre-service teachers are often hesitant to participate in discussions about diversity, inequity, and stereotypes (Cochran-Smith, 2001; Horm, 2003). For pre-service teachers with little cross-cultural knowledge or experience, they often bring to their teacher education programs attitudes and beliefs that will negatively impact the diverse students they teach (Horm, 2003; Sleeter, 2001; Townsend, 2002). In order for teachers to be effective with diverse students, it is crucial that they first recognize and understand their own worldviews; only then will they be able to understand the worldviews of their students (Bennett, 1993). Researchers assert that in order for teachers to interact effectively with their students they must confront their own racism and biases (Banks, 1994; Gillette & Boyle-Baise, 1995; Nieto & Rolon, 1995), learn about their students' cultures, and perceive the world through diverse cultural lenses (Banks, 1994; Gillette & Boyle-Baise, 1995; Nieto & Rolon, 1995; Sleeter, 1992; Villegas, 1991).

The concept of diversity is a complicated issue that needs to be addressed in teaching, learning, and research. Science educators acknowledge that preparing teachers and working with teachers to teach science in urban schools for culturally, linguistically and ethnically diverse students are challenging tasks (Barton, 2001; Lee, 2003). Luykx et al. (2005) stated that challenges may involve teachers' “resistance” to teaching for diversity due to lack of knowledge or feelings of inadequacy or lack of preparation integrating nonmainstream students' languages and cultures into instruction. For pre-service teachers to understand the complexities of teaching science in urban schools, part of this means understanding their views of diversity, science, and teaching diverse learners. In other words, teachers are expected to have the knowledge and skills to relate to many cultures and understand student diversity. Therefore, the aim of this study was to answer the question “how can we develop a science educational activity which will change so-called multicultural problem into an advantage in a classroom consisting of the students from different countries”.

## Method

In this study action research methodology was used. The project was conducted in two weeks. There were several educational activities in the project; the activity that the science group followed was one of those activities. The science group worked on the topic for 16 hours. The researchers presented four topics related to multicultural science education to the science group students and they selected one from the following topics:

- How can an effective science education be designed by considering both intercultural interactions and developments in science and technology.
- How can we develop a science educational activity which will change so-called multicultural problem into an advantage in a classroom consisting of the students from different countries?
- Develop an activity which requires distance education and which will help students from different countries contribute each others' science education.
- Plan a project for students participated in IP program by considering our discussion topic when you go back to your countries.

The science group which was composed of pre-service teachers from different countries decided to work on the second topic presented above. Then, workshops had been carried out by the researchers and the students.

## Sample

The sample was composed of students enrolled in the project named “Integrative Teaching in Multicultural Environment” (<http://www.intimets.sakarya.edu.tr>) in the frame of ERASMUS program. The first stage of the project was conducted at Faculty of Education, Sakarya University in Turkey, 13th-24th October 2008. In the sample there were two pre-service teacher students from Belgium, one from Denmark, one from Latvia and five

from Turkey. The major of the students were primary education, physical education, special education, social science studies and computer and instructional technology.

### Workshops

Participants of the science group cooperated to work on the selected topic. Since the group itself was multicultural, participants used their own experiences in this process to investigate the advantages and disadvantages of teaching in multicultural environment. They designated advantages and disadvantages of multicultural environment as follows.

**Table1. Advantages and disadvantages of multicultural environment.**

Advantages	Disadvantages
<ul style="list-style-type: none"> <li>• may learn language from other countries</li> <li>• may learn the other cultures</li> <li>• may use the knowledge from other countries</li> <li>• may learn much more values</li> <li>• may break down the stereotypes</li> </ul>	<ul style="list-style-type: none"> <li>• may loose your own language</li> <li>• new stereotypes may formed</li> <li>• when there are a lot of people from other countries, the success of the class will go down</li> <li>• the unity of a city or country can not be keep save</li> </ul>

They discussed how these disadvantages can be changed into advantages. They proposed the followings:

- Respect the differences
- Interaction with other cultures
- Learn from each other, not about each other

By the help of these suggestions, they cooperated to develop science teaching materials. At the end of the project they prepared poster and a DNA model. In the poster, participants presented examples in which elements special to their cultures were used for science teaching. These examples are,

- Yogurt and pickle (can be used while teaching fermentation, special to Turkey)
- Toy block (can be used while teaching physics, special to Denmark)
- Chocolate ( can be used while teaching chemistry, special to Belgium)
- Latvian Cheese (can be used while teaching chemistry, special to Latvia)

After that, they developed DNA model. While developing the model participating students used candies that they brought from their countries. DNA is a double helix of two polynucleotide strands. Each nucleotide is composed of one of the four types of bases (Guanine, Cytosine, Adenine, Thymine), a deoxyribose sugar and a phosphate group. Each of DNA components was symbolized by using a character that belongs to one of the nations. For example:

- Since the word Turkey contains the letter “t” they have used Turkish delight to represent Thymine.
- Since the word Belgium contains the letter “g” they have used Belgium chocolate to represent Guanine.
- Since the word Latvia contains the letter “a” they have used Latvian candy to represent Adenine.
- Since the word Culture contains the letter “c” they have used a common candy to represent Cytosine.
- Since the word Denmark contains the letter “d” they have used Denmark candy to represent deoxyribose sugar.

At the end of the workshops students come to conclusion as: each DNA has a message, the message of our DNA model is “although the participants come from different cultures, have different ideas, different characteristics, they all can come together to work in harmony for the same aim”.

## **Conclusions and Implications**

Culture is the way we think, feel and behave as a society. We are born into a culture and through socialization processes we learn about our culture which ultimately represents our reality and our world view (Chinoy & Hewitt, 1975; Cruz-Janzen, 2000; Gollnick & Chinn 2002). Although it is extremely important that children learn about their culture, it is also important for them to learn that not everyone is the same. This is especially important for children who live in a community that is not racially, ethnically, or culturally diverse. Multicultural education is ideal in helping young children understand the lives of people who may look, dress, speak, think or eat differently from the way they do. Therefore, whether a classroom is monocultural or not, it is imperative that teachers provide multicultural materials and activities and allow students to be active participants in these activities. This helps to prepare young children to meet the diversity that is inevitable (Midobuche, 1999; Manning, 2000; Salmon & Akaran, 2001).

Young children enjoy learning about different people and each other. An integrated program that includes multicultural activities and materials will help young children understand that their world is larger than their community (Salmon & Akaran, 2001). In a classroom that is heterogeneous, children have the opportunity to experience, first hand, people who are different from themselves. However, it is different in a homogeneous classroom. In this type of classroom the teacher has to make a determined effort to help children understand differences as they relate to them and the people with whom they may come in contact. (Gayle-Evans, 2004).

Programs need to prepare teachers who can effectively instruct students of diverse backgrounds and cultures. A broader implication for teacher education programs is the need to prepare teachers who can teach all students to live and function in diverse communities and contribute to social prosperity at the national and global levels. The skills, attitudes and knowledge learned through multicultural education are important for all students. Teacher educators play an instrumental role in identifying and implementing appropriate strategies for realizing multicultural education objectives. To adequately perform their tasks, teacher educators must identify ways of assessing the effectiveness of the activities and programs they employ for actually promoting multicultural education aims (Pettus & Allain, 1999).

It is obvious that there would be many problems special to multicultural environment while teaching in such a medium (Moore, 2006). However, these problematic conditions also can supply new instruments for beneficial purposes, to enrich educational environment and for an alternative education. For example, one of the participating students from Denmark indicated that “the roofs in Denmark are steeper than the roofs in Turkey”. This can be a good example for teaching subjects related to pressure. That kind of examples can enrich teaching and learning process. In addition, the activities that are conducted in the workshops also increased the interaction and students had a chance to understand each other. The activities conducted became a good experience for students of realizing what would happen in a multicultural environment. They developed empathy of how their students can learn better and easily in multicultural environment. In other words, the conducted activities helped students imagine what constitutes multicultural science education in content and pedagogy, a difficult thing to do since there are relatively few examples of what this looks like for students to model (Barton, 2000). With the increase of interactions between cultures it is inevitable for both students and teachers to face with multicultural environments. Therefore, similar studies can contribute to the education of pre-service teachers for such circumstances.



