European Association for Research on Learning and Instruction (EARLI)

5th European Symposium
Special Interest Group (SIG), Conceptual Change

Bridging the gap between mental models and situated cognition?
Theoretical and methodological considerations

Stockholm · Sweden · June 14 –17, 2006

abstracts
program

www.ccsig2006.su.se

Department of Education · Stockholm University

European Association for Research
on Learning and Instruction

5th European Symposium
Conceptual Change:
Bridging the gap between mental models
and situated cognition?
Theoretical and methodological considerations

June 14-17, 2006
Stockholm, Sweden

Abstracts
Program

Edited by: Ola Halldén, Gunilla Petersson, Åsa Larsson and Liza Haglund

Sponsors:
The Swedish Research Council,
The Department of Education, Stockholm University, The Banc of Sweden, Terententary Foundation

5th European symposium on conceptual change
Bridging the gap between mental models and situated cognition?
Theoretical and methodological considerations
Stockholm, Sweden. June 14-17, 2006

Web Site: http://www.ccsig2006.su.se/welcome.php
E-mail: ccsig2006@ped.su.se

Book of abstracts

Department of Education
Stockholm University
SE 106 91 Stockholm Sweden
08-16 20 00
fax 08-15 83 54

Photo on the cover: Stockholm Visitors' Board/Richard Ryan

Contents

Preface and acknowledgements 4

Committees of the conference 5

Wednesday, June 14th 6
10.30 – 12.30 Opening session 6
Opening Keynote Adresses 6
13.30 – 15.30 Paper session A 7
13.30 – 15.30 Paper session B 11
16.00 – 18.00 Symposium in honour of Guyo Hatana 14
Thursday, June 15th 15
08.30 – 10.00 Keynote addresses & Panel discussion 15
10.30 – 12.30 Paper session A 16
10.30 – 12.30 Paper session B 19
10.30 – 12.30 Paper session C 23
13.30 – 15.30 Paper session A 27
13.30 – 15.30 Paper session B 31
13.30 – 15.30 Paper session C 34
16.00 – 16.30 Poster session 38
16.30 – 18.00 Keynotes addresses & Panel discussion 41
Friday, June 16th 42
08.30 – 10.00 Keynote addresses & Panel discussion 42
10.30 – 12.30 Paper sessions A (Thematic paper presentation) 44
10.30 – 12.30 Paper sessions B 48
13.30 – 15.30 Paper sessions A 52
13.30 – 15.30 Paper sessions B 56
16.00 – 18.00 Invited symposium 59
Saturday, June 17th 62
09.00 – 11.00 Panel discussion 62
11.30 – 12.00 Conclusion 62

Participants' index.... 63

Participants' list....65

Paper sessions - overview....68

Preface and Acknowledgements

On behalf of the International Scientific and Local Programme Committees I would like to welcome you to the 5th European Symposium on Conceptual Change: Bridging the Gap between Mental Models and Situated Cognition? Theoretical and Methodological Considerations, in Stockholm, Sweden, June 14 – 17, 2006.

This meeting is organised by the Department of Education, Stockholm University and supported by the European Association for Research on Learning and Instruction, EARLI. It has been made possible by generous financial support from the Department of Education, Stockholm University, and by grants from the Swedish Research Council, the Bank of Sweden Tercentenary Foundation, and EARLI.

This volume brings together the abstracts of the keynote lectures, the invited symposium, the papers, and the posters of the symposium. It includes contributions from the leading researchers around the world investigating conceptual change from a variety of perspectives. Special emphasis has been given to the relationships between context and conceptions and the debate between constructivists and advocates of sociocultural theory. The central question raised is whether these perspectives can be united or even merged, or whether they should be developed in fruitful disagreement.

The organisation of this meeting would not have been possible without the help from a great number of people. I would like to express my sincere gratitude to the members of the local and scientific committees, to the organisers of the invited symposium, and to the many members of the SIG and particularly to the coordinators Xenia Vamvakoussi and Gunilla Petersson. I would also like to especially acknowledge the help of my colleagues Stella Vosniadou and Erno Lehtinen and the encouraging and kind response I have received from all other colleagues I have asked for contributions. Special thanks must go to the members of the RCD group at the Department of Education, Stockholm University, who formed the crew for the preparation of the symposium: Karin Ehrlén, Liza Haglund, Åsa Larsson, Cecilia Lundholm, Karolina Österlind, Homan Panahi, and Li Wang. For the work of converting the manuscript of this book into a copy ready for typing I want to thank Anders Persson.

The realisation of this symposium would not have been possible without the eminent work done by Gunilla Petersson who has been responsible for all practical details as well as for the over all organisation of the symposium and to her I owe my deepest thanks.

Ola Halldén

Chair of the 5th European Symposium on Conceptual Change.

Committees of the conference

Chair of the conference
Ola Halldén, Stockholm University, Sweden

Scientific committee
Silvia Caravita, Instituto di Scienze e Technologie della Cognizione, CNR, Italy
Ola Halldén, Stockholm University, Sweden
John Leach, University Leeds, UK
Erno Lehtinen, University of Turku, Finland
Margarita Limon, Universidad Autónoma de Madrid, Spain
Lucia Mason, University of Padua, Italy
Gunilla Petersson, Stockholm University and Karolinska Institute, Sweden
Roger Säljö, University of Gothenburg, Sweden
Marianne Wiser, Clark University, USA
Stella Vosniadou, University of Athens, Greece

SIG Coordinators
Gunilla Petersson, Stockholm University and Karolinska Institute, Sweden
Xenia Vamavakoussi, University of Athens, Greece

Local organising committee

Head of the committee
Gunilla Petersson

Web design, construction, and administration
Emma Wibom
Mårten Nilsson

Economy
Gun-Britt Norberg

Local organisers
Karin Ehrlén
Liza Haglund
Åsa Larsson
Li Wang
Cecilia Lundholm
Homan Panahi
Karolina Österlind

Editorial board for proceedings
Ola Halldén
Gunilla Petersson

Wednesday, June 14th

10.30 - 12.30 Opening session

(Vårgårdsalen)

Ola Halldén, Stockholm, University, Sweden
Gunilla Petersson, Stockholm University, Sweden

Opening Keynote Addresses

Stella Vosniadou, University of Athens, Greece
Roger Säljö, University of Gothenburg, Sweden

13.30 - 15.30 Paper session A

(Vårdgårdsalen)

Chair and discussant: Helge Strömdahl

The role of external representations in the ordering of fractions

*Christos Pantsidis and Stella Vosniadou, Cognitive Science Laboratory, University of Athens, Greece

We report the results of an experiment that investigated the role of external representations in 6th graders' understanding of the ordering of fractions. There is general agreement that external representations help students grasp the meaning of mathematical concepts (e.g. Lesh, Behr & Post, 1987). However, it is not the case that mathematical meaning is always conveyed by the mere presence of representations (Clements & McMillen, 1996). Following Vosniadou, Skopeliti, and Ikospentaki (2005), we assumed that the effect of external representations is subject to interpretation based on students' prior knowledge, and that external representations can be distorted if they come in conflict with prior beliefs and presuppositions. Following Stafylidou and Vosniadou (2004) we hypothesized that students' errors in the ordering of fractions may systematically reflect one of the following erroneous beliefs: a) the bigger fraction is the one with the larger numerator and denominator, b) the bigger fraction is the one with the smaller numerator and denominator, and c) the belief that all fractions are smaller than the unit. The external representations used were a) pies, and b) number lines. Elementary school students are more familiar with pies than with number lines, but pies may give rise to the misconception that all fractions are smaller than the unit. Prior research (Stafilidou & Vosniadou, 2005) has shown that students' belief that fractions are always smaller than the unit is a serious obstacle in their understanding of the concept of fraction.

The sample of the study consisted of 236 6th grade Greek students. They were divided into two experimental groups: pie and number line. Differences in the ordering of fractions between the two groups were tested using a pre-post questionnaire. The students were given a pre-test in which they were asked to order nine sets of two fractions each. They were then shown one of the external representations and were asked to take it into account before deciding on how to order the fractions. A third, instructional intervention took place two weeks after the second test and while the experimenter had time to examine the kinds of ordering errors the students had made. Specific instruction was provided on how the students could use the external representation correctly. The final post-test was administered two weeks after the instructional intervention.

The results showed no differences between the experimental groups in the pre-test. As expected, students' errors in the fraction ordering task were similar to those predicted by Vosniadou & Stafylidou (2004). The external representation influenced the participants' ordering choices. Overall, the pie improved students' performance, whereas the number line did not. The presentation of the number line increased errors according to which students understand as bigger the fraction with the larger numerator and denominator. These errors appear to stem from students' erroneous interpretation of the external representation. Confusion between the entire and the fractional unit was also observed at the use of pies, with the difference however that it was limited to the case of improper fractions only. The experimenter explained these errors and demonstrated the correct use of the external representations in the instructional intervention. At the post test results showed that both external representations improved students' performance.

Conceptual Changes in the Transition from Arithmetic to Algebra

*Judi Humberstone and Robert Reeve, University of Melbourne, Australia

A good understanding of algebra is a prerequisite for advanced mathematical problem-solving; however,

many students fail to gain such an understanding and continue to apply mental models derived from arithmetic to erroneously solve algebraic problems. Although the issue of how students make the transition between arithmetic and algebra is a matter of theoretical and practical significance, it has received little empirical attention. To characterise differences in students' mental models associated with this transition we assessed the arithmetical and algebraic reasoning competencies of 72 12-year-olds. Our aim was to identify different patterns of arithmetic-algebraic competencies to characterise the transitions in mental models associated with the acquisition of algebraic reasoning.

Students participated in a three-phase study. In the first phase they completed pre-algebra tests that assessed the abilities to (1) solve simple algebraic equations, (2) understand the relationships between the algebraic symbols and written aspects of word problems, and (3) to classify a set of symbolic equations into conceptually-related groups. In Phase 2 students solved algebraic word-problems with assistance. The assistance comprised a sequence of hints reflecting the steps required to map algebraic symbols onto word problems. In Phase 3, students solved algebraic equations similar to those encountered in Phase 1, and a new set of algebraic equations and word-problems.

In order to identify different competency subgroups we conducted a cluster analysis (Wards Method) on the correct performance for Phase 1 measures which yielded a five-group solution that accounted for 75% of the variance. These groups could be ordered in terms of arithmetic and algebraic abilities and represented a range of different kinds of arithmetic-algebraic understanding (mental models). The Phase 2 assistance measure was related to Phase1 group sophistication—the more algebraically competent groups required less assistance to solve the Phase 2 problems. Problem-solving proficiency in Phase 3 was also associated with cluster group membership. We also analysed the relationship between students' problem solving strategies and errors. Correspondence analysis revealed a close association between algebraic reasoning errors and cluster group membership.

The pattern of findings were consistent across all measures (i.e., the associations between cluster group membership, assistance and problem solving errors) on the basis of which we believe that it is reasonable to suggest a sequence of well-ordered mental models that represent conceptual changes associated with the transition from arithmetic to algebraic understanding. Specifically, these models reflect a progression from predominantly arithmetic-based reasoning, through beginning algebraic to incomplete algebraic processing, and finally to complete algebraic reasoning. In particular, the findings suggest that the transition from arithmetic to algebra depends on the acquisition of an understanding of the relationships between written and symbolic mathematical expressions. We believe that our research has implications for the diagnosis of students' arithmetic-algebraic competence that could be used to design targeted intervention programs.

Aspects of students' understanding of rational numbers from a conceptual change perspective
*Xenia Vamvakoussi and Stella Vosniadou, University of Athens, Greece

We report preliminary results of a study that investigated 11th graders' understanding of the structure of rational numbers intervals. According to the conceptual change theoretical framework that we adopt (Vosniadou, 1994) we assumed that the idea that numbers are discrete is a fundamental presupposition of children's initial theories of numbers, which are based on their understanding of natural numbers. We expected that this fundamental presupposition would be robust enough to shape students' conceptions of rational numbers intervals up to the 11th grade. In addition, in previous studies (Vamvakoussi & Vosniadou, 2004) we have found evidence that the form of the numbers (e.g. decimal numbers or fractions) that define an interval also constrains students' responses on tasks regarding the number of numbers in the interval. In this study, we aimed at further investigating this finding.

The participants of the study were 202 11th graders, coming from 3 schools in the area of Athens. They were asked to fill out questionnaires which comprised 14 forced-choice questions, asking about the number and the form of numbers that exist in a given interval. The numbers defining the intervals were two pairs of integers,

two pairs of decimals with one decimal digit, two pairs of decimals with 3 decimal digits, two pairs of similar and two pairs of dissimilar fractions, as well as a pair of an integer and a decimal with one decimal digit and a pair of an integer and a decimal with 3 decimal digits. There were five alternatives, namely "there is no other number", "there is a finite number of decimals", "there is a finite number of fractions", "there are infinitely many decimals", "there are infinitely many fractions", "there are infinitely many numbers of various forms: Decimals, fractions, etc.". There was also the alternative for students to state that they disagree with the above and write down their own opinion. According to our results, the fundamental presupposition is still robust in 11th graders. The form of the numbers defining the interval also constrains students' accounts of the intervals. For instance, students perform better when the numbers are integers. In addition, there is a strong tendency on part of the students to state that there cannot be any fractions between two decimals or any decimals between two fractions.

Acknowledgement
The present study was funded through the program EPEAEK II in the framework of the project "Pythagoras - Support of University Research Groups" with 75% from European Social Funds and 25% from National Funds.

The over-use of proportionality: Erroneous conception or scholastic effect?
*Wim Van Dooren[2], Dirk De Bock[3], and Lieven Verschaffel[1]

1 Center for Instructional Psychology and Technology, University of Leuven, Belgium
2 Postdoctoral Fellow of the Research Foundation, Flanders
3 European University College Brussels, Belgium

Due to its wide applicability, the proportional idea gets a central place in mathematics and science curricula. In the long run, however, schooling experiences and the intrinsically simple, self-evident character of the proportional idea cause a deeply entrenched tendency in students to apply proportionality "anywhere", also when this is inadequate. The ubiquity of proportional relations seems to become part of students' "framework theory", and proportional strategies become a panacea for solving mathematical and scientific problems. This may create a conceptual obstacle for students, and hinder future learning and problem solving.