---

## References

- Banks, J. (1994). *Multicultural education: Theory and practice*. Needham Heights, MA: Allyn and Bacon.
- Barton, A. C. (2000). Crafting multicultural science education with preservice teachers through service-learning. *Journal of Curriculum Studies*, 32(6), 797-821.
- Barton, A.C. (2001). Science education in urban settings: Seeking new ways of praxis through critical ethnography. *Journal of Research in Science Education*, 38(8), 899-917.
- Bennett, J. (1993). *Cultural marginality: Identity issues in training*. In M. Paige (Ed.), *Cross cultural orientation* (pp. 109-136). Lanham, MD: University Press of America.
- Chinoy, E., & Hewitt, J. (1975). *Sociological perspective*. New York: Random House.
- Cochran-Smith, M. (2001). Preparing teachers for culturally diverse schools: Research and the overwhelming presence of whiteness. *Journal of Teacher Education*, 52(2), 94-106.
- Cruz-Janzen, M. (2000). From our readers: Preparing pre-service teacher candidates for leadership in equity. *Equity & Excellence in Education*, 33(1).
- Gayle-Evans, G. (2004). It Is Never Too Soon: A Study of Kindergarten Teachers' Implementation of Multicultural Education in Florida's Classrooms. *The Professional Educator*, XXVI (2), 1-15.
- Gillette, M., & Boyle-Baise, M. (1995, April). *Multicultural education at the graduate level: Assisting teachers in developing multicultural perspectives*. Paper presented at the annual meeting of the American Education Research Association, San Francisco, CA.
- Gollnick, D., & Chinn, P. (2002). *Multicultural education in a pluralistic society (6th ed.)*. Upper Saddle River, NJ: Merrill/Prentice Hall.
- Horn, D. M., (2003). Preparing early childhood educators to work in diverse urban settings. *Teachers College Record*, 105(2), 226-244.
- INTIMETS Project (2008) <http://www.intimets.sakarya.edu.tr>
- Irwin, L. H. (1999). Do rural and urban elementary teachers differ in their attitudes toward multicultural education in elementary schools? *Contemporary Education*, 70 (3), 38-44.
- Johnson, J. A., Musial, D., Hall, G. E., Gollnick, D. M., & Dupuis, V. L. (2004). *Introduction to the foundations of American education*. Boston: Allyn & Bacon, Inc.
- Lee, O. (2003). Equity for culturally and linguistically diverse students in science education: A research agenda. *Teachers College Press*, 105, 465-489.
- Luykx, A., Cuevas, P., Lambert, J., & Lee, O. (2005). *Unpacking teachers' "resistance" to integrating students. language and culture into elementary science instruction*. In A.L. Rodriguez & R.S. Kitchen (Eds.), *Preparing mathematics and science teachers for diverse classrooms: Promising strategies for transformative pedagogy* (pp. 119-141). Mahwah, NJ: Lawrence Erlbaum.
- Manning, M. L. (Winter 2000). Understanding diversity, accepting others: Realities and directions. *Educational Horizons*, 77-79.
- Midobuche, E. (1999, April). Respect in the classroom: Reflections of a Mexican-American educator. *Educational Leadership*, 80-82.
- Milner, H. R., & Smithey, M. (2003). How teacher educators created a course curriculum to challenge and enhance preservice teachers' thinking and experience with diversity. *Teaching Education*, 14, 293-305.
- Moore, F. M. (2006). Multicultural pre service teachers' views of diversity and science teaching. *The Research and Practice in the Social Sciences*, 1, 98-131.
- Nieto, S., & Rolon, C. (1995, November). *The preparation and professional development of teachers: A perspective from two Latinas*. Paper presented at the invitational conference on Defining the Knowledge Base for Urban Teacher Education, Emory University, Atlanta, GA.
- Pettus, A. M., & Allain, V.A. (1999). Using a questionnaire to assess prospective teacher's attitudes toward multicultural education issues. *Education*, 119 (4), 651-657.
- Salmon, M., & Akaran, S. E. (2001). Enrich your kindergarten program with a cross-cultural connection. *Young Children*, 56(4), 30-32.

- Sleeter, C. E. (1992). *Keepers of the American dream: A study of staff development and multicultural education*. Washington, D. C: The Falmer Press.
- Sleeter, C. E. (2001). *Cultural difference and power: Multimedia CD-ROM*. New York: Teachers College Press.
- Townsend, B. L. (2002). Leave no teacher behind: A bold proposal for teacher education. *International Journal of Qualitative Studies in Education*, 15(6), 727-738.
- Villegas, A. M. (1991). *Culturally responsive pedagogy for the 1990s and beyond*. Trends and Issues Paper No. 6. Washington D. C. : ERIC Clearinghouse on Teacher Education.

# LATENT MASCULINITY IN SCHOOL PHYSICS INVESTIGATION ACTIVITIES: MICROANALYSIS OF SMALL GROUPS AND WHOLE CLASS INTERACTIONS

Josimeire M. Julio  
E.E. Reny de Souza Lima, Santa Luzia - Brazil

Arnaldo M. Vaz  
Universidade Federal de Minas Gerais, Belo Horizonte - Brazil

## Abstract

*This is an inquiry on aspects of masculinity that are latent on upper secondary physics classes within a Brazilian school. We investigate relations between such latent aspects of masculinity and scientific knowledge and also between latent aspects of masculinity and the learning context. We observed one entrants' class from within the classroom along one year and conducted in depth analysis of audio and video recording of an activity that simulates a scientific team's work. This activity occupied six lessons for that class, early that year. Such microanalysis enabled us to characterise common interactions among boys. For instance, when boys faced competition or challenging situations, showed curiosity for the phenomena portrayed in the activity, or defied previously established rules for the conduction of the activity, some aspects of masculinity observed seemed result from western hegemonic masculinity standards. Among these aspects of masculinity, it was possible to identify some that inhibited collaborative relationship, diversity valuation and mutual respect within the learning situations investigated. Difficulty to identify such nuances of masculinity might make them unlikely to be perceived or, rather, let them be naturalised. Once masculinity manifestations can compromise the development of classroom activities and learning group activities, it's worth considering them.*

## Introduction

In the 90's, in a turn on gender inequalities in education, girls in average had better performance and left school on higher classes than boys'. This was also the time when boys and young men progressively appeared on worrying headlines and educational statistics. Such fact became a matter of concern in different social and economic contexts, both in developed and developing countries. The subsequent debate highlighted flaws on the way boys are educated in schools, which, in turn, called attention to models of masculinity that permeate boys' universe. Connell (1995) refers to masculinity as a position on gender relations, which has an influence on a person's practices and ways she relates to physical, personal and cultural experiences. Therefore, different masculinities might be manifested, even on one single individual. In the West, the hegemonic masculinity model legitimates and values competition, hierarchy, individualism, sexual performance, bodily power, rationality, emotional detachment, dominance and courage to take risks.

Masculinities develop according to complex factors associated with social organisation. Many such factors operate at school. Thus, boys still have privileges that place them at the top of performance rankings, particularly in school disciplines of high prestige like natural sciences, information technology (computing) and advanced mathematics. An evidence of such distinction is that in secondary education, women tend to stay invisible for the

majority of science and mathematics books, perpetuating the vision that these are male disciplines (Giddens, 2006). In western culture, scientific knowledge is many times associated with male characteristics. Physics, for instance, is iconic of an ideal rationalism, much valued in the West.

This is an inquiry on aspects of masculinity that are latent among Brazilian upper secondary schoolboys and can be seen within physics classes. We give particular emphasis here to relations between such latent aspects of masculinity and scientific knowledge, on the one hand, and between latent masculinity and the learning situation, on the other. This paper presents analysis of interactions between boys during a student-centred activity designed to pass on an idea about the nature of professional activity in physics. It challenges students to solve open-ended problems, thus requiring them to take decisions, investigate phenomena and establish some co-operation among themselves. We turn here to Connell's concept of masculinity (1995), first, to investigate which stimuli this teaching sequence makes on boys' masculinities and, second, to learn how such masculinities interact in such context.

## 1. Masculinity Patterns

Masculinity is essentially a relational concept. It is conceived observing modern European/American culture, which deals with men and women's characteristics as polarised elements. Masculinity appears on a contrast with femininity, and exists only on a system of gender relations.

“*Masculinity*’, to the extent the term can be briefly defined at all, is simultaneously a place in gender relations, the practices through which men and women engage that place in gender, and the effects of these practices in bodily experience, personality and culture.” (Connell, 1995, pp. 71).

Schippers (2007) summarises the content of this definition in three components. The first is the individual's social location, which can be changed by practices, regardless of gender. The second component of masculinity is the set of practices and characteristics understood to be “masculine”. The widespread cultural and social effects of these practices is masculinity third component in Schippers's summary, particularly when such practices are embodied by men and women. In sum, masculinity shows different configurations and depend on the way personal and single experiences fit in a system of ephemeral and unstable gender relations. There is no single masculinity, there are multiple masculinities, they change in time and are dependent on characteristics of the group in which they manifest (CONNELL, 1995).