The most intensively studied case of over-use of proportionality is the widespread belief that if a figure enlarges k times, the area and volume increase k times too. A series of studies showed that even with considerable support, students only rarely shift away from proportional reasoning for such problems. In these studies, however, the phenomenon was observed with collective tests containing school-like word problems. This may have influenced the results. Research suggests that students perform differently when mathematical problems are disentangled from their scholastic chains and embedded in meaningful, authentic activities. The current study aims at investigating this effect with respect to students' over-use of proportionality.
72 sixth graders – who on a pretest over-relied on the proportional model – were involved in individual interviews. They were distributed over three interview conditions:

- S-condition: The student solved another non-proportional problem, formulated as a typical school-like word problem.
- D-condition: The student got the same word problem, together with a drawing.
- P-condition: The student was introduced in the real problem context with the real materials, and needed to do a meaningful task or performance.

The results showed that the provided drawings had a positive effect on students' answers, but offering problems as performance tasks had a stronger beneficial impact. 21 of 24 students in the S-condition approached the word problem proportionally. 2 made another error and only one found the correct solution. In the D-condition, 8 of 24 students approached the word problem proportionally and 16 gave the correct answer. In the P-condition, only 2 students applied a proportional approach, 2 students made another error and 20 answered

correctly. Generally, P-condition students who found the correct answer needed considerably less time than D-condition students, and were more strongly convinced about the correctness of their answer.
At a posttest (containing traditional word problems) taken shortly afterwards, nearly all students in the three conditions again over-used proportionality to answer a non-proportional problem, although it was mathematically similar to the one encountered during the interviews.

In sum, our study shows that the methodological choice to investigate students' over-use of proportionality with traditional, scholastic word problems is not a neutral one, since it affects students' solution behavior. When engaged in more meaningful, authentic tasks, students approach problems very differently, and are less inclined to over-use proportional methods. Our study additionally shows that the beneficial effect of meaningful, authentic tasks is merely temporary or context-specific, and has no influence on word-problem solving behavior later on, even not shortly afterwards.

13.30 - 15.30 Paper session B

(von Kochsalen)

Chair and discussant: Sandra Jovchelovitch, London school of Economic, UK

Differentiation and coordination in conceptual change

Ola Halldén and Åsa Larsson, Stockholm University, Sweden

In a study on seven years old children's conceptions of the shape of the Earth the hollow sphere model was discussed in terms of a compounded model. It was argued that the culturally accepted view of the Earth is a differentiated model. Based on these and other, similar findings it was hypothesized that conceptual changed involves continuous processes of assimilation into one conception and a simultaneous differentiation within this compounded conception. So, it is conceivable that it is the differentiation process that eventually results in conceptual change. The model for conceptual change would thus be a process of assimilation into a compounded conception A together with a simultaneous process of differentiation eventually resulting in a conceptual change into the conceptions A1 and A2 (fig. 1).

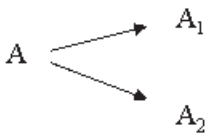


Figure 1. Conceptual change as differentiation.

In an ongoing study on children's conceptions of the Earth 37 children will be interviewed every year between their being four to six years of age. The first two interview sets have been completed, and here preliminary results from the first round will be presented.

When asked to draw a picture of the earth 14 children draw one or several circles, 15 children made a drawing related to the ground or the soil, and 8 children seemed to have no idea about the word earth. During the interview a picture of the Earth was shown and when seeing this 10 out of the 15 children who had drawn the ground or the soil began to speak about the earth as a globe. For the children it looks like the word "earth" has two different and quite distinct meanings.

When confronted with the problem where people live the children tried different solutions. For most of the children it was quite clear that we live down here and not on an earth up in the sky. In order to account for the picture on the spherical earth some children equated it with the moon or other planets and concluded that people do not live in these places. Other looked at the picture as a map and said that people live on this ground, but still there also for these children was an earth up in the sky. For these children, however, the picture sometimes was handled as a picture of the global earth and sometimes as a picture of the ground where people live. In this sense these children can be regarded as having some sort of dual model of the Earth.

So far, from our interviews, it seems reasonable to conclude that conceptual development involves starting with two quite diverse conceptions, followed by a merger of them into a single compounded conception, and finally a differentiation within that compounded conception leading to a new differentiated conception. Thus, we would get at the following conceptual change pattern:

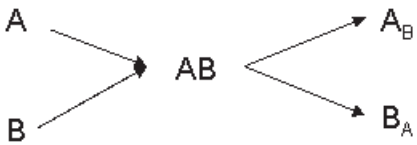


Figure 2. Two conceptions, A and B, integrated into one compounded conception, AB, that is differentiated into the two conceptions A_B and B_A.

Mental models of the earth reassessed I: Adults' responses to children's tasks.
*Nobes Gavin and Panagiotaki Georgia, University of East London, UK

In this paper we report three studies that investigated the claim that children have naïve mental models of the earth (e.g., Vosniadou & Brewer, 1992). These researchers and their colleagues have asked children to draw or make play-dough models of the earth, and to answer questions such as "what is below the earth?" and "does the earth have an edge?" The children's responses have led these investigators to conclude that children are influenced by strong constraints ('entrenched presuppositions') of flatness and support, and that children construct their own theory-like views, such that the earth is flat, hollow with people living inside, or that there are two earths – one flat and another round one in the sky.

In the first of our studies, adults (N=350) were given the drawing task that the mental model theorists gave to children as young as five years. Fewer than half of the university students drew the earth in the expected 'scientific' way, and 15% drew flat, hollow or dual earths that were indistinguishable from young children's. Responses to the questions were equally startling: for example, half described people as living 'on top' or even 'inside' rather than 'around' the earth. Follow-up interviews revealed that, while some of the adults had poor understanding of the earth, none believed the earth to be flat, hollow or dual. The respondents' written and verbal comments indicated that their apparently 'naïve' responses resulted from their misinterpretation of the apparently simple instructions and questions.

The second study systematically explored these possible reasons for adults' 'naïve' responses. Students (N=484) were given either the original drawing task or a new version in which the same questions and instructions were rephrased to minimise the ambiguities and confusion revealed in the first study. For example, respondents were told to imagine that they were in a spaceship looking down on the earth before they were asked to draw it. Non-scientific responses were substantially reduced: 4% drew flat, hollow or dual earths, and naïve answers to questions dropped to 20% or less.

In the third study adults (N = 59) were given Vosniadou and colleagues' (2004) model-making task. Almost a quarter made the models that Vosniadou and her colleagues have interpreted as showing that children believe the earth to be flat, hollow or dual.

Together, these studies indicate that 'naïve' representations of the earth are drawn and made, and non-scientific answers given, because the instructions and questions are ambiguous and challenging. The mental model theorists' apparently simple tasks – designed for young children – confuse even university students. These findings explain the discrepant results of previous studies with children, and support the view that, in this domain, children do not have strong constraints or mental models (e.g., Nobes et al. 2005; Panagiotaki et al., 2006; Siegal et al., 2004; Schoultz et al., 2001). We will discuss the implications for methodology and for our understanding of children's and adults' (sometimes misleading) sensitivity to situational influences within the context of the research interview.

For developing successful learning strategies in teaching: the analysis of students' ideas
Burckin Dal, Istanbul Technical University, Istanbul, Turkey

Conceptual understanding, and especially the pre-instruction notions held by students, is widely addressed in science, especially in physics and chemistry with research in biology primarily focusing on subdisciplines, such as evolutionary biology. Similar studies in the Earth Sciences are more limited than in other disciplines, especially at the undergraduate level. The present article covers students' conceptions that we have collected. Students were probed on a variety of topics related to the Earth's crust and interior. We describe them using the same modalities as were used to collect these conceptions. They are then related to different formulations, organised into a network, of linked concepts. The aim of this presentations is to relate the conceptions of students, the obstacles that have been spotted and the possibilities of overcoming them.

Developmental Shifts in Children's Categorizations of the Earth
*Irini Skopeliti and Stella Vosniadou, University of Athens, Greece

In this paper we present the results of an empirical study (Vosniadou & Skopeliti, 2005) which investigated the hypothesis that there is a theory change in the development of children's categorizations of the earth. Vosniadou and her colleagues (Vosniadou & Brewer, 1992; Vosniadou, Skopeliti, & Ikospentaki, 2004; 2005) argued that the main reason why children have difficulty understanding the spherical earth shape is because they spontaneously categorize the earth as a physical object (rather than as a solar object) and apply to it the presuppositions of physical objects (i.e. solidity, stability, up/down gravity, etc., Spelke, 1991).

In the present study we investigated elementary school children's categorizations of the earth as well as their beliefs about the shape of the earth. However, the hypothesis that children categorize the earth as a physical object has not been investigated directly. Sixty-two children, 43 1st graders and 19 5th graders, were interviewed individually using a Categorization and an Earth Shape Task.

The results of the study confirmed our hypothesis that there are theory-based categorization shifts in cognitive development and particularly in children's concepts of the earth. While most of the 1st graders categorized the earth as a physical object, this was not the case for the 5th graders who categorized the earth with the solar objects. By 5th grade, most children categorized the earth as a solar object and were able to provide theory-based justifications of their categorizations. Further, high correlations were also obtained between the categorization of the earth and the understanding of its spherical shape, supporting the idea that the shift from categorizing the earth as a physical object to categorizing it as a solar object is probably a prerequisite to a full understanding of the spherical earth shape.

Acknowledgment
"This publication is part of a Ph.D. dissertation which is financially supported by the grant IRAKLEITOS - Fellowships for Research of NKUA- from the Greek Ministry of Education. The project is co-financed within Op. Education by the ESF (European Social Fund) and National Resources."

The Situated Analysis of Conceptual Models
*Gunilla Petersson, Liza Haglund and Åsa Larsson, Stockholm University, Sweden

The aim of this paper is to describe and exemplify with empirical data a model of intentional analysis in order to grasp and make meaning of children's conceptions about an object or a phenomena in a specific situation. The model takes it point of departure in von Wright's (1971, 1979) definition of action and Davidson's (Davidson 2001) principle of charity. The intentional analysis is a further development of Piaget's clinical method (Halldén 1999). Both Piaget's clinical method and the model of intentional analysis depart from a constructivistic view of conceptual development, acknowledging how cognitive structures are constructed in interaction with the individual's surroundings.

16.00 - 18.00 Symposium in honour of Guyo Hatana

(Vårgårdsalen)

Organizers: Ola Halldén, Stockholm University, Sweden and Stella Vosniadou, University of Athens, Greece

Chair: Ola Halldén, Stockholm University, Sweden

Presenters:
Gregg Solomon, National Science Foundation, USA
Lucia Mason, University of Padua, Italy
Peter Bryant, Oxford Brookes University, UK
Roger Säljö, President of EARLI, University of Gothenburg, Sweden
Stella Vosniadou, University of Athens, Greece
Terezinha Nunes, University of Oxford, UK

Thursday, June 15th

8.30 - 10.00 Keynote addresses & Panel discussion

(Vårgårdsalen)

Chair: Gunilla Petersson, Stockholm University, Sweden

Text comprehension and beyond: Situated aspects of document use
Jean-François Rouet, University of Poitiers, France

New knowledge is often acquired through the reading, comprehension and use of textual materials. Current psychological theories define text comprehension as ageneralized, context-free activity in which readers encode linguistic information and use it to construct memory representations, or "mental models" of the situation described in the text. I will stress some limitations of this view, especially when considering the use of texts as documents in learning situations. I will introduce a theoretical framework aimed at overcoming such limitations, by taking into account situated and pragmatic aspects of document comprehension. The framework rests on the assumption that there is more to text comprehension than the mere construction of an internal representation of the text's semantic content. Instead, the use of texts in purposeful situations is fundamentally dependent on the goals that readers set for themselves, on their mastery of scanning and other search strategies, and
on their awareness of genres, sources and authors' purposes. Such a framework adds to existing theories of text comprehension by explaining why students sometimes find themselves unable to make use of document information, even though they may achieve a reasonable level of understanding of the text's semantic contents. The framework also sets an agenda for literacy instruction at the age of information technology.

Panel discussion

Andrée Tiberghien, University of Lyon, France
Erno Lehtinen, University of Turku, Finland

10.30 - 12.30 Paper session A

(Vårgårdsalen)

Chair and discussant: Mario Carretero, Autonomous University of Madrid, Spain

Conceptual change based on the development of conceptual categories: The change in Taiwanese eighth graders' concept of mass

*Chih-Wen Tsai, Yenchao Junior High School, Kaohsiung, Taiwan, Ching-Yang Chou, National Kaohsiung Normal University, Taiwan

This paper probes into the system and the dynamic process of change in Taiwanese eighth-graders' concept of mass when conducting the acid-base neutralization experiment. Microgenetics, incorporated with cognitive-historical analysis and representing agency, is adopted and further developed into microgenetic analysis. During the acid-base neutralization experiment, semi-structural interview on students' concept of mass is conducted in order to gather verbal and non-verbal data for analysis. The audio recordings and videotapes are transcribed and semantically analyzed through microgenetic analysis. The characteristics of different concepts serve as criteria in coding and categorizing keywords. Students' development of conceptual categories and their interaction are then established, detailing the system and dynamic process of the change in the concept of mass.

The findings of this paper are: 1. Each student's conceptual change is highly correlated to the development of his/her conceptual category, with conceptual change being a unique phase in the development of conceptual category; 2. Conceptual change is triggered by external factors such as observation during experiment, questions posed by instructors as well as internal factors such as analogical reasoning and thought experiment; 3. Conceptual change involves four steps: internalization, cognitive revision, concept application and example citing.

Categorizations of Substances in Relation to Explanations of Changes in the State of Matter

*Rania Gikopoulou and Stella Vosniadou, University of Athens, Greece

In this paper we present the results of an empirical study which compared elementary school children's and university students' categorizations of substances in relation to their explanations about changes in the state of matter. We argue that the main reason why children have difficulty in understanding the scientific explanations of changes in the state of matter is because they categorize substances based on their physical state (solid, liquid, gas) rather than on their chemical structure (pure substances, mixtures) and apply to them the properties of the corresponding state (i.e. solids are rigid, liquids resemble water, etc.). Based on previous studies (?ouka, Vosniadou, & Tsarpalis, submitted) we hypothesized that elementary school children will categorize substances based on a physical theory of matter only. Unlike previous studies in astronomy where we observed theory-based categorization shifts even in elementary school children (Vosniadou & Skopeliti, 2005), we hypothesized theory-based categorization shifts only in Chemistry students' categorizations of substances (based on their chemical structure) and not in the categorizations of children or even in the categorizations of university students who did not study science.

The subjects of this study were 84 elementary school children, 42 2nd graders and 42 6th graders, and 36 university students, 20 of Chemistry and 16 of Philosophy and History of Science (PHS) from the University of Athens. They were all given a Categorization Task and a Change of State of Matter Task. The elementary school children were interviewed individually and the university students completed a questionnaire. At the Categorization task they were asked to put together 12 objects which could be categorized either based on their physical state or their chemical structure. At the Change of State Task they were asked questions about the change of state and the chemical structure of matter.