Each society construes a structure of characteristic social practices in which a hegemonic masculinity ethos leads to alliance, subordination or marginalization among the various masculinity standards (CONNELL, 1995). Haenfler (2004) argues that the hegemonic masculinity of western societies legitimises and values in particular competition, hierarchy, individuality, sexual prodigies, body strength, rationality, emotional detachment, domination and courage to take risks. Analysing interactions between men, Connell identified an alternation on their behaviour patterns. Men show resistance, get into power struggles and engage in collaboration, showing four patterns of masculinity, Connell named hegemony, subordination, complicity and marginalization.

The hegemonic masculinity derives from a cultural dynamics in which a group conquers and sustains its leading position on social life. It ensures men's domination and women's subordination. The subordinated masculinity is an inferior and stigmatised position of women and groups of men outside the hegemonic masculinity domain. Homosexuals are the best representatives of subordination pattern, but heterosexual men and boys that show symbolic resemblance with women too rate as such. Hence, the use of abusive dubs such as nerd, mother's boy, four-eyes, geek, among others. Complicity masculinity warrants men in general the privileges that derive from a patriarchal system. It is complicity that links most men with the current hegemonic ethos, even when hegemonic norms are not rigorously adopted. Finally, marginalized masculinity refers to cases in which there is interplay of gender with class or race structures. For instance, it refers to situations in which members of racial and social groups, subordinate for reasons other than gender, stand out as representative of dominant groups of hegemonic masculinity stance; for instance, black athletes that become exemplars for hegemonic masculinity.

According to Connell (1995), masculinities and femininities, apart from constituting personal identity, are present on social relations, institutions, professions and market dynamics, for instance. From this point of view, social institutions are subject to *generification* in case members of one sex massively outnumber the other. This is what happens on domains of science and sectors of technology; a gender cultural character “masculinizes” them (CONNELL, 1995). From the point of view of European Philosophy, science and technology are considered the motive force of progress, both being culturally framed as part of male kingdom (CONNELL, 1995). This follows from the sexual roles theory, which was eventually incorporated by popular culture and expresses one of patriarchal ideology themes: the idea that the men are rational and women are emotional (CONNELL, 1995).

We consider that masculinity representations overlapping Physics need to be investigated. We decided to investigate how such representations influence the process in which resistance standards of male youth within the classroom, power and collaboration relations among them are produced. Physics possess a social identity traditionally linked to its male, class and ethnic origin and history. We depart from the assumption that each young man relates with Physics his own way, establishing either alliance, complicity or marginalization relations with an ideal of masculinity he associates with this subject matter. In that way, he can incorporate this ideal of masculinity, adapt it or oppose himself against it, even if through unintentional actions. In the present study, we make recourse to Connell’s (1995) concept of Masculinity to investigate the masculinities stimulated along a sequence of Physics classes and the way in which such masculinities relate to each other in such context.

## Methods

The university committee on ethics in research involving human beings approved the procedures we planned to observe during the conduction of this investigation. We made audio and video recordings only of male and female students that voluntarily agreed to take part and were authorized by parents.

Along one year, one of us (Josimeire) stayed in classroom of an entrants’ class from a federal funded high school as a non-participant observer of all physics classes. The other of us (Arnaldo) – besides being the research project co-ordinator – was also the physics teacher in charge of the class observed. It had 17 boys and 8 girls, aged 15+, from a variety of educational, social and economic backgrounds because of school entrance policy. The yearlong observation had an ethnographic character. Based on it, we conducted ethnographical microanalysis of audio and video recordings of a short teaching sequence of six lessons of fifty minutes each that formed a thematic unit, named “variable stars activity”. This sequence of lessons began a few days after the start of the academic year, time when the students did not know well because that is their first year in the school. For this teaching sequence, students were distributed in nine groups of three or four students. We analysed data as in descriptive research: familiarity with individuals and class gained on the yearlong observations helped us to analyse dominant characteristics of the way individuals and groups worked during these six lessons. Descriptions allowed new analyses of episodes that focused on (a) the relation between people within a group; (b) the relation between the group and the activity; (c) the relation the group established with Physics; (d) the relation between the group and other context elements, such as teacher and other groups.

Data gathered conducted to (i) identification of common characteristics of boys involved in the learning situation; (ii) descriptive characterisation of aspects that facilitate boys’ action; (iii) descriptive characterisation of aspects that inhibit boys’ action; (iv) comparison between results obtained in steps ‘ii’ and ‘iii’ for different kinds of learning situations according to two points of view, that of Physics and that of the activity. We examined boys’ actions considering them as male actions and manifestations in relation to Physics and in relation to that particular activity. Such actions were analysed within Connell’s (1995) theoretical frame of masculinity representation. We attempted to identify among such actions nuances of a hegemonic masculinity standard.

## **Results**

We noticed that there were predispositions to challenge, to discovery and to competition. These were manifested in different manners among boys, but were not observed among girls. We noted, however, that this disposition manifests itself in different degrees and in different masculinity configurations. For instance, in events in which we identified the hegemonic masculinity model, boys presented dispositions to conflict, dominance and power disputes, which impaired both group progress and its members' learning.

We observed that some boys engaged on occasion when the activity gave them an opportunity to compete, to use their force or to assume domination of some kind. When that happened, they did not establish a collaborative relation within the group. This masculinity configuration prevailed among some boys and manifested in different manners within groups. In some cases, boys tried to impose their leadership without giving colleagues chance to argue or expose their ideas, thus getting in conflict with them. In another case, one boy's individualistic stance and dominating rationality impaired the advancement of his group on the investigation. There were also masculinity configurations in which the challenge and the competition with other groups guided the planning and organization of the tasks. In these cases, the collaborative work prevailed and students managed to articulate curiosity for phenomenon with tasks that would lead them to the "scientific discovery" asked for.

The hegemonic model of competitiveness, strength, dominance and courage to take risks manifests itself also during collective discussions. Boys showed to be foolhardy both in the manner they call teacher's attention and in the manner they express themselves. All boys that intended to take part in whole class discussions tended to enter discussion before making a sign or wait his turn, while girls waited in silence with their hands up. These boys' strategies point to behaviours that once naturalized in school inhibit other modes of participation within the collective space of classroom. Another nuance of the hegemonic model that was latent in boys' participation in such discussions was the dispute for ownership of "scientific knowledge" in the activity simulation.

## **Conclusions and Implications**

The results obtained reveal nuances of the western hegemonic masculinity model that inhibit the collaborative relationship, the diversity valuation and mutual respect. The masculinity concept allowed us to perceive that such nuances were latent in several relations established in class. The difficulty to identify them suggests a risk that they run unnoticed or that they become naturalized within educational institutions. On the other hand, we could also observe that the teacher and the learning situation might minimize the effects of those nuances, directing masculinities in favour of collaborative stances, as well as girls' and boys' development.

Finally, it is important to highlight a particular overlap between the hegemonic masculinity standard and performance in upper secondary school physics. Physics is a prestigious school subject that might involve challenging situations, such as the open-ended investigation activities. Important dimensions of boys education are put at risk when – on a subject like physics – they are guided by the western hegemonic masculinity model; that legitimates and value, for instance, competition, ultra-rational objectivity, individualism, emotional detachment, dominance, etc.

**Acknowledgments:** CNPq and CAPES, Brazil.

## References

- Blakemore, Judith, & Centers, Renee (2005). Characteristics of boys' and girls' toys. *Sex Roles*, 53 (9-10), 619-633.
- Connell, Robert W (1995). *Masculinities: knowledge, power and social change*. Berkeley, Los Angeles: University of California Press.
- Donini, Elisabetta (2000). La costruzione culturale delle scienze della natura, in PORZIO SERRAVALLE (a cura di), *Saperi and libertà. Maschile and femminile nei libri, nella scuola and nella vita*, A.I.E., Milano
- Erickson, Frederick (1992). Ethnographic microanalysis of interaction. In: Lecompte, M. D.; Mttroy, W.; Preissle, J. (Eds.). *The handbook of qualitative research in education*. Academic Press: Harcourt Brace Jovanovich.
- Giddens, Anthony (2006). Education. In Giddens, Anthony. *Sociology: with the assistance of Simon Griffiths* (pp. 682-737). - 5th ed. - Cambridge : Polity. XXIV, 1094 s.
- Haenfler, Ross (2004). Manhood in contradiction: the two faces of straight edge. *Men and Masculinities*, 7 (1), pp.77-99.
- Hodson, Derek (1998). Mini-Special Issue: Taking practical work beyond the laboratory. *International Journal of Science Education*, London, v. 20, n. 6, pp. 629-632.
- Kamari, Z.; Millar, R (2004). Reasoring from Data: how students collect and interpret data in science investigations. *Journal of Research in Science Teaching*, v. 41, n. 7, pp. 748-769.
- Swain, Jon (2006). Reflections on patterns of masculinity in school settings. *Men and Masculinities*, 8 (3), 331-349.
- Salminen-Karlsson, Minna (2007). Girls' Groups and Boys' Groups at a Municipal Technology Centre. *International Journal of Science Education*, London, v. 29, n. 8, pp. 1019-1033, jun.
- SCHIPPERS, Mimi (2007). Recovering the feminine other: masculinity, femininity, and gender hegemony. *Theory and Society*, v. 36, n. 1, pp. 85-102.
- Weaver-Hightower, Marcus (2003). The "boy turn" in research on gender and education. *Review of Educational Research*, 73 (4), 471-498.





# CULTURAL INFLUENCES ON STUDENTS' VIEWS ABOUT THE ORIGINS OF LIFE

Pam Hanley  
University of York

Marcus Grace  
University of Southampton

## Abstract

*This paper examines how students accommodate any differences between their own religious or cultural beliefs and the teaching of the origins of life in school. Four schools were selected for the study (one a Christian faith-based school, one not faith-based but drawing mostly from Muslim families, and two with mixed catchment areas). Students' views and beliefs were elicited using questionnaires and interviews. The findings show that students have a number of perspectives on the way science and religion do, or do not, inter-relate. Further, we have categorised those with religious beliefs into four groups according to their attitudes to engaging with science and religion: 'resistors' (who see science and religion in conflict); confused (wanting to reconcile two worldviews but struggling to do so); 'reconciled' (who have found a way to accommodate their religious and scientific outlooks) and 'explorers' (who actively inquire into the relationship between the two). Teachers need to be sensitive not only to the students' cultural backgrounds when addressing this topic, but also to how individuals might conceptualise the inter-relationship of science and religion.*

## Introduction

The theory of evolution has a central role in biology, with Darwin's ideas about natural selection being described as 'among the most powerful and significant pieces of knowledge we possess' (Millar and Osborne, 1998). Evolution also provides an instructive example of how theories are developed and become accepted by the scientific community. And yet it is a theory that is far from universally accepted: a recent survey (BBC/MORI 2006) showed that just under half the UK population believe in evolution as the best account of the origin of life (48%) with 22% believing in creationism and 17% in intelligent design (ID).

For various reasons, evolutionary theory has always been more controversial in US schools, with calls for 'intelligent design' (ID) - a belief that life has developed in small stages but is so complex it must have been guided by the hand of an unnamed 'designer' - to be taught alongside evolution. Historically, the matter has been much less contentious in the UK, but recent claims that some schools have been 'teaching' creationism and a national programme of activity by the ID movement, alongside growing sensitivity about religious and ethnic diversity in schools, has led to official guidance about how creationism and ID should be handled in the science classroom (DCSF, 2007).

There is a considerable body of literature examining the acceptance or otherwise of evolutionary theory and the cultural influences on this, but the majority of it focuses on the American experience and the teacher viewpoint. Although students' attitudes towards evolution and creationism are often discussed (eg Jones & Reiss 2007, Anderson 2007) very little empirical evidence has been published (Williams, 2008). In England, science and RE are both compulsory up to the age of 16, so most students cover the origins of life in both subjects but possibly in different ways and from different viewpoints.

## Rationale

The main research questions addressed in this study are:

- how do students accommodate any differences between their own religious or cultural beliefs and the teaching of the origins of life in school?
- is there any conflict between what they are taught in science and religious education (RE) lessons and if so, how do they deal with that?

This research has been informed by Barbour (2000), who proposed a taxonomy which defines four broad approaches to the relationship between science and religion:

- conflict (science and religion are in opposition, with just one of them being valid)
- independence (the two spheres are different endeavours - science is how and religion is why)
- dialogue (God made the universe intelligible so that scientists can explore it and better understand the workings of his mind; the disciplines are related through similar questions and methodologies)
- integration (encouraging, for instance, the search for evidence for God in nature or the reformulation of faith beliefs in the light of scientific developments).

## Methods

The study was based on a purposive sample of 4 schools: one faith-based (Christian) school; one non-faith school where the vast majority of students are Muslim; and two non-faith schools where students come from a mix of non-faith and faith backgrounds. A combination of self-completion questionnaires and depth interviews (in pairs and small groups) was used. Although research was also conducted among teaching staff, this paper focuses on the results from students aged 14-16. The sample sizes are shown in Table 1.

**Table 1. Sample sizes by type of school**

	Questionnaires	Interviews
Christian school	41	21
Muslim catchment	30	14
Mixed schools	138	29

The survey data were analysed using descriptive statistics and the qualitative data using constant comparison methods to develop grounded theory (Strauss & Corbin, 1994).

## Results

### Views about origins of life

The student survey began with a question designed to elicit students' opinions about the origins of life: 'How do you think life on earth came into being?'. It was an open-ended question to avoid constraining students' answers and potentially imposing researcher preconceptions by presenting them with a list of possible responses. The question was carefully phrased to avoid assuming any particular worldview (for example using the verb 'develop' in relation to life's origins might have presupposed evolutionary thinking). The wording was intended to indicate the focus on the origin of life rather than the universe. However, the answers show that this question was interpreted in a variety of ways as scientific theories that were put forward included the Big Bang (ie how the universe was created) and evolution (how life has developed). Nearly all the students who described themselves as Muslims opted for a religious explanation, eg "*God gave life. Everything is stated in the Qur'an*"; "*... God made the universe and Earth and He created life, it didn't just appear. Life on Earth can't just begin by itself, can it?*". Those students who defined

themselves as Christian gave a greater range of answers with only a minority making statements along the lines that “*God created the world*”. Many combined a religious and scientific explanation: “*God caused the big bang and then set evolution to happen*”; “*I think that life on earth started with the big bang, but God did the rest of the work. He created life and gave it a purpose. It’s like God is the scientist who made the earth as an experiment*”. An approximately equal proportion put forward scientific theories only (eg “*Through evolution from bacteria*”; “*The big bang followed by lots of evolution*”). Table 2 shows the responses after grouping into broader categories determined by whether the explanation given was exclusively religious, exclusively scientific, or a combination of both.

**Table 2. Students’ views of how life on earth came into being**

	Christian	Muslim	No reli beliefs
	77	26	59
	%	%	%
Science only	31	4	85
God only	21	92	2
God/science mix	31	0	2
Other	7	0	3
Unsure/DK	4	4	9
Not answered	4	0	0

Having expressed their opinions in free writing, students were asked to select one of three options that described how human life may have originated. An ‘other’ category was also available. The wording was based on the 2006 BBC/MORI survey:

- Human beings were created by God pretty much in their present form.
- Human beings have developed over millions of years from simpler forms of life. God had some part in this process.
- Human beings have developed over millions of years from simpler forms of life. God had no part in this process.
- Other

Almost every Muslim student (92%) agreed that they were ‘created by God pretty much in their present form’. Again, there was more variation in the sub-sample of Christians, but the most popular option was that they ‘have developed over millions of years from simpler forms of life. God had some part in this process’ (62%). Unsurprisingly, those with no religious beliefs mostly subscribed to an evolutionary process with no intervention from God (88%) (Table 3).

**Table 3: Students' views of how humans came into being**

	Christian	Muslim	No reli beliefs
	77	26	59
	%	%	%
God created humans	14	92	2
God had some part	62	0	7
God had no part	18	0	88
Other	5	8	7

Muslim students cited their religion as the predominant influence on their views about the origins of life whereas Christians were more mixed in what they identified. Muslims were also twice as likely to describe their belief as 'very strong' or 'strong'.

#### Views about the inter-relationship of science and religion

The depth interviews explored student perceptions of the relationship between science and religion further. Some students (mainly those without religious beliefs) did not engage with the topic. They had never considered it before and were unwilling or unable to do so now; they were placed in the 'Indifferent' category. There were four main ways that the remaining students conceptualised the inter-relationship between science and religion (interlinked; in parallel; in tension; reject science or religion).