With respect to elementary school children, the results showed that most 6th graders categorized substances based on their physical state and were able to provide theory-based justifications of their categorizations, but this was not the case for 2nd graders. All elementary school children also had difficulty in understanding the scientific explanations of changes in the state of matter. With respect to university students, PHS students categorized substances based on their physical state, like 6th graders, and also faced difficulties in the Change of State Task. Only chemistry students categorized substances based on their chemical structure and were able to provide scientific explanations about the changes in the state of matter.

The results of the study confirmed our hypothesis that there are theory-based categorization shifts only in Chemistry students' categorizations of substances. High correlations were also obtained between the categorization of substances and the understanding of Change of State, supporting the idea that the shift from categorizing substances based on their physical state to categorizing them based on their chemical structure is probably a prerequisite to a full understanding of the Change of State of Matter.

Proportionality as a conceptual obstacle: Considerations from a dual-process framework

*Ellen Gillard[1], Wim Van Dooren[12], Walter Schaeken[3], and Lieven Verschaffel[1]

1 Center for Instructional Psychology and Technology, University of Leuven, Belgium
2 Postdoctoral Fellow of the Research Foundation, Flanders
3 Laboratory for Experimental Psychology, University of Leuven, Belgium

Proportional reasoning is useful in many everyday life situations. It takes a central place in the school mathematics curriculum, where it is often trained with missing-value problems (three numbers given, a fourth is unknown). Research has, however, demonstrated that students often over-use proportional methods. E.g., most 6th graders answer "90" to the non-proportional problem "Ellen and Kim are running around a track. They run equally fast but Ellen started later. When Ellen has run 5 rounds, Kim has run 15 rounds. When Ellen has run 30 rounds, how many has Kim run?"

Previously, we interpreted the phenomenon both from a 'mental model' perspective (the ubiquity of proportionality becomes part of students' 'framework theory', creating a conceptual obstacle hindering future learning) and from a 'situated cognition' viewpoint (classroom missing-value word problem solving is a contextually situated practice, and gets associated with proportional reasoning). We claim that a dual-process account (e.g., Stanovich & West, 2000) may bridge the gap between both kinds of explanations for students' thinking.

According to dual-process theorists, there are two distinct cognitive reasoning systems:

- S1 (heuristic system): Automatic, associative and undemanding of computational working memory capacity.
- S2 (analytic system): Controlled, deliberate and effortful, thus heavily demanding of computational working memory capacity.

S1 responds rapidly, based on similarity to stored prototypes. S2 operates on 'decontextualized' representations, is serial and time-consuming. Fast S1-heuristics often provide correct responses, but sometimes, S2 needs to override responses generated by S1 to obtain correct responses. Hence, a failure to provide the normatively correct answer may be attributed to the pervasiveness of S1.

We suggest that, due to the omnipresence of proportionality and the extensive classroom exercising of proportional methods (e.g., Van Dooren, 2005), a 'proportional heuristic' is created as part of S1, which is triggered by contextual features related to 'solving missing-value word problems in classroom'. Students' over-use of proportionality is then attributed to S1's pervasiveness and S2's failure to intervene.

We conducted an experiment to test three key assumptions of this dual-process account, namely: when solving non-proportional missing-value problems,

(1) (inappropriate) S1-based proportional reasoning is fast and relatively undemanding of working mem ory capacity;
(2) correct reasoning, based on S2-intervention, is slower and demands more working memory capac- ity;
(3) burdening working memory, which hinders S2-intervention, results in more proportional answers, but also in faster reaction times compared to correct answers.

In individual computer-based sessions, 90 6th graders solved various non-proportional missing-value prob- lems. For half of them, working memory capacity was experimentally burdened using a secondary task. The analysis of answers and reaction times generally confirmed the above-mentioned assumptions for some non- proportional items, but not for others.

In sum, a dual-process account of the over-use of proportionality combines the explanation of problem solv- ing behaviour in terms of contextual features (stored prototypes eliciting S1-heuristics) with similar responses recurring over different situations (various response types may have similar heuristic roots), hence accounting for transfer of knowledge. Individual differences in performances in similar situations can be explained in terms of fluctuations in available working memory capacity.

Eye movement measurement as a method for tracing cognitive conflict in reading science text

*Mirjamaija Mikkilä-Erdmann, Erkki Anto, Marjaana Penttinen and Riitta Kinnunen, University of Turku, Finland

During recent years there has been lot of research on conceptual change (Limón & Mason 2002). Previous studies have mainly focused on outcomes of interventions while the process has remained unexplored. Hence, the target of this study is to investigate how cognitive conflict works as an indicator for the process of concep- tual change during on-line reading and how the conflict could be traced using eye movement methods.

Eye movement research has been unexploited in the areas of cognitive conflict and conceptual change. Eye movement research has been traditionally used for studying text processing on the word or sign level (Rayner 1998). Recently the interest and possibilities of expanding the focus of the studies on science text reading have increased (Mikkilä-Erdmann 2002). Eye movement research has proved that cognitive processes can be traced during reading (Hyönä, Lorch & Rinck 2003). Furthermore, cognitive conflict has been accepted as at least one of the elements of conceptual change (Kang, Scharmann & Noh 2004). Hence, the goal of this study is to find out if cognitive conflict can be seen in eye movements during text processing.

The participants were thirty 11-12 year old children from a local primary school. The participants read a science text concerning photosynthesis in a laboratory where their eye movements were recorded using the EyeLink II equipment. Pre-test-post-test- design was used.

While analysing data a concept called ”look from time” proved to be useful. Look from time describes the time the reader spends fixating to other sentences while reading one.

The participants were divided in three groups based on the change of scores in questions measuring concep- tual change from pre-test to post-test. Group one showed either no change in their scores or even occasional regression. Group two slightly improved their scores from pre-test to post-test. Group three improved their scores for more than 20 percent and were seen to have experienced conceptual change to some extent.

To compare groups one and three a paired samples t-test was conducted. Those participants who experienced conceptual change had a significantly longer look from time than members of group one. While assuming cog- nitive conflict to be a possible route to experiencing conceptual change, the results indicate that look from time may be a useful way of tracing cognitive conflict in reading process. We see the eye movement research as a new challenge for learning more about inducing cognitive conflict in reading process.

10.30 - 12.30 Paper session B

(von Kochsalen)

Chair and discussant: John Leach, University of Leeds, UK

Patterns of Conceptual Change: The Development of Elementary School Students' Explanations of "Floating and Sinking"

*Ilonca Hardy, Michael Schneider, Angela Jonen, Kornelia Möller, and Elsbeth Stern, Max Planck Institute for Human Development, Germany

Conceptual change may be characterized as the restructuring of (naïve) concepts of science phenomena whereby students link newly constructed scientific ideas to current concepts, refining or dismissing them in case of incommensurability. During this process, misconceptions may re-occur, or else are kept simultaneously with new explanations, leading to fragmented knowledge. In a repeated measures design (pretest, posttest, one-year follow-up) with 161 elementary school students, we investigated patterns of conceptual change with regard to students' explanations of "floating and sinking" in two constructivist learning environments differing in degree of instructional support, including a baseline group without instruction (see Hardy et al., submitted). Three sum scores reflecting different levels of conceptual understanding were computed from a total of 33 multiple-choice items, labeled as misconceptions such as a one-dimensional focus on size or weight, explanations of everyday life such as the concept of material kind, and scientific explanations focusing on density and buoyancy. The items allowed to score both the correct rejection of misconceptions and the adoption of scientific and everyday explanations with regard to objects' behavior in water.

Three research questions were investigated: (1) Which are the interrelations between the levels of conceptual understanding, and do they change over time? (2) Is it possible to identify differential patterns of development with regard to students' levels of conceptual understanding? (3) Are the relations among conceptual levels moderated by different forms of instruction? In a first step, a path model allowing scores of conceptual understanding to correlate with each other at each measurement point was employed. Each score at t=2 was predicted by all scores at t=1, and each score at t=3 was predicted by all scores at t=2. Results showed that at each measurement point, correlations between explanations of everyday life and scientific explanations were relatively high, while misconceptions correlated only modestly with these scores. Surprisingly, while individual differences predicted development within levels of understanding, there were no significant influences of conceptual scores across levels of understanding. For example, the extent to which students held misconceptions at the pretest did not predict their ability to construct scientific explanations in the instructional unit or to adhere to these explanations one year after the instruction. In order to identify individual developmental paths, we computed latent class analyses where a comparison of mean scores at each measurement point allowed the identification of six patterns. Three of these were characterized as integrated understanding, where misconceptions decreased significantly through instruction and scientific explanations increased, while three patterns showed fragmented understanding, where misconceptions were kept simultaneously with newly constructed explanations. While fragmented conceptual understanding was most prominent with the baseline group, a total of 35% of the instructional groups could also be located in these classes. Further research needs to investigate the processes by which instruction may facilitate or hinder this complex interplay between levels of conceptual understanding.

Children's conceptions about floating and sinking: A microgenetic approach

*Pnevmatikos, D., Kariotoglou, P. and Nikolopoulou E., University of Western Macedonia - School of Education, Greece

In recent 20 years contemporary cognitive developmental theorists agreed children's cognitive structures should not be modelled as systems of logical operations but as systems for making meaning. During the decade followed the first critiques of the Piaget's theory, several different lines of inquiry have been pursued.

Theory-theorists focused on the content of the acquired knowledge and view children's knowledge as qualitative different from that of adults. *Neo-Piagetian* theorists support the notion that development is still strongly influenced by factors of a general-maturational nature and the dynamic interplay of these factors propels development through a set of powerful reorganisations that cannot simply be reduced to cumulative learning.

Only few investigators, however, offered balanced accounts of content and process, but in limited domains such as arithmetic (e.g. Siegler, 1996) and more recently biology (Opfer & Siegler, 2004). The *microgenetic* approach proposed by Siegler has been applied to study development of procedures, rules and strategies and it almost rarely has been applied to study the acquisition of declarative knowledge, such as that involved in conceptual development. Thus, the purpose of the present study was to examine the usefulness of the method for informing our understanding of conceptual growth. This framework distinguishes among five dimensions of cognitive growth: its source, breadth, path, rate, and variability. These five dimensions might be useful also to study particular aspects of concept development. In the present study we will present the application of this framework to the dimension of the *path of change* (the sequence of strategies or knowledge states through which children progress while gaining competence of the concept) in the concept of floating – sinking.

Method

Participants
Sixty four children (4x16) of 5.5, 7.5, 9.5 and 11.9 years of age examined.

Tasks
Children's task in the four experimental conditions was to predict the place that an object will balance in a vessel containing water, given its balance in four different conditions: changing the size of the vessel (larger/smaller) and changing the size of the immersed object (larger/smaller).

Results

Most of the children found to use systematically three complex rules (e.g. the heavy/light objects are sinking/floating) which constrain them to solve the tasks and one simple rule which allow them to solve the task in a scientifically accepted way. The scientific solution of the tasks demands the use of a simple rule applied in an absolutely different ontological field: from the filed of extensive quantities (e.g. the volume of water) to the field of intensive quantities (e.g. the relation of densities between the object and the water. Thus, microgenetic methodology revealed that the difficulties in conceptual change sometimes reflect the difficulty children have to shift from one ontological category to another, and do not always reflect the complexity of the rules which are demanded to the conceptual change process. Consequences of this evidence to educational contexts are discussed too.

Is there a Theory of Conceptual Change (CC)? (Is CC a good label?)
Shoshana Keiny, Ben-Gurion University, Beer-Sheva, Israel

Research on Conceptual Change began by investigating students' conceptions in different Science topics, such as Growth and Health (Schaeffer), Photosynthesis (Driver et al.), Energy (Glasersfeld), Force (diSessa), Day night cycle (Vosniadou), etc. The leading paradigm postulated by Posner that guided research reduced conceptual change to the cognitive aspect of learning. "Cognitive conflict" was thus accepted as the best answer (Posner et al, 1982). Yet, "meta-cognitive awareness" a necessary condition for conceptual change, was not sufficient. Going beyond the "cold" cognition, affective factors like motivation (Pintrich, 1993) students' prior knowledge and their epistemological beliefs were investigated (Cinn & Brewer, 1993; Vosniadou, 1994).

The alternative model suggested by the Phenomenography School, is an experiential perspective that depicts conceptions as being characterizations of catagories of description reflecting person-world relationships

(Merton & Booth, 1989; Linder, 1993). Accordingly, conceptual change is achieved by changing one's relationship with the context, by being able to perceive the context differently, indicating that one has changed as a person. It follows that instead of focusing on alternative conceptions, or students' strong resistance to change their preconceptions, our aim as educators, should be to develop new meaningful relationships between students and the new contexts introduced within the educational environment. Another argument posed by Wiser is whether conceptual change is revolutionary, namely a paradigm shift, or evolutionary, a process of learning that allows students a fundamental ontological reorganization? (Wiser et al 2001) We agree that it is both revolutionary and evolutionary. That leads us back to our focal question whether there is at all a theory of conceptual change? This study was designed to cope with the question, by providing better understanding of the micro processes of conceptual change, within a collaborative learning context.

Our context of research is Collaborative Action Research. We facilitate different groups of teachers, principals and administrators within the educational system, whose aim is to bring about radical change of educational orientation. We contend that a collaborative context encourages a confrontation of different ideas, which fosters meta-cognitive awareness of one's own conceptions. On the other hand, learning within the group is dialogical seeking for mutual understanding and new meaning thus yielding conceptual change.

Our case study is a group termed "the discourse group" consisting of 6-7 participants, each of which acts as facilitator of an educational change project. We have been meeting regularly for 6 years with the aim of gaining deeper understanding of collaborative learning and conceptual change of both the individual participant and the group. All our meetings are recorded transcribed and serve as data base for discourse analysis. By using the methodology of "semiotic evolution", we shall show how the Group Reality serves as template for the conceptualizing the participants' experiential input (Individual Sensual Reality). In other words, how we can trace conceptual change in the group discourse.

Constructing Knowledge in Teacher Training By A New Institutional Organization of Knowledge
Sarit Segal, Levinsky College of Education, Israel

Educational institutions are usually reviewed from the point of view of their learned contents or of their teaching methods, or by the interactions between contents, teaching and the interests and the macro-social structures. Teaching and contents are, of course, key constituents of the teachers' training system as well, however, the characteristic educational discourse focusing exclusively on these two, misses in most of the cases a fundamental constituent having important implications on both of them. This constituent is called the "institutional organization of knowledge".

Institutional organization of knowledge is the system for arranging knowledge which precedes the activity of teachers in the classroom (teaching) and the subject matter learned (the curriculum). Every organization of knowledge creates an environment, which serves particular cognitive purposes, and counters other ones. The organization of knowledge in school is designed to realize a particular aim – the inculcation of existing knowledge. Simultaneously, knowledge is organized at the university level with a different aim in mind – the production of new knowledge. The problem is that till now no model of institutional organization of knowledge has been created whose goal is the development of pupils' cognition.

> * We need a new organizing framework for educational knowledge intended specifically for constructing knowledge in teacher education. We propose such a framework, a '*pedagogical discipline*', which is different in nature from the '*school subject*' of the present schools, and from the '*research discipline*' of the university. Among the characteristics of this differentiation are: The cognitive aim, preferred performance, structure of questions, selection of knowledge, Sources of information, Spread of knowledge and ways of thinking.

Colleges, that organize knowledge in a school-like fashion, perpetuate this approach and produce teachers

who continue to discourage pupils from active construction of knowledge. Thus, *if programs devoted to designing thinking-oriented teacher training do not focus on a structural change of the institutional organization of knowledge in colleges and the cognitive environment it creates, it will be virtually impossible to turn them into knowledge- constructing-oriented institutions.*

Our model proposes this kind of a structural change in the approach to teacher training. It is intended to undermine the structured concepts and substitute them with more productive ones. Its central pillar is a new organizing framework for developing thinking – a '*pedagogical discipline*', which is different in nature from the 'school subject', the basis for the present organization of knowledge in schools, and from the 'research discipline' of the university.

Characteristics	**Existing model**	**Proposed model**
The cognitive aim	Inculcation of pedagogical and disciplinal knowledge	Development of pedagogical thinking based on constructive disciplinal knowledge
Spread of knowledge	Multiple formal courses studied sequentially in fixed time units	Problem-based learning in flexible time units and flexible social learning groups
Preferred performance	Examinations and pseudo-academic papers	Papers focused on pedagogical dilemmas analyzed from a variety of perspectives
Structure of questions	Closed questions	Open-ended questions
Selection of knowledge	"Accepted" knowledge selected by the teacher trainer	Emphasis on disciplinal insights and conflicts between them
Sources of information	Secondary sources (teacher lectures, miscellaneous texts)	Variety of sources (texts, lectures, observations, interviews, field research)

10.30 - 12.30 Paper session C

(Örnesalen)

Chair and discussant: Andrée Tiberghien, University of Lyon, France

Conceptual Change in the History of Science as a Tool in Physics, Astronomy and Cosmology Teaching

Alicia Camilloni, University of Buenos Aires, Argentina, and *Marcelo Leonardo Levinas, University of Buenos Aires, Argentina.

Our main objective is to find the way to ensure students' awareness of the process of conceptual change of scientific concepts. We have some relevant experience in the field of social sciences introducing problematic situations to produce conceptual change, following the historical development of basic concepts, and analyzing historical contexts (Camilloni and Levinas, 2001). For the present work we have chosen a similar approach, combining many relevant physics, astronomy and cosmology concepts, and taking into account their development in different historical contexts. In our theoretical framework, we pay special attention to some controversial issues such as continuity or discontinuity in scientific knowledge, stability or instability in the generation of explanations, coherence or fragmentation, and borrowing or ownership of knowledge. We aim to help students to deal with some relevant science problems, to understand some key scientific concepts and explanations, and to develop some relevant notions about science. We don't work with rational reconstructions; we take into account the historical and cultural contexts: "Rational reconstructions are ultimately ahistorical in nature. Where the aim is to convey process of science, by contrast, teachers should highlight the historical context of a case. Ideally, students should have the sense that they are peering over the shoulders of working scientists, while having the opportunity to make decisions in their stead" (Allchin, 2000).

We aim at proving the effectiveness of conceptual change when students achieve a deep and conscious understanding of the *assumptions* underlying the "old" and the "new" theory, the "right" and the "wrong" explanation. The crucial factor is the understanding of the differential epistemic nature of theoretical propositions, hypothesis, assumptions and data. We have designed some didactic activities making use of the history of science as an organizing tool: some scenarios are built to make understandable the reasons why some theories were accepted, rejected and replaced with modern theories. We introduce sequences and select some understandable and relevant scientific problems taking into account their motivational potential and the challenging stimulus they represent to students. Our idea is to present and discuss interesting phenomena and some of the so-called crucial experiments (mental or real) in their respective contexts that allow different and fruitful interpretations by alternative theories. In each case, we specifically aim at the identification of the *fundamental* hypothesis and the *auxiliary* hypothesis needed to support it. The interesting history of the concept of *Earth* (the controversies about its shape, size, position, movement) is taken as the core of the sequences. We find that this is a natural way to introduce and discuss fundamental concepts such as: trajectory, cause of movement, inertia, mass, natural place, weight, force, planet, sun, orbit, season, day and night, etc.

The idea is to promote a comparative analysis of relevant scientific theories in the framework of their construction in a collaborative learning task discussing and evaluating its breath and consistency. We pay special attention to the problem of assessment, being the theories about conceptual change a real challenge to the theory of formative and self-evaluation. Therefore, self-assessment, both individual and collective, is an important constituent of our proposal. Coherence among the principles of teaching, learning and assessment requires the development of student's metacognitive knowledge and regulation in order to achieve conscious and intentional conceptual change.

Changing Epistemological Beliefs: The Surprising Impact of a Short-term Intervention
*Dorothe Kienhues, Rainer Bromme, and Elmar Stahl, University of Muenster, Germany

In the study presented here we investigated the potential for influencing epistemological beliefs through a short instructional intervention.

Many studies on epistemological beliefs, which are beliefs about the nature of knowledge and knowing (Hofer & Pintrich, 1997), indicate that more naïve beliefs are linked to poorer learning strategies and thus lower performance, whereas sophisticated beliefs facilitate the learning process in various ways. Due to this fact, it seems desirable for teaching to have instructions at one's disposal for fostering the change of epistemological beliefs. Nevertheless, up to now very little evidence on the potential influence of instructional impact on epistemological beliefs exists.

We assume, in line with Bendixen (2002), that fostering changes in epistemological beliefs is similar to the challenge of promoting conceptual change. One method often and successfully used for fostering conceptual change is that of refutational text (Allen, 1991; Guzzetti, Snider & Gamas, 1993). In this study, we therefore investigate the influence of a refutational instruction on epistemological beliefs about genetics (DNA-fingerprinting), which we compared to the impact of the "mere" presentation of information about this topic (informatory instruction). To investigate possible interactions between pre-existing beliefs and kind of instruction, we put emphasis on two different groups of learners, one with stronger naïve epistemologies and the other with stronger sophisticated beliefs (ntot=58). In matching the different instructions with the groups of differing beliefs, a two-by-two design framing four research groups emerged.

We hypothesized a change in epistemological beliefs towards a more sophisticated view for the naïve group receiving the refutational instruction. We did not expect any significant changes for the other research groups.

To determine whether the different instructions were effective in influencing epistemological beliefs, pre-instructional and post-instructional beliefs, measured by Hofer's instrument (DEBQ, 2000) and the CAEB by Stahl and Bromme (submitted), were compared. The most central finding was that - with regard to the CAEB - the naïve refutational group and, against expectation, also the sophisticated informatory group yielded significant changes between the two measurement phases. While the former changed towards a more sophisticated view, the latter became more naïve in comparison to the initial evaluation of beliefs. Accordingly, only the groups receiving instructions which did not support their initially view changed. The direction of change was a function of the instructional content. The results will be considered with regard to the importance of cognitive conflict or epistemic doubt for changes in epistemologies. It will be discussed that the results differed depending on the instruments regarded. All in all, it has to be emphasized that a short-term intervention can provoke changes in epistemological beliefs. Ideas for educational instruction will be presented.

The Educational Model For Personal Epistemology Enhancement
Florian C. Haerle, University of Nevada, USA

Personal epistemology, the beliefs of individuals about the nature of knowledge and knowing, has been subject to empirical research over the last thirty-five years. A considerable body of research provides evidence for its relevance for learning in general (e.g., Hofer & Pintrich, 2002), and its impact on conceptual change learning in particular (e.g., Mason, 2003). Different frameworks have been established that conceptualize the development (e.g., Kuhn, 1991) and the dimensionality of personal epistemology (e.g., Hofer & Pintrich, 1997). However, none of these frameworks provide specific educational implications on how these beliefs can be addressed during classroom teaching in order to be enhanced and/or to foster more fruitful conceptual change learning.

In this presentation I will propose the Educational Model for Personal Epistemology Enhancement (EMPEE) that is partially based on empirical research but also draws from theoretical models in personal epistemology

(Bendixen & Rule, 2004; Hofer, 2001) and conceptual change models in curriculum and instruction (Kattmann, Duit, Gropengiesser, & Komorek, 1996; Westphal, 1990). EMPEE is conceptualized, first, to explain how different epistemological factors can influence the personal epistemology of learners in classroom teaching (see Figure 1). These factors are the Learners' personal epistemology (i.e., learners' beliefs about knowledge and knowing), Teachers' personal epistemology (i.e., teachers' beliefs about knowledge and knowing), Epistemic knowledge representations (i.e., epistemological assumptions that underlie educational and scientific knowledge representations, such as school curricula and empirical publications), and Epistemic instruction (i.e., epistemological assumptions that underlie instruction). All interrelations between the four factors are explicitly described as reciprocal and depicted by double- headed arrows.

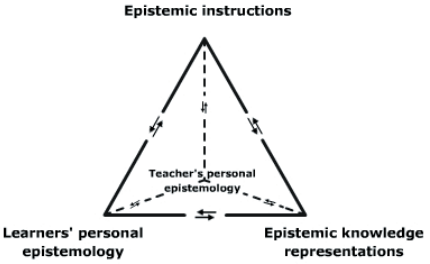


Figure 1: Educational Model for Personal Epistemology Enhancement

Second, EMPEE demonstrates how these factors can be taken into account to enhance learners' beliefs about knowledge and knowing in educational contexts. As a result, this can positively impact conceptual change learning (e.g., Mason, 2003), moral and argumentative reasoning (e.g., Bendixen, Schraw, & Dunkle, 1998), and self-regulated-learning (e.g., Butler & Winne, 1995).

Third, it also has the potential to describe the 'epistemic climate' of classrooms (Bendixen & Rule, 2004); that is, the overall nature of knowledge and knowing emerging from all four factors in a classroom and their reciprocal relations. Finally, EMPEE provides a framework to address the epistemological aspects of curriculum development, teacher education, and scientific research in education and educational psychology.

The model compensates for the shortcomings of existing models. For instance, the models in the field of personal epistemology (Bendixen & Rule, 2004; Hofer, 2001) focus solely on how factors influence personal epistemologies in research context (i.e., personal epistemologies of learners and teachers), while conceptual change models in the field of curriculum and instruction (Kattmann, et al., 1996; Westphal, 1990) are exclusively dedicated to providing theoretical guidelines on how to teach and what to teach to foster learners' personal epistemology in educational contexts (i.e., epistemic instruction and knowledge representations). Hence, this empirically and theoretically derived model is innovative for the following reasons. First, these four epistemological factors have not yet been integrated in this particular way. Second, these factors exclusively focus on epistemological aspects of education, which represents a new perspective on personal epistemology. Third, all interrelations between the four components are explicitly described as reciprocal. The incorporation of these aspects increases the model's explanatory power and its pedagogical relevance for learning and instruction.

Conceptual labs – experiences from a decennium of design and implementation
Jonte Bernhard, Linköping University, Sweden

One of the important aim of education should be to help students acquiring a "functional understanding" of the subject studied. Marton and Tsui (2004) have stated this as:
"Developing a learner's capability of handling novel situations in powerful ways, is considered to be one of the most important educational aims."

In engineering and in science education one implication of this is that students should learn to understand theories and models and their relation to objects and events in the "real" world and learn to apply these models and theories. Especially during lab-work students are expected to link observed data, to either theoretical models, or to the real world they are exploring. However a large body of research have shown that acquiring a functional understanding is problematic for many students and "traditional" teaching does usually not bring about insightful learning.

In this paper I will describe a series of projects designing and implementing "conceptual labs" which first started in the academic year of 1994/95 while I was employed at a smaller university in Sweden. This work was continued from 1999 at Linköping University and has mainly been focused on mechanics (students studying to become teachers and engineering students) and on electric circuit theory (engineering students).

Initially the projects were evaluated using conceptual tests such as the Force Concept Inventory (FCI) and the Force and Motion Conceptual Evaluation (FMCE). In later years an in-depth analysis of students' courses of action in labs using video-recorded data has also been made.

The approach taken in the design and implementation of these innovative curricula concur very well with the emergent paradigm described as "design experiments" (Brown, 1993; Cobb et al., 2003) or "design-based research". In line with this emergent tradition we will account for how our designs have functioned in authentic settings and focus on interactions that refine our understanding of the learning issues involved. The educational principles guiding the design will be presented together with data supporting their success. A common denominator of these curricula is that they use interactive technology and encourage active learning and peer co-operation. Systematic variation according to the theory of variation (Marton and Tsui, 2004) is introduced in the design of tasks and students' pre-conceptions are taken into account.

One of the conclusions from our data is that the traditional dichotomy between a lab being highly structured or open inquiry could be questioned. Rather the good learning results with our curricula are probably due to the labs being both highly structured in some sense and open inquiry in some sense (cf. "guided discovery") affording both variance and invariance in the learning space. However (cf. Bernhard, 2003) it has also been shown that learning is not determined by the technology but the design of the tasks. An analysis of the instructions in cases with poor learning results show that the necessary variation is not offered. By investigating how the students frame the activity and how different encounters shape their framing, we can further improve learning environments.

13.30 - 15.30 Paper session A

(Vårgårdsalen)

Chair and discussant: Hans Niddered, Mälardalens University

How different contexts can produce partial conceptual change: an example of a decisive crucial experiment

*Marcelo Leonardo Levinas, University of Buenos, Argentina, and Mario Carretero, Autonomous University of Madrid, Spain.

This paper attempts to make a contribution to the well-studied relationship between conceptual change theories and the history and philosophy of science (see, e.g., Giere, 1992; Hoddeson, in press). Nevertheless, we think there are still relevant unresolved problems in this area, such as finding a suitable explanation for continuity and discontinuity in science development or working out through what different mechanisms old theories are rejected and replaced with new ones.