Some saw the spheres as 'interlinked'. It was a position mainly reserved for those with religious commitments and represented a combination of Barbour's 'dialogue' and 'integration', as shown by these two quotes:

*You can see that there's a lot of theories that science has come up with now that's already written in the Qur'an ...* B FG4<sup>1</sup>

*The big bang created the earth, but I think God created what was on it and everything that is on earth today evolved from creatures that God created.* Christian

Others saw the spheres as completely separate with no interconnections ('in parallel'). This position enables students to hold their religious beliefs comfortably alongside their acceptance of science, and echoes the position Barbour describes as 'independence':

*They ask different questions, they expect different answers ... science is more about evidence and proof and facts and what happens, and religion is more to do with God and why things happen and what's behind it.* B FG2

A third group saw the spheres as overlapping but 'in tension' as they could contradict each other:

*I'm stuck in the middle so I get evolution from school and religion from church and I'm able to get both sides of the argument ... it's good because you think of God and how he would have made it and you think of particles going together and that makes sense, but ... Some things can really clash and they just don't make sense ...* C Pr1

The final group also perceived the spheres as contradictory, but unlike the 'in tension' position, they did not struggle to accept both paradigms – their position was that only one sphere had validity. That was either science: *I don't think there's any proof that God made the universe and the world and whatever but there's proof with science how it formed and stuff. I just think religion is something that people believe in.* (A FG4); or religion: *I just believe the Christian way and that's it, yeah.* (D FG1). This is the 'conflict' position in Barbour's taxonomy. There tended to be strong feelings around this stance.

<sup>1</sup> Quotes are identified by School and which Focus Group or Pair attended, or by self-defined religious belief if from the survey

## Perception of science and religious education lessons

When students' views about the science and RE teaching in school were explored, a common theme was characterised by the following quote:

*With science it's just basic facts with evidence but with [RE] you don't have hard core sort of evidence with what you're saying, so it's what you think is right or wrong based on your conscience (B FG5)*

Despite the science curriculum in England being re-designed to emphasis scientific literacy and teaching about the nature of science, most participants still characterised it as being all about facts, evidence and proof, not open to opinion, and only airing one side of an argument. RE in contrast had no 'hard core evidence': it was about comparing ideas and viewpoints and expressing your own opinions. Science tended to be taught using more passive techniques (textbooks, teacher talk) and the goal was to gain knowledge for the exam; RE was less about being right or wrong and often involved discussion and debate. Some religious believers found the approach in science blinkered and frustrating:

*S1: I think that in science they kind of only explain one side of the argument, they don't tell you what different things could have happened*

*S2: I sort of expect it because that's what we need to cover in an exam, but it's a bit annoying because you don't know which one to believe ... in RE you get to discuss it and find out for yourself but in science it's just "This is it, got it?, that's what it is" A FG3*

It was rare indeed to hear the kind of opinion expressed by this Muslim girl at School B:

*Because we do learn science in RE, we can pull our knowledge of RE science into our science lesson and vice versa, which helps us a lot because then we have a greater understanding of our own ideas about religion and science fitting together. B FG4*

Asked how they thought teachers might best respond if a student made a challenge from a religious perspective in the science class, the opinion of most participants coincided with the government's guidance – that the teacher be respectful, engage to some extent, but never forget that this was a science lesson:

*I'd say as long as the students know what they need to know to get their pass in science, which is the scientific version, then they can know as much as they want about the religious faith version of the story, so it's important to discuss it in science lessons if the child wants to. A FG5*

However, a minority of religious believers thought religion should be kept entirely separate from science: *I think they should keep it the way it is, the way that we only talk about scientific parts. B FG1*

## Religious believers' attitudes to engaging with the science and religion

Focusing only on religious believers (primarily in the context of learning about the origins of life) and synthesising their attitudes to science and religion with their attitudes to teaching the two in school, four broad groupings have emerged.

- Resisters believe that scientific and religious views cannot/should not be reconciled:

*[In our school] there's only so many people who aren't Muslims and for us to learn about something which we don't believe in ... we follow our faith for a reason, we shouldn't have to question. B FG1*

Several of the Muslim students were in this camp but, importantly, not all of them.

- The Confused need help to reconcile worldviews. Some are consciously confused and making uneasy compromises:

*I don't really know what to believe because the science is telling you one thing and the RE's telling you another. I was raised up with the RE but the science is more logical so I just kind of bottle out and pretend they're both right A FG1*

Others have not yet managed to think it through very logically:

---

*I think the big bang theory's based more on fact and religious views – yeah, to us basically [religious view is] fact because we believe it and - I think religious views are more based on faith and teachings rather than facts. B FG1*

It is important that students in this category are handled sensitively in science classes as well as RE. They need careful nurturing to move them to one of the following two categories.

- The Reconciled have come to some accommodation between their religious views and the scientific outlook allowing them to accept them both:

*We also debated the big bang theory in RE as well and we felt ... in order for the big bang to have happened there must have been a superior being to have caused it B FG4*

This means they will engage but on their own terms. The key question is: how genuine is the accommodation? Is it something they embrace or a grudging compromise? Comparison between survey and interview data from the Muslim students suggests that the proposal aired quite frequently in the interviews – that the Big Bang was initiated by God – might be a convenient compromise they had picked up from their teachers, as the questionnaires mostly postulated the involvement of God alone in explaining how life on earth came into being. So although on the surface this is not a category to be concerned about, the danger is that some members of this group are really Resisters, or they might tip into the Confused. But some might move comfortably to the final category of Explorers.

- Explorers enjoy the challenge of fitting together religious and scientific viewpoints and might even be willing to adjust their worldview if sufficient evidence is offered (as in the second quote):

*Cos we learn about religion and science together on a daily basis we really have the choice to decide if there's a conflict or not. B FG4*

*The big bang theory's made such a huge impact and people are talking about it more ... once we start learning about everything we start seeing things in a different way and it might change our perspective. B FG1*

Members of this group were not very common in the research. These students need to be given a safe space to explore the issues. RE lessons are the most obvious place for this but science teachers have to be prepared for students initiating such discussions and be ready to handle them sensitively.

## Conclusions and Implications

This research highlights the lack of homogeneity in the views of students who are religious believers. We hypothesise four broad groups to encompass their attitudes to the inter-relationship between science and religion. Distinctions were not completely clear cut as students were not always consistent or completely coherent in their views. This is hardly surprising in such a complex area and among teenagers whose critical thinking and conceptual abilities are still developing. There is a clear need for teachers to be respectful of students' cultural backgrounds when tackling topics where science and religion may be perceived to overlap. They must also be sensitive to differing attitudes about how science and religion do, or should, inter-relate. The findings highlight the potential benefit of establishing cross-curricular links between science and RE departments: exploiting opportunities to co-ordinate content, to compare and contrast the nature of science and the nature of religious beliefs, and also to share teaching skills such as facilitating student discussion. Unfortunately, data from another part of this project shows that this opportunity is very rarely taken.

## Acknowledgements

Thanks to the students and teachers at the four schools that took part in this research.

## References

- Anderson, R.D. (2007). Teaching the theory of evolution in social, intellectual, and pedagogical context. *Issues and Trends*, 91, 664-677.
- Barbour, I. G. (2000). *When science meets religion: enemies, strangers, or partners?* London: SPCK.
- BBC/MORI (2006). Britons unconvinced on evolution. Retrieved September 23, 2009, from <http://news.bbc.co.uk/1/hi/sci/tech/4648598.stm>
- DCSF (2007). Guidance on the place of creationism and intelligent design in science lessons. Retrieved January 16, 2009, from <http://www.teachernet.gov.uk/docbank/index.cfm?id=11890>
- Jones, L. S., & Reiss M. J. (Eds). (2007). *Teaching about scientific origins: taking account of creationism*. New York: Peter Lang.
- Millar, R., & Osborne, J. F. (1998). *Beyond 2000: Science education for the future*. London: King's College London.
- Strauss, A., & Corbin, J. (1994). Grounded Theory Methodology: An Overview. In N. K. Denzin, & Y. S. Lincoln (Eds.), *Handbook of Qualitative Research* (pp. 273-285). London: Sage.
- Williams, J. (2008). Creationist teaching in school science: a UK perspective. *Evolution: Education and Outreach*, 1(1), 87-95.





# CULTURAL ASPECTS OF DECISION-MAKING ABOUT A CONTROVERSIAL SOCIO-SCIENTIFIC ISSUE: WHALING

Y.Chung Lee  
Hong Kong Institute of Education

Marcus Grace  
University of Southampton

Anita Wallin  
University of Gothenburg

Jenny Byrne  
University of Southampton

## Abstract

*This paper focuses on the views of 16-17 year old science students in three different parts of the world before and after engaging in decision-making discussions about the socio-scientific issue of whaling. The students, located in England, Sweden and Hong Kong were provided with the same decision-making task and identical resources. The activity resulted in modified solutions across all three groups of students. All groups showed a large post-test increase in support of whaling for scientific research. The Hong Kong group tended to accept whaling under wider circumstances than their English and Swedish counterparts. Conversely, more English students showed a disapproval of whaling for commercial benefits or research purposes than the other two groups. The Swedish group came somewhere in between in this regard. It is hoped that the findings will help curriculum developers and teacher trainers design materials and programmes to promote decision-making about conservation issues.*

## Introduction

The increasing focus on scientific literacy in the science curricula of many countries, has led to a greater emphasis on students being able to make evidence-based evaluations and decisions (e.g. European Commission, 1995). However, this does not always prove easy in the classroom. Difficulties are particularly apparent for socio-scientific issues (SSIs), where there is not necessarily one 'correct' answer and students need the opportunity to discuss such issues, and separate these arguments from their own values and beliefs (Oulton *et al*, 2004). Osborne *et al*. (2001) believe that changing one's thinking is an indication of good quality argument and this is only possible if there are opportunities to externalise that thinking, and expose one's beliefs to scrutiny by others. This can only take place effectively by engaging in some kind of discussion. This research draws on pedagogic practices used to enhance students' ability to make informed decisions about SSIs through discussion. These practices include the utilization of metacognitive strategies such as reflective thinking to integrate multiple perspectives (e.g. Zeidler *et al*, 2002), integration of knowledge acquisition, argumentation and personal value identification (e.g. Lee, 2007), group discussion using a prescribed decision-making framework (e.g. Grace, 2009), and confronting students with opposing arguments through class discussions to clarify their thoughts (Simonneaux, 2001). The study compares 16-17 year biology students' views about whaling (a well-known international issue) in each of three different locations

(England, Hong Kong and Sweden) before and after a decision-making exercise, to help create an effective programme of professional development for science teachers. The research questions are as follows:

1. Do students from three different international locations have different views about whaling?
2. Do their views change after a short group decision-making activity?
3. What values do they draw upon during the decision-making process?

Biological conservation is a precondition for sustainable development (Solbrig, 1991), and whale conservation is a particularly emotive issue involving some tough decisions about what and how to conserve. Conservation management programmes depend on an understanding of the biology of the organisms concerned and how they interact with their surrounding environment, but as with all SSIs, politics, economics and cultural aspects also play an important role in this decision-making process. Environmental issues are thus socially constructed and some professional biologists believe that cultural values are in fact more important than biological factors in deciding conservation priorities (Spellerberg, 1996).

Rohner (1984) describes the term *culture* as a learned system of beliefs about the manner in which people interact with their social and physical environment, shared among an identifiable segment of a population, and transmitted from one generation to the next. Values relating to conservation issues can be incompatible between, and even within different cultural groups. A high-profile international example of this is the Inuit contention that they should continue whaling on the grounds that it is an intrinsic part of their culture. Hamazaki & Tanno, (2001) reported that the public in nonwhaling countries disapproved of whaling, whereas those in whaling countries generally approved of whaling. Other surveys also indicate that preferences vary between different cultures; but these findings are sometimes contradictory (Kellert, 1996). For example, Callicott (1982) described the widespread and appealing assumption that non-industrial communities (e.g. North American Indian societies) often possess a kind of deep-seated ecological wisdom, with a belief in mutual dependence and equitable status of humans and other species. However, Kellert (1996) reported that people from less industrialised societies often have a less positive attitude towards wildlife, viewing it with fear and hostility.

## **Rationale**

This is a comparative study that considers how cultural differences might affect the way science students engage with conservation decision-making. Understanding how students' views differ before and after the discussion, and what values they draw upon will help educators design appropriate professional development programmes for science teachers in each location. The three environments differ in many respects, for example, the population density in Hong Kong 60 times greater than England, and 800 times greater than Sweden. The population of Hong Kong is predominantly Chinese. With its history as a British colony, and now a special administration region of China, Hong Kong has been widely regarded as a 'melting pot' of the East and the West. In Sweden the concept of "Allemansrätt" (all peoples' right to move freely on uncultivated private land) is part of that country's cultural heritage, a comparatively alien idea to citizens in England. However, England is home to some of the largest conservation organisations in the world.

## **Methods**

16-17 year olds in co-educational schools in the three locations engaged in an hour-long decision-making discussion about whaling. The activity involved 21 students in Sweden, 45 in England and 19 in Hong Kong. They were put into peer-groups (of 4 to 7 students). The activity was set out in the following stages:

1. Students were given background information about the whaling issue. This included a short introductory video presenting a real case study about a whaling community.

2. Students then individually wrote down their own suggested solution to the problem with justifications (pre-test).
3. Each student was given two short articles to read from a selection on the following themes: articles from pro and anti-whaling organisations, how whales affect fisheries, the role of marine mammals in aquatic ecosystems, the Japanese Government's position on whaling, health and safety aspects of eating whale meat, whale biology, whaling techniques, and whales' intelligence.
4. Discussion. Using a decision-making framework (based on Ratcliffe & Grace, 2003, and Lee, 2007), students were asked to:
  - i) consider what stakeholders would be affected and what their views might be;
  - ii) consider what further information is needed to make a decision;
  - iii) state the possible solutions, advantages and disadvantages of each, and associated values;
  - iv) make a group decision/solution.
5. Each group presented their decision to the whole class. These were videotaped.
6. Students wrote down their own decision again with justifications in the light of the discussions (post-test).

## Results

### *(A) Students' decisions*

Analysis of the pre and post-test results enabled the decisions to be classified into six categories:

1. Whaling for human or community survival reasons – accept whaling if it is necessary to fulfil human needs, e.g. survival of aboriginal people who rely on whale meat as the main food source, or whaling as an indispensable part of their culture legitimizing trading of whale meat as a source of personal or national income.
2. Regulated whaling – impose restrictions to whaling, e.g. some sorts of quota system.
3. Whaling using humane methods – kill whales only in a humane way.
4. Whaling for commercial gains - legitimize trading of whale meat as a source of personal or national income; whaling is considered as a normal hunting activity like fishing.
5. Whaling for scientific research - allow the catching or killing of whales for research purposes.
6. Anti-whaling - disapprove of any form of whaling under any circumstances

With the exception of “anti-whaling”, none of these categories are mutually exclusive, that is, students might have opted for one or a combination of these as their decisions. Figures 1 and 2 show the comparison of students' decisions between the pre-test and post-test in England, Hong Kong and Sweden.

### Pre-test individual decisions

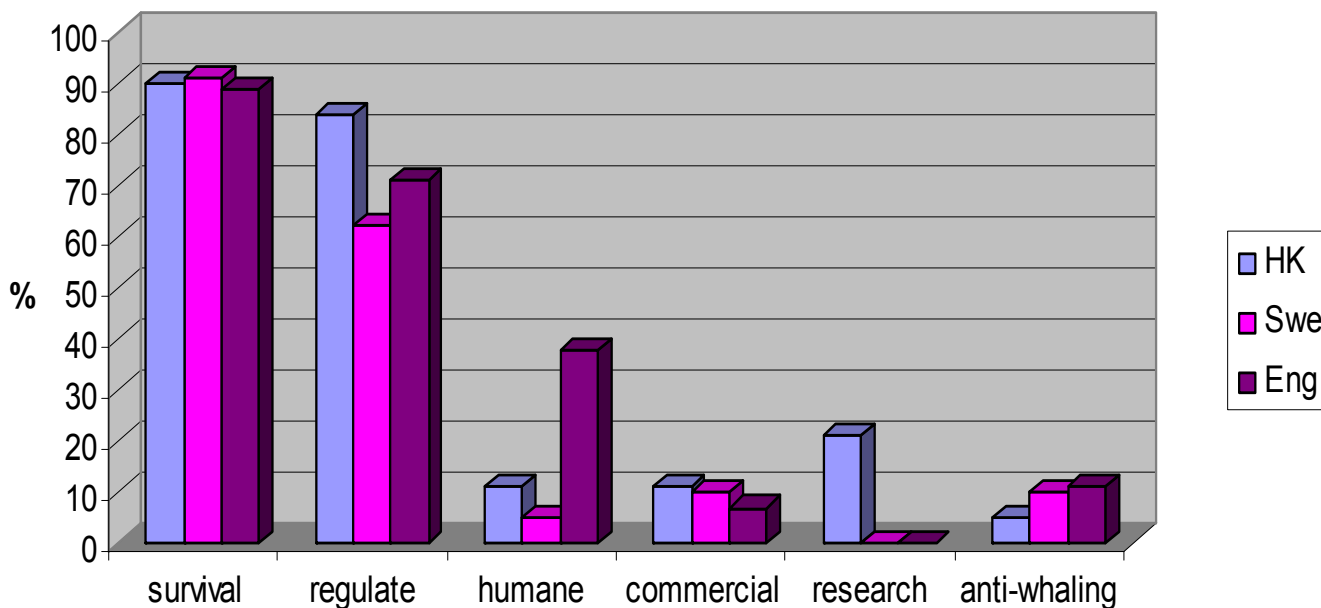


Figure 1. Pre-test comparison of students' decisions in England, Hong Kong and Sweden.