Our approach attempts to look more deeply into three aspects related to these issues:
a) The role of crucial experiments as an example of how prior assumptions (mainly auxiliary hypothesis) play a fundamental role in conceptual change (Levinas and Carretero, 2004).
b) The historical context against which both phenomena and experiences are considered. We do not mean rational reconstructions which are not directly related to the process of history but are only its product. If our aim is to convey the process of science, then we should highlight the historical context of each particular case (Allchin, 2000). The importance of context becomes clear when students learn science and it shows clearly how context is decisive in the processes of conceptual change (Carretero and Levinas, in press)
c) Frequently, we face what we call partial conceptual change, which "allows" a concept to have "areas" defined by different paradigms. Whenever the partial change is not about a concept but about a complete theory, some of its principles may change but others may not; therefore, there is a drastic change in some sense, and there is also continuity in another sense. We could mention the paradigmatic example of axiomatic systems. Let us refer to non-Euclidean geometries in which some concepts change with respect to its significance in Euclid's Elements but others do not (e.g. "point" does not change, but "straight line" changes in some aspects). The fifth postulate also changes, while the other four Euclidean postulates do not.

Our idea is to explain how different theoretical assumptions bring about radically different interpretations of the same experimental results and how conceptual change is produced in this way. In order to provide a concrete and detailed example of our position, we will be considering some features of Einstein's special relativity theory as it was originally formulated in 1905 and examine its peculiar relationship with the results of the 1887 Michelson-Morley (crucial) experiment. We intent to show why in different historical contexts the same experiment can be considered to provide different –often incompatible- conceptualizations of the "same" phenomena. This fact enables us to answer the question of how the mentioned experiment could have been interpreted in a completely different way in the seventeenth century when the Earth's motion was still a questionable hypothesis (Cassini and Levinas, in press).

Ways of Seeing, Conceptualisation and Conceptual Change: Theoretical and methodological considerations

Mina O'Dowd, Lund University, Sweden

In this paper it is argued that any discussion of conceptualisation and conceptual change is incomplete with out inclusion of and reflection upon the role that ways of seeing plays. As Berger has argued, studying ways

of seeing is vital for understanding of the world, our relationships and others. Lippman has proposed:

"We do not first see, then define, we define first and then see...We are told about the world before we experience it. We imagine most things before we experience them. And those preconceptions, unless education has made us acutely aware, govern deeply the whole process of perception" (1922, pp. 81- 90).

Brophy & Good stress that "people differ in the general accuracy of their interpersonal perceptions", constructing more or less correct perceptions of Others. According to the authors, "incorrect perceptions reflect the perceiver's own needs" (Brophy & Good, 1974: 33). As Schur has proposed, the identification of the Other is essential to the manner in which we perceive the world around us: by identifying the "Other" we confirm our own perceptions of what "We" are (1979:48-66).

Vico's account of the life of nations, in which he traces development from "imagination" (fantasia) to "reflection" (reflessione), underlines the importance of language, seen as a sensus communis or a "mental dictionary". Through language we are provided with the stuff of which our preconceptions of the world are made. According to Vico, language itself can be viewed as common sense, i.e., "judgment without reflection, shared by an entire class, an entire people, and entire nation, or the entire human race" (Element XII, §145, pp.63-4).

O'Dowd (2000) has shown that ways of seeing influence how knowledge is conceptualised in educational research and how it is then represented, providing the grounds to view conceptualisation and ways of seeing as inseparable and problematic, i.e., what you see is what you get. Moreover, this view highlights the importance of preconceptions and their influence on what we see. Or as Lippman will have it, this view stresses the vital role of education in making us aware of the preconceptions that govern what we see. In the paper the above discussion is supported by empirical data on the visual representation of the body in contemporary Sweden, using photography as "a mirror" to understand how the body is conceptualised and represented. This data provides the background for a discussion of the preconceptions that govern how the body is conceptualised, the relation between sensus communis and seeing, and the role of reflection on judgment and language. In addition it provides insight into what Jenks has called the "perilously intertwined" relationship between "seeing and knowing", and constitutes a contribution to the discussion of the theoretical and methodological consideration regarding conceptualisation and conceptual change.

From conceptual change to conceptual evolution: looking for invariants in the gradual understanding of the conversely proportional relation within F=ma

Patrice Potvin, University of Québec, Canada

Aims

The main goal of the research was to obtain a description of the natural flow of thoughts of students freely exploring the logics of a simulation about mechanics and to identify invariants –if any- in their conduct. Hypotheses were about conceptions, models, intuitive rules (Stavy, 2000), and p-prims (Disessa, 1993). An obligation was to obtain these verbalisations in a situation such that it would be possible to consider it as a constructivist learning context.

Methodology

Twenty secondary school students (4 for each level) with no previous training in physics were interviewed for a total time period of 5 to 6 hours each. These interviews were conducted in accordance with Vermersh's explicitation interview type, which requires the interviewer to accompany the subject without ever asking for justifications for choices made or actions taken, and to gather verbalisations that are as close as possible to the natural flow of evocation. It is believed that it is through this type of verbalisation that the research process can identify authentically intuitive invariants. Subjects were set before a computerized microworld (enabling

them to explore articulations between the parameters of Newton's second law [F=ma]) and were asked to make sense of the simulation to the point that they could make efficient predictions.

Outcomes

Among many other interpretations concerning various aspects of the verbalisations, it is quite interesting to record that every one of our twenty subjects clearly displayed a typical –and quite resistant- intuitive understanding of the conversely proportional relation between "m" and "a", regardless on the explorative path they took. This interpretation presented every characteristic of a linear (with negative slope) relation instead of the asymptotical shape typical to every conversely proportional relation.

Theoretical and educational significance

This research is, from our point of view, a good example of the possibility to identify invariants in the conduct of students exploring the logics of open learning situations. It is believed that the intuitive rule that we identified –and that we named "More C – less B" in conformity with Stavy and Tirosh's (2000) way to label such objects- can be useful in both situated cognition contexts and conceptual change based pedagogical strategies (here we can establish a link with the symposium). Indeed, not only does this intuitive rule seem to be widespread and persistent enough to be anticipated in open learning contexts, but also seems to able us to predict the emergence of classic student answers (or conceptions) already identified in the literature. Thus, further qualitative research –based on interview techniques that can be inspired by Vermersh's methods- seems to be needed to document the existence of such invariants. As educators, taking account of the tools (and not only of answers) students spontaneously bring to learning is of obvious interest.

Knowledge-Building Community: Applying the Third Approach in Education to Teacher Training
*Sarit Segal and Miriam Mevorach, Levinsky College of Education, Israel

The research studies the cognitive changes of first year teacher trainees during the process of knowledge-building-community and the influence of the process on their field experience.

The educational pendulum swings between regular didactic teaching (adult-run model "old education") and the "child in the center" education (children-run or "new education").
Basically, in the adult-run model ("old education") students are neither expected to deeply understand the taught subjects and their purposes nor to show interest in them. Their role is to accept knowledge from an active teacher who runs the process: students are not partners in setting the agenda nor are they even expected to understand it.

In the children-run ("new education") children are active constructors of knowledge, while adults' involvement is considered to be a potential obstruction of the learning. Ideally, in the children-run model, children discover the reality by themselves or by reciprocal interactions with their peers.
I suggest abandoning the pendulum movement by neither a compromise nor by "optimal balance" between the two unilateral models, but by a third model: a model with the terms "knowledge constructing" and "understanding" in its core. The presentation will demonstrate teaching teacher trainees according to the third model. Teaching according to the third model implements the model's three theoretical assumptions: the activated thinking process is saturated with good thinking values which reflect in the study methods used; it is a social process as it is a community of learners who constructively share the created knowledge; and it arouses the cognitive feelings of the learners.

Generally, the school dominant teaching method and the school organizational structure supporting it and supported by it is based on four atomistic pictures- basic and condensed images well imprinted on teachers' minds: learning is listening; teaching is talking; knowledge is an object; being a good student is being a knowledgeable student (one who holds many "objects" in his head). According to the alternative atomistic

picture of learning is to be involved and to understand (in other words: good learning is involvement in the process and understanding the product); teaching is creating conditions for good learning (indirect teaching); knowledge is “a story” or “a structure” that people not only find but also invent; being a good student is being a student who knows how to refer to knowledge- supportively, creatively and critically.

The framework of our Knowledge-Building Community is based upon these four alternative pictures. The framework is based on three phases while the forth phase is in the background of these phases. These phases are: A fertile question, research, summarizing performance; and in their background is the apprentice phase.

The purpose of the learning is an integrative combination between the student’s existing knowledge and the newly acquired disciplinal knowledge, around a central theme. The learning process arranges itself around asking questions. The importance is not necessarily providing the best answer to the raised question, but the multiple answers and the comprehension that the question does not have an unequivocal answer but numerous different answers, which occasionally contradict each other. The group discussion continues to the controversy of the discovered answers and the need for a personal choice according to one’s unique personal ability. The search for a reply in different subject disciplines and multiple diverse sources provides importance to student’s personal preferences, self expression and creativity.
Part of the encounters is run in the college, and part of them is team work with the tutor available by mail.

Research’s Data Sources: transcripts of audio-tapes of groups’ discussions and observation reports from training schools. Results and the importance of the research: knowledge-building community undermines the teacher trainees’ structured concepts of learning and substitutes them with more productive ones. This process is reflected on their field experience, and helps constructing their pupil’s active knowledge.

13.30 - 15.30 Paper session B
(Von Kochsalen)

Chair and discussant: Russell Tytler, Deakin University, Australia

What is history? Perceptual seduction in learning at a museum
*Liza Haglund and Ola Halldén, Stockholm University, Sweden

Learning at museums is often thought to be connected to important features of objects; the objects displayed often have a veracious resolution and density and they are often in their natural scale which convey a sense connection with the past (Leinhardt & Crowley in press. p.4). In this paper, we argue – paradoxically – that these specific features of objects may, in fact, obstruct learning.

Fifty-five students, aged 12, from a suburban school in Stockholm visited a museum in order to learn about the 17th century. The museum that the students went to see is built around the original Vasa ship, which sank in the harbour on her maiden trip towards Poland. The aim of the study was to investigate the students' reasoning in history, in relation to their visit at the museum. Back in school students were invited to work on three learning tasks. This paper draws on data collected in relation to one of these tasks.

Previous research has shown that students' difficulties in learning history have to do with difficulties that students have in discerning which kind of explanation that is appropriate to use in a particular situation (Lee et al. 1998; cf. also Halldén 1997; Jacott & López - Manjon 1993; von Friedeburg and Hubner 1970; Södring Jensen 1978; Voss, Carretero, Kennet & Silfies 1992). Agency has been found to be at the core of students' explanations whether they are of teleological or structural nature. The present study shows that what is at stake, is not primarily the kind of explanation that is put forth but rather the students' conceptions of what is worth explaining, and to decide when an explanation is complete enough to meet the perceived demands of the situation in hand (cf. Halldén 1986). The Vasa ship and the accident in which it was lost appeared to have been such salient features of the students' visit to the museum that they actually got in the way of the students' learning of history. There were also examples of students who explicitly and deliberately reflected on and questioned what history is and should be. The results can be seen as reflecting students' struggle to grasp what history is all about. The study also stresses the need for taking into account the concept of salient feature in the analysis of data.

Students' Interpretations of the Use of Literal Symbols in Inequalities
*Konstantinos P. Christou and Stella Vosniadou, University of Athens, Greece

In this paper we present the results of a new empirical study which was based on individual interviews with 10th grade students from Greece. Students were given a series of inequalities which contained letters and were asked to comment whether they are true or false for any numerical value that could be assigned to the letters. Literal symbols such as letters from the alphabet are used in algebra to stand for numbers. When letters stand for numbers, they stand for any real number, unless they are used in specific contexts which may constrain the range of numbers that the letters are allowed to take. Students' interpretation of the use of letters in algebra is frequently responsible for students' difficulties and mistakes in areas such as problem solving, solving equations, learning about function, etc. In order to examine how students interpret the use of letters in algebra, the conceptual change theoretical framework developed by Vosniadou (1999) is adopted. Based on this theoretical framework and its application to mathematics learning we would expect that students' prior knowledge of natural numbers would constrain their interpretation of literal symbols in algebra, leading to misconceptions.

In a previous study (Christou & Vosniadou, 2005), we examined 8th and 9th graders' interpretation of the use of letters in algebra, using three types of questionnaires. From this research it came out that students'

interpretation of the use of letters in algebra was influenced by two factors: a) the belief that a literal symbol corresponds mostly to natural numbers and b) the belief that the phenomenal negative sign of an algebraic expression must be retained. Students' belief that the letters in algebra correspond mostly to natural numbers originates in their tendency to think in the context of natural numbers only.

In the present study students also appeared to be affected by the belief that letters stand mostly for natural numbers. When asked to substitute numbers for the letters to test whether the inequality is true of false, many students replaced the letters only with natural numbers. Some of the students were willing to substitute negative whole numbers for the letters but the majority of them appeared reluctant to assign fractions or decimal numbers to the letters.

Acknowledgment

The present study was funded through the program EPEAEK II in the framework of the project "Pythagoras - Support of University Research Groups" with 75% from European Social Funds and 25% from National Funds.

Approach to Learning in Geoscience Education : the practice of Rocks
*Dal Burckin, Istanbul Technical University, Turkey

The results of this study support findings from elsewhere regarding the nature and complexity of cognitive change and the potential value of analogies in supporting understanding in science. Using explanatory frameworks to evaluate the extent and nature of cognitive change in relation to children's understanding of how rocks are described and classified, has added to our knowledge of how one particular analogy operates in the classroom as well as thrown light on the nature of cognitive change in this domain. The pedagogic approach described here resulted in young students learning to determine, recognize and explain fundamental textural differences in a range of rocks, equivalent to the key textural characteristics of igneous, sedimentary, and metamorphic rocks. Furthermore, students were able to relate these characteristics to a range of rock properties. They arrived at this understanding through a series of practical activities and observations, which tested and modified their speculations about the characteristics of rocks. The results of this work demonstrate that this investigative approach, which focuses on grain relationships in rocks, develops students' ability to meaningfully generalize about the abstract relations of rock groups in the way required for making sense of rocks scientifically. In achieving this, the teaching methodology fulfils the key recommendations drawn from the investigations outlined in the Science Concept and Concept Exploration project (Russell et al , 1993) to provide 'input about techniques and conceptual frameworks which geologists use', which are 'intellectually safe, accessible and practicable.'