### Post-test individual decisions

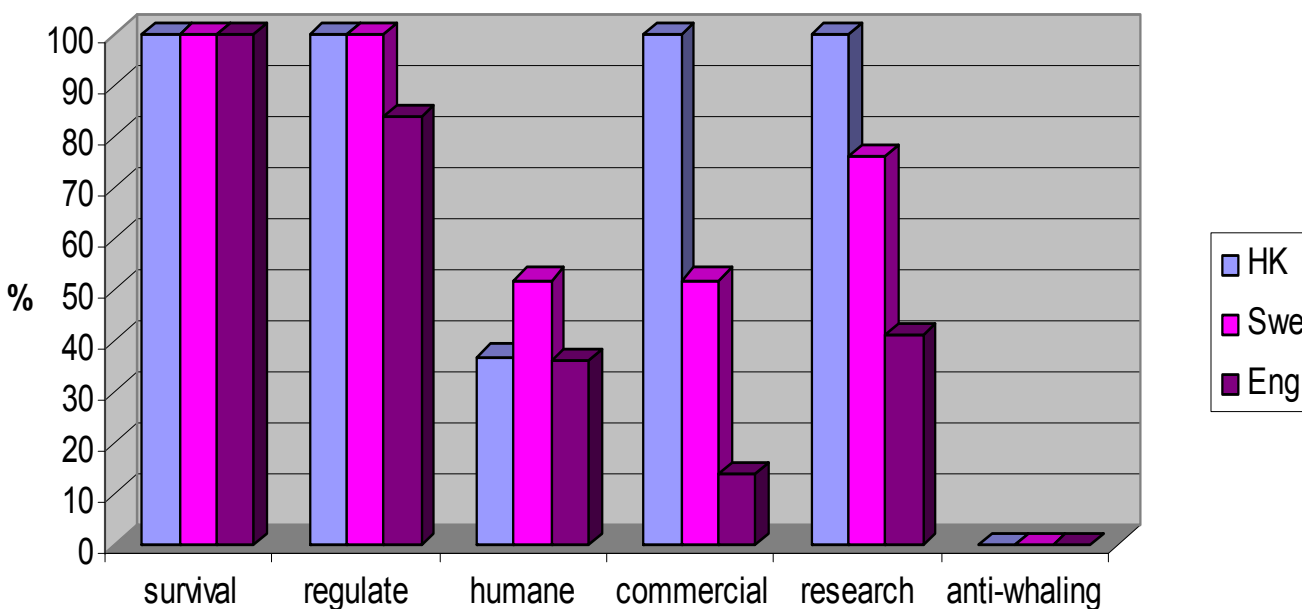


Figure 2. Post-test comparison of students' decisions in England, Hong Kong and Sweden.

The data shows that the large majority advocated whaling of some kind, mostly for community 'survival' reasons. Very few students took an anti-whaling stance in the pre-test, and after discussion this was reduced to zero. However, at the same time many agreed that some sort of regulation or control is needed to ensure that whale populations will not be adversely affected. Post-test more students advocated regulated, humane, commercial and

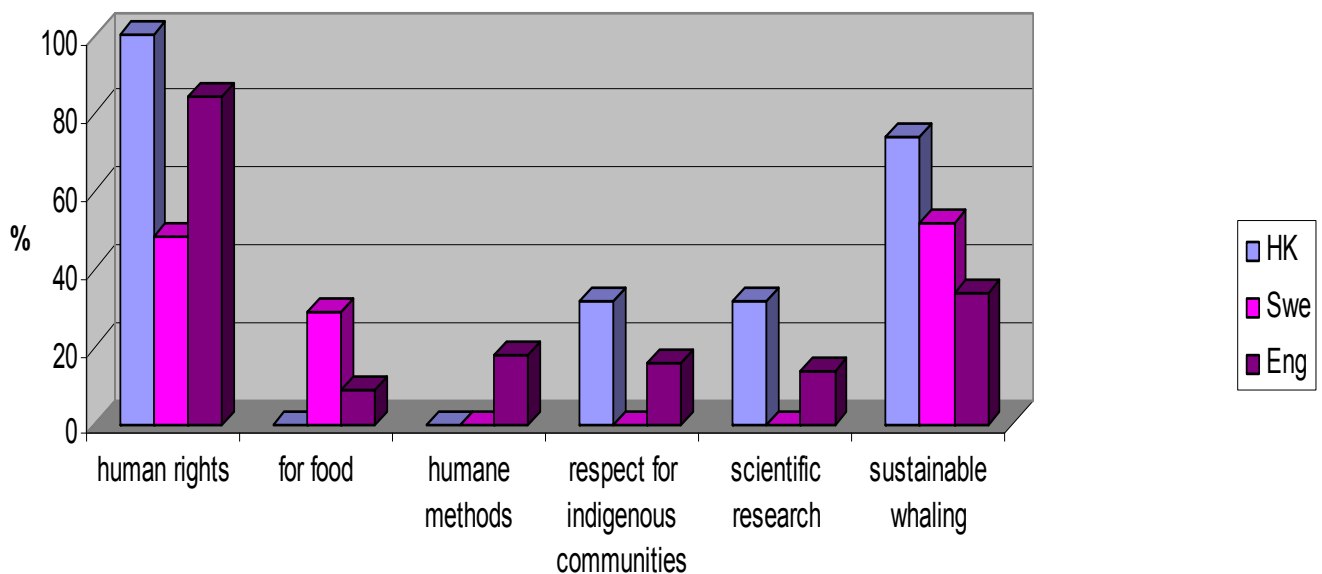
research whaling (ie they became more pro-whaling). There was a national difference in acceptance of commercial and scientific whaling, with Hong Kong students being most accepting and English students the least.

**(B) Justifications for students' decisions**

The pro and anti-whaling justifications provided by students were categorised. Figure 3 shows the reasons students gave for accepting whaling were divided into the following categories:

1. Humans' right to survive
2. Whales are a legitimate source of food like other animals
3. The use of humane methods
4. Respect for indigenous cultures/communities
5. Value of scientific research
6. Restrictions to maintain sustainable populations

**Post-test justifications for pro-whaling**

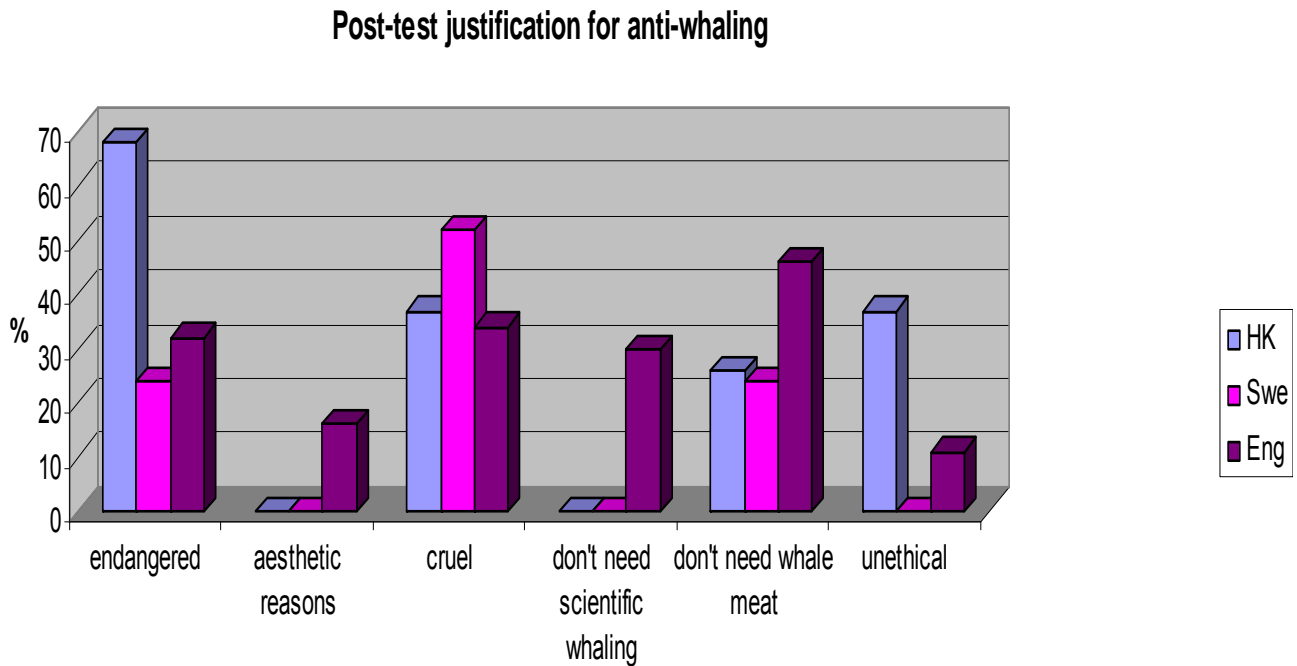


**Figure 3. Students' justifications for accepting whaling.**

The justification raised by a lot of students in each location was that humans have a right to survive, so if this depends on whaling it is an acceptable activity. 100% of Hong Kong students held this view, 84% of English students and only 48% of Swedish students. Other national differences were also apparent; Hong Kong students were supportive of whaling for research and respect for indigenous cultures, whereas unlike the other students Swedish participants did not mention of acceptance of whaling for research, using humane methods, or respect for indigenous people.

Figure 4 shows the reasons students gave for proposing that whaling was unacceptable. These reasons were:

1. Whales might become endangered or extinct
2. Aesthetic reasons
3. Whaling is inhumane/ cruel
4. No need for scientific whaling
5. Developed countries do not need whale meat
6. Whales have the right to survive; it is unethical/immoral to kill whales



**Figure 4. Students' justifications for not accepting whaling.**

The concern about whales becoming endangered was a common justification against whaling in all the three locations. This concern became more prominent amongst Hong Kong and English students after the activity, yet it became less important to the Swedish group. All the three groups, especially the Swedish students, became more concerned about the cruelty of whaling after the activity. The English students were the only ones who justified their decisions against whaling with aesthetic reasons (e.g. whales are magnificent or beautiful), although this was a fairly small proportion of students. The English students were also alone in the post-test in rejecting the value of scientific whaling. A greater proportion of Swedish students were against whaling if it was carried out using inhumane/ cruel methods.

## Conclusions and implications

Although it is not possible to generalize from a single comparative case study involving only one class in each of the three locations, several patterns emerged from the findings of this study, which are worthy of further exploration. Students from the three locations shared similarities as well as differences in reasoning and decision-making about whaling. The activity overall appeared to result in modified solutions across all three groups of students, but this impact seems to have been less pronounced among the English students (Figures 1 and 2). For example, the number of English students only supporting whaling if humane methods are used remained as a large minority, whereas among Hong Kong and Swedish students there was a marked increase in those supporting this (particularly in Sweden). Similarly, English students' support for whaling for commercial gains remained fairly stable, whereas there was a substantial post-test increase in support for this among Hong Kong and Swedish students. All three groups showed a large post-test increase in support of whaling for scientific research.

Regulation of whaling for the protection of whales was accorded a high priority in all the three locations (Figures 1 and 2). However, most students post-test were more sympathetic with indigenous communities who have traditionally been relying on whales as their staple food. This indicates that although students strived to avoid whales from becoming endangered, they tended to accept whaling when human lives and community welfare are at stake. This dualism of adopting both anthropocentric, and biocentric or ethical values appeared to characterize the reasoning of most students, a phenomenon which apparently transcended cultural boundaries. This dualism led students to come to a compromised view in their final decision by accepting whaling but only with certain caveats.

All three groups became more tolerant of whaling after the activity as evidenced by the increased acceptance of whaling for human or community survival reasons, economic gain and to an extent, research purposes. Although there were students in each group who in pre-test disapproved of any form of whaling under any circumstances, there were none recorded post-test suggesting that the activity had moderated their anti-whaling views. The Hong Kong group seemed to be the most tolerant of whaling and they tended to accept whaling under wider circumstances than their English and Swedish counterparts. Conversely, more English students showed a disapproval of whaling for commercial benefits or research purposes than the other two groups. The Swedish group came somewhere in between the English and the Hong Kong groups in this regard.

A limitation to this study is the reliance on written records to assess students' reasoning and decision making processes. This type of evaluation method is convenient to administer and can gauge the views of a large group of students at the same time.

The above analysis implies that 'culture' may be an important factor that affects students' reasoning and decision making through their influences on values, and the way they negotiate different viewpoints in coming to a decision. The findings will also help teachers, curriculum developers and teacher trainers design materials and programmes to promote decision-making about conservation issues. Subject to confirmation by further research based on larger samples, the present findings have implications for the discussion of socio-scientific issues, especially global ones which entail international collaboration. Since the resolution of many controversial issues such as climate change, habitat destruction, and depletion of fossil fuels requires concerted international efforts, it makes a lot of sense for students from different localities to establish some mutual understanding so that in future they could communicate and collaborate with each other in tackling these issues more effectively. The next phase of this research is to share the students' views with their counterparts in the other locations.

## Acknowledgements

The authors wish to thank the students and teachers who took part in this research.

## References

- Callicott, J. B. (1982) Traditional American Indian and Western European attitudes toward nature: an overview. *Environmental Ethics* 4, 293-318
- European Commission (1995) *Teaching and Learning. Towards the Learning Society*. White Paper on Education and Training (COM(95) 590). Brussels: European Commission.
- Lee, Y. C. (2007). Developing decision-making skills for socio-scientific issues. *Journal of Biological Education*, 41(4), 170-177.
- Grace, M. (2009) Developing high quality decision-making discussions about biological conservation in a normal classroom setting. *International Journal of Science Education*, 31 (4), 551-570
- Hamazaki, T. and Tanno, D. (2001). Approval of whaling and whaling-related beliefs: Public opinion in whaling and nonwhaling countries. *Human Dimensions of Wildlife*, 6, 131-144.
- Kellert, S. R. (1996) *The value of life: Biological Diversity and Human Society*. Washington D. C.: Island Press
- Oulton, C., Dillon, J., & Grace, M. M. (2004). Reconceptualizing the teaching of controversial issues. *International Journal of Science Education*, 26(4), 411-423.
- Osborne, J., Erduran, S., Simon, S. and Monk, M. (2001b) Enhancing the quality of argument in school science. *School Science Review*, 82, 301, 63-70.
- Ratcliffe, M, and Grace, M. (2003). *Science education for citizenship*. Maidenhead, Philadelphia: Open University Press.
- Rohner, R. P. (1984) Toward a concept of culture for cross-cultural psychology. *Journal of Cross-Cultural Psychology*, 15, 111-138
- Simonneaux, L. (2001). Role-play or debate to promote students' argumentation and justification on an issue in animal transgenesis. *International Journal of Science Education*, 23(9), 903-927.

- Solbrig, O. T. (1991) The roots of the biodiversity crisis. *Biology International*, 23, 5-13 (International Union of Biological Sciences)
- Spellerberg, I. F. (1996) *Conservation Biology*. Harlow: Longman
- Zeidler, D. L., Walker, K. A., Ackett, W. A., and Simmons, M. L. (2002). Tangled up in views: Beliefs in the nature of science and responses to socioscientific dilemmas. *Science Education*, 86, 343-367









## **CONTEMPORARY SCIENCE EDUCATION RESEARCH: SCIENTIFIC LITERACY AND SOCIAL ASPECTS OF SCIENCE**

**This book includes a collection of papers on the following topics:**

### **Discourse and Argumentation in Science Education**

Understanding, supporting and promoting argumentation discourse in science education, discourse analysis, the talk of science classrooms, and meaning making in science classrooms

### **Scientific Literacy**

Teaching about scientific literacy, decision-making about socio-scientific issues, and public engagement of science

### **Environmental Education**

Ecological education, experiential education, education for sustainable development, indigenous science, and attitudes and interests towards environmental issues

### **Cultural, Social, and Gender Issues**

Equity and diversity issues: Sociocultural, multicultural, bilingual, racial/ethnic, gender equity studies and science education for the special needs