Phenomenography and conceptual change
*Ming Fai Pang, The University of Hong Kong, Hong Kong, and Ference Marton, Gothenburg University, Sweden

Learning has to an increasing extent been seen in terms of changing ways of seeing the world. How people act in a situation depends on how they see that situation. While changes in people's ways of seeing have from the mid-seventies to the mid-nineties mainly been conceptualized as a function of changes in cognitive structures, during the last decade have such changes been mainly conceptualized as a function of people's changing participation in practices (see, for instance, Saljo, 2000).

In a perspective complementary to the above two, we do not focus on why people change their ways of seeing certain situations, but rather on what it means experientially that one's perception of the same thing changes. We describe these changes as changes in the learner experience, in her attentional field, in her capability of

discerning certain aspects of certain situations and attending them simultaneously. Based on the variation framework as presented in an embryonic form by Marton and Booth (1997) and in a more developed version by Marton et al. (2004) and Marton and Pang (in press), differences in the perception of the same situation originate from the fact that different people may notice, pay attention to, or focus on, different features of the same situation. A way of seeing a situation, or a particular meaning of a situation, is thus defined in terms of the features that are noticed and focused on simultaneously. According to Marton and Pang (in press), noticing and giving attention to a feature of a situation amounts to the discernment of that feature, and the discernment of a feature amounts to experiencing a difference between two things or between two parts of the same thing. This is because we cannot discern quality X without simultaneously experiencing a mutually exclusive quality ~X.

But how can that which is learned be used in novel situations? The idea is that once one has discerned those different things, one would be likely to be able to discern them in novel situations in the future. To discern something for the first time requires the experience of a specific pattern of variation, and so does discerning them again and again. If a person's sight were to dramatically worsen, then they could only discern it by remembering what their sight was like earlier, or the person must experience the two states simultaneously. New values in the dimensions of variation can be discerned only through the simultaneous experience of variation. The same is true of the discernment of previously determined dimensions of variation in novel situations.

We will try to illustrate the points which we have made by means of some examples of changing ways of seeing (understanding) some economic aspects of the world around us in some empirical studies that we have conducted (see Pang & Marton, 2003, Pang & Marton, 2005, Marton & Pang, in press).

13.30 - 15.30 Paper session C

(Örnesalen)

Chair and discussant: Jean-François Rouet University of Poitiers, France

Facilitating conceptual change in educational argumentation – conceptualization and evaluation of a problem-oriented learning environment

*Robin Stark and Thomas Puhl, Saarland University, Institute of Education, Germany

Both in science and in practice, social scientists (for example educationalists) have to construct scientific arguments. In order to account for individual positions and actions, they have to refer to scientific theories and empirical results. Therefore, constructing valid and convincing arguments in educational discourses is a core ability which, however, cannot be expected to emerge automatically from traditional university training. We often overtax our students by providing them with theoretical approaches without showing them why, in which contexts, when, and how they can be applied. In addition, we frequently overstrain students even more by the way we teach empirical research methods and statistics. As a consequence, even advanced students of education often have serious problems constructing scientific arguments. In the paper to be presented, three types of misconceptions concerning educational argumentation are exemplified. Starting from these misconceptions, various approaches and principles of situated learning were applied to conceptualize a problem-oriented, computer-based learning environment (WALe) which is supposed to enhance quality of educational argumentation. The transition from everyday life-argumentation or deficient scientific argumentation to competent scientific argumentation is conceptualized as conceptual change. The main component of WALe is a hypertext that displays a complex and authentic educational discourse in the context of a fictitious workshop situation. Objective of this workshop is the decision on a didactical approach for university courses. The workshop is guided by a researcher who presents data of a field study on these didactical approaches. Proponents of different didactic "philosophies" as well as students, and statistics experts discuss the presented results from multiple perspectives. The explicit and implicit argumentation of the participants is demonstrated and explained by the learning environment. In addition, tables are presented that show means and standard deviations. Furthermore, the raw data, all statistical analyses, and a detailed glossary are available. All statistical analyses can be reproduced and reanalyzed by the learners; moreover, new analyses can be carried out in order to answer open questions and to provide the empirical foundation for new arguments. In order to evaluate WALe, a field study was carried out with a sample of 50 advanced students of education. Beforehand, cognitive and motivational learning prerequisites were recorded. Then, the participants were instructed to work with the learning environment at home and to answer questions in a learning diary. After two weeks, the students had to take a posttest that required interpretation of empirical results and construction of educational arguments. First results indicate that working with the learning environment can substantially improve the quality of educational argumentation. However, students with unfavorable learning prerequisites need more instructional support, for instance by means of a special tutorial. Based on these results, conclusions for the facilitation of conceptual change in complex and ill-structured domains are drawn.

On the dynamics of approaches to learning: the effects of student-activating versus teacher-directed instruction.

*Katrien Struyven, Filip Dochy and Steven Janssens, KULeuven, Centre for Research on Teaching and Training, Belgium

In contrast to learning styles, approaches to learning are not characteristics of learners, they are determined by a 'relation' between a learner and a context, an interaction between an individual and his/her teaching/learning environment. A learner can adopt a deep approach in one context and a surface approach in another, depending on the characteristics of the context and the learner's interpretation thereof (Marshall & Case, 2005). In contrast to traditional lectures, student-activating teaching methods are intended to challenge students to acts of knowledge construction rather than knowledge acquisition and, consequently, deepen student learning be

yond the levels of reproduction and rote learning in favour of 'deep approaches to learning'. But, do they?

This study uses the differences in the teaching/learning environment to investigate the dynamics of students' approaches to learning. The premise that student-activating teaching methods deepen students' approaches to learning, when compared to lectures, underpins the hypothesis that is being tested for the course on Child Development within the Elementary Teacher Education Program, delivered to 598 students in a set of 10 lessons. The first group (Lectures) of pre-service teachers (N=114) was instructed in the content on Child Development within a lecture based setting, characterized by direct teaching through formal lectures and being assessed by means of a multiple choice test. Students in the student-activating learning environment (Active, N=484) had to explore and discover the contents in the course book by means of assignments that required students to 'actively' browse and study the information in order to solve the problems set in the tasks, such as problem based tasks, role playing and case studies.
Students' approaches to learning were measured by means of the Approaches to Learning and Studying Inventory (ALSI) that was used in a pre-test/post-test design.

Results (Table 1) show that the direction of change in approaches to learning was opposite to the premise that student-activating instruction deepens student learning. Instead, the latter pushed students towards a Surface Approach (SA) to learning and students' Monitoring Studying (MS) and Deep Approaches (DA) to learning suffered lowering. These shifts become comprehensible, when students comments are considered which pointed at problems caused by the student-activating setting such as high workloads, lack of feedback/structure, fragmented knowledge and 'free riders' in team work.

Table 1
Descriptive statistics and ANOVA analysis of students' approaches to learning by instructional treatment.

	Active			Lectures			ANOVAs			
Post – Pre-test	N	M	SD	N	M	SD	dfmodel; error	F	p	R^2
DA 2– DA 1	401	-0.07	0.48	99	-0.00	0.46	1; 498	1.79	.1817	0036
SA 2– SA 1	402	0.19	0.64	95	0.08	0.44	1; 495	2.44 .	1187	0049
MS 2– MS 1	397	-0.12	0.48	99	-0.05	0.48	1; 494	1.64 .	2012	0033
OS 2– OS 1	401	-0.09	0.59	99	-0.26	0.59	1; 498	6.54 .	0108*	0130
EM 2– EM1	401	0.02	0.63	99	-0.12	0.60	1; 498	3.97 .	0469*	0079

However, the ANOVA analyses only show significant dynamics for the Organising Studying (OS) and Effort Management (EM) scales. The stress associated with the forthcoming examinations in the lecture condition serves the explanation purposes.

Appropriation of Knowledge through Conceptualisation, Modeling and Problematisation
Toussaint, Rodolphe M. J., University of Québec à Trois-Rivières, Canada

Theoretical Background

Formation of concepts is a dynamic process which mobilizes former knowledge in order to apprehend the environment and to offer relatively stable answers (Murphy, 2002). The concepts thus formed represent a mental model of the phenomenon or group of phenomena and constitute the cognitive structure of the individual in order for him to interact with the natural environment. Mental models are often incomplete, unstable and are induced from common knowledge. They are generally simplified representations of complex systems and offer cognitive strategies used in the everyday life (Johnson-Laird 1993, 2001; Gentner, 1983). These constructions, confirmed by everyday life events, are persistent and may block the acquisition of new knowledge which must be built "against" these common representations (Toussaint & Lavergne, 2005, 2002; Vosniadou et al., 2001; Duit, 1999; Robardet, 1995). Models are however of prime importance in the description of complex phenomena and the formulation of hypothesis vis-à-vis problematic situations. Generally context-dependant and similar to the system represented, the model can however be increasingly abstract and thus attain a greater

explanatory capacity (Giere, 1999; Gobert & Buckley, 2000; Nersessian, 1999, 2002). Problematisation of complex situations depends on the student's ability to conceptualize and make categories. He must also be able to distinguish and gather data, to decide on a goal and to consider constraints (Sternberg, 1994; Weil-Barais, 1991; Houdé, 1992).

Objectives

Our main objectives were: a) to characterize student-teachers' aptitude to problematize complex phenomena; b) to study some of the scientific reasoning displayed by the students in a simple task.

Method

The sample included 65 undergraduate students training to teach at the primary grades. Our teaching strategy put a large emphasis on "problematisation", on qualitative reasoning, and on modeling of complex phenomena. Each class consisted of a workshop with a particular scientific thematic and related situation-problèmes, co-elaboration of hypothesis for solving the problem, and didactic consideration for application with primary-grade children.
Content analysis was made on 2 questions of the workshop on "Earth, Sun, Moon rotation and revolution" by 1) selection, simplification and transformation of initial data; 2) condensation in thematic units, fragment of the discourse with intra-specific meanings and interelated meanings; 3) emerging, rather than pre-organized categories (Bardin, 1993; Blanchet et al., 1992; van der Maren, 1995; Huberman et al., 1991).

Analyses and interpretation

Most of the student-teachers described the perceived relations of the phenomenon and the relations between the model and the real world (physical and iconic). A particular conceptual organisation of complex phenomena is developed by most student teachers, based on perceptible instances of objects and partial understanding of related concepts.
The main observation to be made for that group is the alleviation of the anxiety generated by science instruction and science learning. Usually, science has been seen as providing solutions for all problems.

Beliefs about racial tolerance – experiential influences or structural development?
Rivka T.Witenberg, School of Psychology, Australian Catholic University, Australia

The research about the development of tolerance provides a fertile field for exploring the relationship between constructivist and socio-cultural perspectives. In any given nation, research on racial tolerance must consider the specific cultural and social backdrop against which the investigation takes place (Gaasholt & Togby, 1995).

This presentation will report on a series of studies about reasoning on racial tolerance involving students between the ages of 6 to 24 years conducted in Australia, Israel, the Ukraine and the USA. The design involved culture specific short dilemma-like stories. Real life incidents were utilised as the basis for the stimuli events (stories). In addition to their tolerance judgements, participants were asked to explain and justify their responses.

Overall the findings of the studies show that all young people, irrespective of cultural context, make tolerant or very tolerant judgements. However there are also clear indications that contextual information, culture, age and gender influenced tolerance judgments and justifications. In examining the underlying beliefs that guided the reasoning process of children and young people between the ages of 6 and 24 years, common underlying beliefs emerged contingent on age and gender. For the tolerant responses, three main general belief categories were identified. They were based on the belief that others should be treated fairly (fairness), empathetically (empathy) and that reason/logic ought to govern judgments (reasonableness). Fairness emerged as the most

used belief to support racially tolerant judgments, linking racial tolerance to moral reasoning, rules, and values. Fairness was appealed to by respondents from all four countries. Particularly noticeable is that within the age groups, 6- to 9-year-olds appealed to fairness more often in comparison to the 11- to 12- and 15- to 16-year-olds but at the same time 11- to 12- year-olds appealed to fairness more often than 15- to 16-year-olds. None of the 6- to 7-year-olds appealed to reasonableness whilst from about 15 years of age, this mode of thinking was used to support tolerance and was specifically favoured by males. The data also showed an association between females and fairness/empathy which was mediated by age with none of the youngest participants appealing to empathy. Together, these findings are an indication of developmental trends. Cultural differences also were evident in the way reasonableness and empathy were used to support tolerance.

Alan Fiske (1991) offers a plausible explanation based on theories of social cognition and relationships for the phenomenon of young children's use of fairness. He argues that fairness bursts out at about the age of four and is generalized to social issues due to the maturation process leading to the externalization of innate cognitive models. Cognitive models, whether innate or acquired, imply a theory about a fair world. The question arises as to whether it is experiential influences or structural development that creates a shift from appealing almost exclusively to the principle of fairness to appealing to other beliefs or combinations of beliefs with increasing age and socio-cultural background. Speculatively, it can be suggested that age brings increased socio-cultural knowledge which interplays with the structural development. This presentation will explore these relationships.

16.00 – 16.30 Poster session

The concept of time and its evolution over time
– an example of the dialectic relationship between concepts and artefacts
Jonte Bernhard, Linköping University, Sweden

"We find metaphysics in machines, and machines in metaphysics" is the last sentence in Peter Galison's (2003) book "Einstein's Clocks, Poincaré's Maps – Empires of Time". In this paper we will explore the dialectic relationship between concepts and artefacts and how concepts have altered their meaning due to the evolution of artefacts and discourse.

Although physics has abandoned Newton's absolute theological time his essentialist view of time and other concepts is still present. Consequently most textbooks in science have an essentialist view of concepts and seldom discuss the problematic nature of the concept of concepts (sic!). Also the discussion of conceptual change often misses that the concepts themselves change.

The concept of time and its evolution over time is chosen to illustrate my point of view. I will also argue that the meaning of a concept is its use in discourse and since artefacts are essential elements of discourse as mediational tools the meaning of a concept is closely related to the artefact involved. Thus the "same" concept could have different meaning in different discourses due to the artefact chosen to represent it. It is well known that scientific concepts are not empirical unless they point to the possibility of factual observations and factual observations are only possible given a conceptual background. Without watches the concept of time has no empirical meaning and would accordingly be meaningless! Thus the initial sentence above could restated in the language of sociocultural theory as "we find concepts in artefacts, and artefacts in concepts".

Refutation text: Effects on learning and attention
Broughton Suzie, Sinatra Gale, Reynolds Ralph, University Nevada, USA

A rich body of literature shows that the most effective intervention strategies for promoting conceptual change include a combination of activating students' background knowledge, reading a refutational text, and participating in supplemental scientific investigation activities. This study will examine the influence of the selective attention strategy (SAS) on one such intervention: reading refutational text. According to the SAS, readers learn important information because they allocate extra attention to certain elements in the text. The amount of attention the reader allocates to the refutation statement may be an indicator of the level of engagement the reader has with the information to be learned and may account for the power of refutational text in promoting conceptual change.

Undergraduate college students will be assigned to read either a refutational or a non-refutational text. Both texts introduce the same topic (seasonal change) but the refutational text elicits and directly challenges the students' misconceptions of the phenomena. Individual participant's reading times will be tracked and recorded sentence-by-sentence in order to examine the effects of the SAS on the processing of refutional text and promoting conceptual change. Our hypothesis is that students who devote more attentional resources toward processing the refutational text segments will exhibit greater conceptual change than those who devote less attention to the refutational segments or than those who read the non-refutational text. This study is currently underway and data collection will be completed by April with findings ready to report by June, 2006.

Individual conceptual change processes during learning from science text - a multimethod online approach

*Erkki Anto, *Marjaana Penttinen, Mirjamaija Mikkilä-Erdmann and Pekka Salonen, University of Turku, Finland

The target of this study is to investigate individual cognitive processes leading towards conceptual change. This study was theoretically motivated by the recent research on conceptual change through text and by recent research methodology on online text processing (eye movement measurement, observation table) (Mikkilä-Erdmann 2002; Hyönä, Lorch & Rinck 2003).

The four participants were chosen among thirty 11-12 year old children who participated in a larger research project. Pre-test-post-test- design was used. The observed cases significantly improved their scores in questions measuring conceptual change. The treatment consisted of two readings, the topic being photosyntesis. During the first reading eye movements were recorded using the EyeLink II equipment. The second reading was carried out using the videobased observation table. A stimulated recall interview was administred after the post-test.

The eye movement measurement results show that our four cases processed the text significantly longer than their peers. Furthermore, results concerning the video material are still in process. However, preliminary results indicate that multimethod online approach brings us new dimensions in understanding conceptual change.

Conceptual change in teacher education: Enhancing concepts of cooperative learning

Ulrike-Marie Krause and *Robin Stark, Saarland University, Germany

Cooperative learning is regarded as an effective means to promote knowledge acquisition, social aspects, and motivation. Although cooperative learning has repeatedly proved effective in scientific studies, implementation of group work in class is rather scarce and often lacks efficiency because of inadequate cooperation conditions. Therefore, we currently conceive an e-learning environment ("EULE") on cooperative learning for teacher education. Design and evaluation of the learning environment is part of a program that supports e-learning at Saarland University. The learning environment has two main objectives: enhancing knowledge on cooperative learning and changing adverse attitudes. Starting point are results of a questionnaire study (N = 156 students of education) and reports of teachers and teacher trainers with respect to existing concepts of cooperative learning, especially concerning misconceptions and unfavorable attitudes (e.g.: "Cooperative learning is too time-consuming"). The learning environment explicitly refers to these concepts and adaptively displays theoretical considerations and empirical findings in order to induce cognitive conflicts and promote conceptual change. EULE is supposed to bridge the gap between theory and practice, therefore the didactical approach follows principles of situated learning: Instruction is based on authentic contexts; moreover, students are prompted to analyze realistic group work situations and make decisions on how to proceed. Diverse instructional aids are provided, such as elaborated feedback and a comprehensive glossary. The learning environment will be implemented and evaluated in summer 2006 in regular and continuing teacher education at Saarland University. Repeated measurement of knowledge and attitudes will permit diagnosis of conceptual change.

Fostering students' understanding of one- and two-dimensional relative motion using immersive virtual reality

Gurlitt, Johannes, University of Freiburg, Germany, Kozhevnikov Maria and Blajenkovia Olessia, Rutgers University, USA

The goal of the present research is to explore the strengths and limits of virtual reality for learning relative motion concepts. In particular, we are interested which unique features of an immersive virtual reality environment have the potential to assist undergraduate physics students to learn relative motion concepts. Five

students with previous physics background completed perspective taking and cognitive-style-tests and rated their beliefs about the relative nature of motion. Then, we pre-tested students with a conceptual test on relative motion that consisted of five one-dimensional and four two-dimensional relative motion problems. After the test, students were exposed to virtual reality activities with 5 levels of increasing complexity. Each level included an observational mode in which students observed the motion of two gliders from a laboratory frame of reference, a prediction mode in which students were asked to predict the velocity of one of the gliders in the frame of reference of the other glider, and a verification mode in which the students could observe the motion of one of the gliders while virtually moving on the other glider. After finishing the simulation, students were given a beliefs-questionnaire and a relative motion problem-solving test similar to the one given to them before the simulation. The analysis of the students' protocols indicates that carefully designed virtual reality environments are able to give students an inclusive, surrounding, and vivid illusion of being in a moving frame of reference and thus facilitate their understanding of relative motion concepts.

Learning in local environment: Conceptions held by adolescence on environmental issues: A case study of Rufiji Basin-Tanzania

Fika L. Mwakabungu, Stockholm University, Sweden

The study focuses on analysing individual reasoning on issues of environment and sustainable use of natural resources. In the analysis the relationships between the individual, nature, and society are taken into account. From my Master study (Mwakabungu 2003), I interviewed eight children (aged 9-16 years) who lived in rural areas and they had substantial experience in charcoal making. I presented the result that children have rich experience and practical knowledge in relation to charcoal production, knowledge which does not exist in the primary school curriculum. However, children experienced difficulties in explaining the concepts which are taught in school but are out of their life experience. The current study focuses on the knowledge about fishing and the natural environment for fish, which are taught in formal school and at the same time experienced in daily life. The fourteen schooled adolescents (14-18 years) and five adolescents (16-19 years) who have not got an opportunity to be in formal schooling were interviewed. Both groups do fishing in two different rural areas in the Rufiji Delta. Three teachers were interviewed to see how they interpret and teach the environmental topics as addressed in school curriculum. Using an intentional analysis model (Halldén 1999, 2002), the initial results show that both groups share common lines of reasoning on environmental issues mainly related to: society and nature, and individual and society. Teachers find difficulties in teaching the environmental topics with the reason that they teach them according to their experience and not as experts.

16.30 - 18.00 Keynote addresses & Panel discussion

Keynote addresses

Chair: Xenia Vamvakoussi, University of Athens, Greece

An Instructional Design Perspective on Theories of Learning
Paul Cobb, Vanderbilt University, USA

From my perspective as a designer, accounts of learning are pragmatically useful to the extent that they simultaneously give insights into both learning processes in specific subject matter domains and the means of supporting realization of those processes in classrooms. I operationalize the definition of pragmatic usefulness by arguing that an account of learning should enable us to document both the collective development of the classroom community and the developing reasoning of individual students, and should also feed back to inform the improvement of our instructional designs. I clarify that the approach I and my colleagues have taken to developing an analytical approach that satisfies these criteria involves appropriating and adapting constructs from a range of different theoretical perspectives on learning including sociocultural theory, distributed cognition, and cognitive theory. I discuss each of these perspectives in turn and describe both why each is potentially useful and why we have found if necessary to modify constructs for our purposes as designers. The resulting analytical approach views students' developing reasoning as situated with respect to the classroom process in which they participate and to whose constitution they contribute. I argue that this is a strength because it enables us to relate the process of students' learning to the means by which was supported and organized. This in turn makes it possible to formulate testable conjectures about how the instructional design for supporting learning might be improved.

Re-thinking the 'Education' of Reason: The ambivalent legacies of Piaget and Vygotsky for understanding knowledge in context
Sandra Jovchelovitch, London School of Economics and Political Science, UK

The link between the psychological and the social has been contested throughout the history of psychological science and perhaps nowhere this is as clear as when psychologists theorise knowledge and cognition. In this talk I would like to retrieve the legacies of Piaget and Vygotsky to our understanding of situated cognition and unpack an intellectual puzzle that took shape at the beginning of the 20th century when psychologists, sociologists and anthropologists debated the social and cultural origins of logic, cognition and mind. I shall argue that while both Piaget and Vygotsky left us a comprehensive legacy to understand the relationship between knowledge and social context they also fell prey to the dominant view that shaped the concerns of their time: how knowledge progresses from 'lower' to 'higher' forms, or to use Piaget's famous terminology, what shapes the 'education' of reason. It is precisely the process of 'educating reason' that I would like to put under critical scrutiny by showing that far from being an abstract standard of development it is a process 1) largely defined by Enlightenment and positivist representations of what makes rational knowledge and 2) it expresses emotional, social and cultural assumptions typical of Western societies. Yet, I shall suggest, in this ambivalent core of our traditions lie the resources for understanding further the notion of situated cognition and the fundamental connection between human reason and the multiple contexts in which it is realised.

Panel discussion
Hans Niedderer, Mälardalens University, Sweden
Lucia Mason, University of Padua, Italy

Friday, June 16th

08.30 – 10.00 Keynote addresses & Panel discussion

(Vårgårdsalen)

Keynote addresses

Chair: Kaarina Meerenluoto, University of Turku, Finland

Teaching for conceptual understanding: an approach drawing on individual and sociocultural perspectives

John T. Leach, The University of Leeds, UK

The acquisition and participation metaphors for learning have been the subject of much debate in the academic community since the early 1990s. Learning is portrayed either as a process of participation in social activity, or as the acquisition of something by a cognising individual. Significant attention has been given in the literature to the relative merits of each metaphor for describing learning in various settings. However, much less attention has been given to the implications of each metaphor for planning and executing teaching.

In this paper, I focus upon teaching for conceptual understanding in science classrooms. I present key aspects of individual and sociocultural perspectives that have been used to theorise science learning, going on to consider the potential, and limitations, of these perspectives in informing the planning of teaching for conceptual understanding in science. I then present an approach to planning and conducting science teaching that is informed by both individual and sociocultural perspectives.

Because there are differences in ontology and epistemology between disciplines, it is unlikely that an approach to planning and conducting teaching developed for one discipline will translate directly into another discipline. Nonetheless, I imagine that some features of the approach outlined in this chapter will be of interest in subjects like history, geography or mathematics which share some ontological and epistemological features with science.

The chapter concludes with a discussion of this approach to planning and conducting teaching compared to others that have been advocated.

Towards a more robust psychology of learning: Charting key transition points in a program of exploration of student learning in science

Russell Tytler, Deakin University, Australia

This paper will trace the development of perspectives on student learning through studies I have been involved in over the last eight years, in which I have moved from a student conceptions perspective to a current position that pays much more attention to students' multiple subjectivities and to interpretations of learning as representation. In tracing the key growth points in this transition, I argue that the problem with conceptions/mental model views of knowledge is not the focus on individuals, so much as presumptions concerning the nature of the knowledge that is 'gained'. The paper will describe the key findings and unfolding insights from 1. a cohort study of developing understandings of air pressure, 2. a longitudinal study on science learning that has increasingly situated understanding within wider perspectives on individual subjectivities, and 3. a study

exploring how traditional problems with student understanding of evaporation can be productively re-conceptualised as a representational issue. The focus of analysis in each study has been on the performative response of individuals to conceptual challenges. The key perspectival transition points have been the realisation that a. students' explanatory conceptions are unstable and contextual, and retain intuitive and associative pathways that render them fundamentally complex and repeatedly emergent, b. students' responses cannot be usefully understood without reference to the way they interpret the nature of tasks and their commitment to particular ways of making sense of and reasoning about them, and c. learning fundamentally involves representational re-negotiation, so that knowledge is best thought of not as a transcendent set of concepts, but as the capacity to call upon and flexibly utilise productive representations. The paper will describe a research program to re-interpret major conceptual issues in terms of students' representational resources, and will explore what this might mean for the way we think about ontology and epistemology in relation to learning science.

Panel discussion
Sandra Jovchelovitch, London School of Economics and Political Science, UK

10.30 – 12.30 Paper sessions A (Thematic paper presentation)

(Vårgårdsalen)

Organizer: Hans Niddered, Mälardalens University, Sweden

Chair and discussant: Erno Lehtinen, University of Turku, Finland

Learning studies in physics

In this thematic paper presentation, learning processes in different sub-domains of physics will be analysed. The session will include six presentations:
* General introduction of learning process studies (Hans Niedderer)
* Research methods in learning process studies (Andrée Tiberghien and Jean-François Le Maréchal)
* Learning processes and parallel conceptions – learning about the particulate nature of matter (Alejandra Garcìa-Franco and Keith S. Taber)
* The evolution of students' conceptual "topography" during instances of a teaching learning episode (Alexandros Barbas and Dimitris Psillos)
* Some thermal phenomena revisited in a new perspective (Karin Petersson and Helge Strömdahl)
* Influences of taught content on student learning in quantum atomic physics (Marion Budde and Hans Niedderer)

The common idea of these papers is to follow students' constructions "during" the whole process of learning as "conceptual evolution" or "learning pathways" in more detail as in studies, where mainly conceptual change from "before" to "after" teaching is studied.

Contributions:

General introduction of learning process studies - theoretical background, methods and selected results

Hans Nidderer, Mälardalen University, Sweden

In 1991, an international workshop on "Research in Physics Learning - Theoretical Issues and Empirical Studies" was held in Bremen with the aim of initiating learning process studies with data not only from pre and post but also from during the teaching and learning process (Duit, Goldberg & Niedderer 1992). As a result nine special issues were formulated as "needs" about "learning pathways", "cognitive systems", "methodology", "conceptual ecology" and others.

Often, learning pathways can be represented as a sequence of conceptions developed by students during instruction (Petri & Niedderer 1998; Psillos & Kariotoglou 1999; Taber 2001; Clement & Steinberg 2002).

Research about cognitive systems has shown that a student can have more than one conception in parallel at the same time (Taber 2000; Petri & Niedderer 1998 and 2003; Hartmann & Niedderer 2005) thus showing some conceptual ecology.

Many authors have used "intermediate conceptions" or "intermediate explanatory models" to describe steps of learning, which are not at all intended by the teacher. That means that they should be seen as a cognitive development using students' prior cognitive elements to make sense of the new teaching content (Niedderer 2001).

Using data from during the teaching and learning processes is perhaps the crucial issue in the methodology of learning process studies. All studies reported in this thematic paper session follow single students. Of course we need to know about the learning processes of all students in a class. Methodological problems around this issue will be discussed.

Research methods in learning process studies

*Andrée Tiberghien and Jean-François Le Maréchal, University of Lyon, CNRS, France

This communication reviews different methods used in several research studies investigating learning processes during teaching sessions (Givry 2004, Elbilani & Le Maréchal 2005, Kucukozer, 2005). The theoretical frameworks and the consequence on the methodological choices are discussed to compare the common aspects and differences and analyse the respective interests and limits of the methods.

This review is based on two main perspectives: (1) different theoretical approaches to deal with knowledge and meaning and (2) the levels of granularity with which knowledge and time are taken into account.
The studies involved in this review have several common characteristics and differences:

* The length of the data collection during the learning process lasts from few hours to several weeks. It influences the kind of knowledge that can be attributed to the learner and the way of splitting the transcription into episodes.
* Various levels of granularity are implicitly or explicitly used to analyse the elements of knowledge attributed to a learner or to a group (students and teacher) in each episode. They lead to different "re-compositions of these elements" to characterize the learners' evolution or the learning processes.
* The analysis of the taught knowledge can either mainly consist in listing the concepts involved in the teacher's production or be a re-construction of the teachers' or learners' scientific ideas based on their productions.

The first results show that attribution of meanings to the learner's productions is influenced by the analysis of the taught knowledge and by the way the students' initial conceptions are taken into account.

Learning processes and parallel conceptions – learning about the particulate nature of matter

*Alejandra Garcia-Franco[1] and Keith S. Taber[2] [1]Faculty of Education, National University of Mexico [2]Faculty of Education, University of Cambridge, UK

Evidence from science education and historical studies of scientists suggest that conceptual change, even when it presents as a sudden moment of insight, must actually represent a Gestalt-shift between two co-existing ways of conceptualising a concept area. Scientists develop new ways of 'seeing' the world slowly whilst continuing to work with established thinking (Thagard, 1992). There is much research showing that many students may hold and use alternative conceptions relating to science topics, whilst being able to demonstrate the prescribed curriculum knowledge in 'academic' contexts. Understanding of a complex topic area may sometimes be seen in terms of the 'profile' of use of alternative parallel conceptions. This may be true for both scientists (Bachelard, 1968) and learners (Mortimer, 1995). For example, in-depth studies of learning about the chemical bond has described conceptual development as a shift in the tendency to select one parallel conception over others (Taber, 2001). Some approaches to considering learning in science have focussed less on the conceptions and frameworks elicited (perhaps seen as 'molecules' of conceptual knowledge), than on the more basic ('atomic'), tacit, conceptual resources considered to be available to learners, and which are believed to be combined in various ways to build up such higher level structures (Hammer, 2004). The present paper explores this way of modelling cognition, using data from interviews of secondary age students in the UK, who were asked about basic chemical and physical phenomena (Garcia-Franco, 2005).

The evolution of students' conceptual "topography" during instances of a teaching learning episode
Alexandros Barbas and *Dimitris Psillos, Aristotle University of Thessaloniki, Greece

In this work, we investigate aspects of the evolution of student teachers' conceptual "topography" during interactions taking place in a teaching learning episode that is part of a Teaching-Learning-Sequence aiming at facilitating students' understanding of links between electrostatics and electrodynamics in simple electricity (Barbas & Psillos, 2005).

In the first task of the episode, the students are asked to sketch annotated drawings of a metal structure (a) when there is no external charge, (b) when there is an external charge. In the following tasks they work on a set of specially developed computer simulations visualizing the microscopic entities and processes involved in the polarization of metals.

We have analysed several students' annotated drawings and their comments as they work on the simulations against the demands of the tasks included in the teaching-learning episode. In this way we have traced their conceptual evolution and have identified the obstacles they encounter.

Results point out that the transition from the microscopic mental representation of insulators to that of the metals involves intermediate hybrid constructs that will be presented in the symposium. Such students' productions are influenced by the visualisation of the orderly arrangement of particles and their localised movements, and are greatly facilitated by visualising and elaborating on the forces acting on free electrons.

Some thermal phenomena revisited in a new perspective
*Karin Petersson and Helge Strömdahl, Linköping University, Sweden

(Draft!!)
Foundational thermal phenomena like temperature, heat and cold are well studied in science education research. But there are neurophysiological/ psychological aspects of the conceptualization of heat and temperature, which are not very well investigated in science education research. What do we feel when we touch, for instance a piece of wood and a piece of metal – is it the temperature, the conductivity, the energy? And most essential – how does the sense experience influence the interpretation of the formal physical meaning of heat and temperature? When the child is going to learn the scientific meaning of the concepts, a conflict situation arises.

Our aim is to find out the detailed structure and possible learning paths via the triadic approach according to HEAT and TEMPERATURE in order to come to grips with the experienced difficulties. This will be done by a meta study of some published papers, neurophysiological data completed by an empirical study of teacher training students' design of teaching sequences which will be performed during spring 2006. Outcomes will be presented at the symposium.

Influences of taught content on student learning in quantum atomic physics
Marion Budde and *Hans Niedderer, University of Bremen, Germany

In this paper we report case studies about resonances between certain elements of taught content as part of the learning environment and the evolution of students' conceptions as part of their cognitive system. The teaching approach uses two alternative quantum atomic models: a probability density interpretation of the ?-function for bound states of an atom alongside with the "electronium" interpretation, which is similar to a charge cloud model.

By carefully following the talk of individual students and relating it to the content of teaching, it is possible to test teaching hypotheses. The analysis was based on definitions of different types of resonances. We present

here for illustration a few of the defined categories:
Congruent resonance: The student constructs in his own independent thinking conceptions, which are essentially equal to the content presented in the learning environment before.
Disgruent resonance: The student constructs in his own independent thinking conceptions, which are essentially different to the content presented in the learning environment before.
Spontaneous (congruent) resonance: Already after the first presentation of a certain content a congruent resonance is happening.

Only few results can be presented here. For Thomas the electronium model shows a congruent resonance from the early stages of teaching. Although Klaus preferred a probability model at the beginning, he finally switched to the electronium model. After the probability and electronium models were discussed in detail, both Thomas and Klaus, and all their classmates, agreed that they preferred the electronium model. For all nine students in the class, the electronium model achieved a high acceptance.

10.30 – 12.30 Paper sessions B

(von Kochsalen)

Chair and Discussant: Stella Vosniadou, University of Athens, Greece

Emotional factors and conceptual change

Karolina Österlind, Stockholm University, Sweden

During the last decade there has been a growing interest in how emotional factors influence conceptual change. The influential model of conceptual change described by Posner et al has been criticised for being incomplete in only accounting for cognitive factors and leaving out emotional factors. It is argued that the realisation of the conditions stated in Posner et al's model requires a certain amount of cognitive engagement and, furthermore, that an individual's cognitive engagement is dependent on emotional factors, for example, an individual's interests or values.

A case study is presented describing the work of one pupil (15 years old) on an environmental issue pertaining to the decline in fish stock in the Baltic Sea. The study was conducted in the upper level of compulsory school. The pupils in the class worked in small groups for a period of six weeks. The empirical material consists of recorded conversations between the pupil and other pupils in the group and between the pupil and the teachers, observational notes and the pupil's written accounts. The empirical material is analysed from an intentional perspective, i.e. a method of analysis that focuses on the pupil's actions understood in terms of problems the pupil is trying to solve. A distinction between task and problem is employed, where task refers to what the pupils are presented with by the teacher with the intention that the pupils are to do something, and problem relates to the pupils' interpretation of the task, that is, what the pupils are actually doing. The aim of the paper is to describe how emotional factors influence a pupil's interpretation of a task.

The result shows that the direction of the pupil's engagement changes when the pupil's values are brought to the fore. The pupil intends to describe the negative impact on fish in the Baltic Sea caused by different kinds of human activity. This is also what the pupil does initially. However, after having read a report on overfishing written by an environmental organisation, the pupil's work takes on another direction. This happens when the pupils values concerning the environmental issue are brought to the fore. The pupil expresses strong opposition to the exploitation of cod caused by overfishing together with an indignation over the politicians for not taking action on the issue. The pupil leaves the problem she was working on, i.e., what the impact on nature looks like, in favour of a problem that concerns the actions of those responsible for the impact: why do the politicians not take action?

The result adds to earlier research in the area by further exploring the link between an individual's values and conceptual change and by showing that values not only influence an individual's cognitive engagement but also affect the direction of the pupils' engagement, that is, the pupils' interpretation of the content of instruction.

What Kind of Conceptual Change Paved the Way for the Scientific Revolution?

Marcelo Leonardo Levinas, University of Buenos Aires-Consejo Nacional de Investigaciones Científicas y Técnicas, Argentina

In this paper we study some fundamental conceptual changes that took place in the so-called scientific revolution of the XVII century. This revolution has not only brought about changes in certain concepts but has also resulted in the creation or removal of other concepts related to the characteristics of the motion of bodies and to the causes of their movements. Changes in the meaning of these concepts have been linked to the diverse

interpretations given to certain phenomena and to many of the so-called crucial experiments (mental or real). Regarding the conceptual changes that paved the way for the scientific revolution, our hypotheses are:
1) This revolution consisted in the replacement of Aristotle's physics, astronomy and cosmology (presented in his books *Physica* and *On the Heavens*) by Newton's physics, astronomy and cosmology (*Principia*). The fundamental characteristic of both systems was their enormous internal coherence —in spite of some anomalies— and the fact that their fundamental concepts practically lack any ambiguities in their meanings. That is the reason why they made such long-lasting influence to knowledge.
2) Over the years, fundamental concepts have experienced some kind of partial changes in their meaning and significance. Moreover, some concepts have emerged (e.g. inertia) while others have been discarded (e.g. natural place). We provide a scheme which summarizes the main ideas of the most important thinkers (e.g. Philoponus, Oresme, Copernicus, Brahe, Bruno, Galileo, Kepler, Descartes, etc.) in order to show the dynamics of conceptual change, i.e. in what way the meaning of the fundamental concepts has varied and has "fluctuated" according to Aristotle's conceptions and those of Newton. Influential thinkers have introduced some specific *partial* conceptual changes in several concepts; this allowed a concept to have "areas" defined by different paradigms. Therefore, we find in their thinking continuities as well as partial discontinuities regarding some important aspects of precedent or subsequent theories. This is clearly seen in the diversity of meanings that fundamental concepts have taken on throughout the history of science.
3) *Two* key concepts have been characteristic of the deep conceptual change brought about by the transition from the Aristotelian system to the Newtonian one.
a) The concept of *cause of movement*, closely related to the conceptual change of fundamental notions such as velocity, trajectory, action, inertia, weight, mass, vacuum, medium, natural place, free fall, acceleration, action at distance, etc., including the notions of space and time. The new key concept in Newtonian physics is *force* as defined in the second law of the *Principia.*
b) The *consolidation* of the concept of *magnitude*. The relationship among magnitudes appeared to be the fundamental element of modern physics because it allowed a new (quantitative) interpretation and understanding of natural phenomena. This notion "solved" the historically traumatic relationship between mathematics and physics. There is a strong and elegant "relationship" in the notion of magnitude between the mathematical element -represented by a *number* (abstract quantity)- and the physical notion -given by a *unit* (concrete quantity)-. Each magnitude is related to a physical concept (and to other concepts and magnitudes) by means of a definition, a principle or a physical law.
In conclusion, the consolidation of magnitude as a physical concept itself, in connection with the universality of all physical laws, is what explains the definite conversion from Aristotelian terrestrial physics —which rejected the use of mathematics? to the principles and laws formulated mathematically in Newton's physics, which are now applied to the whole universe.

Controversial conceptual change described as action – A model proposal in the context of science education

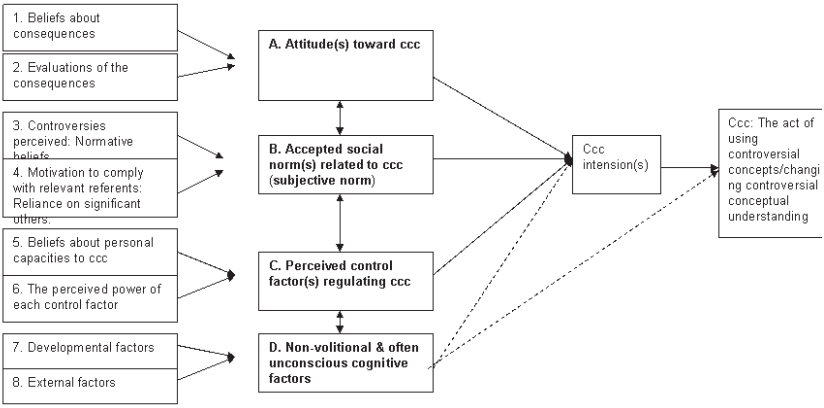
Jostein Säther, Norwegian Teacher Academy, Norway

This theoretical paper addresses the question of how to describe controversial conceptual change (ccc) with reference to science education and the (manmade) greenhouse effect issue in particular.
Outline:
(1) Introduction: Science education as an arena of formation of controversial concepts. The main terms presented. The ideal and problem of making cross disciplinary and integrative models out of competing traditions.
(2) What are the relevant disciplines or fields of knowledge that could inform the process of constructing a unified model of ccc, and how does ccc occur discussed in the light of selected research and debate literature from these disciplines and fields?
After briefly sketching the latest reviews of conceptual change research (e.g. Sinatra, 2005; Vosniadou, Skopeliti & Ikospentaki, 2005) the theoretical foundation for the ccc-model is presented in part 3:
(3) The ccc model and its main terms. Ccc is described as an intentional action stemming from processes related to attitudinal -, normative -, control belief -, developmental -, and contextual factors, and their interac

tions. The ccc model, illustrated by the (manmade) greenhouse effect issue, is much based on elements from Icek Ajzen's theory of planned behaviour (1991), and humanistic thinking about acts/actions (e.g. Halldén 1999; Hollis 1994).

The Controversial conceptual change model (adapted from Ajzen, 1988, 1991; Fishbein & Ajzen, 1975).

Contextual factors: message & communicator characteristics; instruction & dialogues; cultural tools, norms & institut



(4) Hypotheses and research questions. For future research to specify and test the ccc-model, some hypothesis and the principles of their methodology follow:
[I] In certain cases there is a relation between the act of using controversial concepts /changing controversial understanding (ccc) and the related attitude (evaluation), subjective norm, perceived control, and the interactions of attitude, subjective norm and perceived control. In other words:

(A) Ccc depends upon revised beliefs about consequences and revised personal values that give a baseline for evaluation of these consequences. Therefore a. ccc requires change in belief(s) about consequences, or/and b. change in the person's personal value(s).

(B) Ccc depends upon revised beliefs about the thinking of specific referents and changed tendency to comply. Therefore a. ccc requires change of social perception of what other people think, and/or b. change of social relations/change in dependency on other people.

(C) Ccc depends upon revised beliefs about personal capacity and available resources necessary for learning and change. Therefore ccc requires change of self-perception about mastery, achievement, self-efficacy or action control.

(D) Ccc depends on interactions in which the A, B and C factors are variables. Accordingly test – treatment – post-test should be administered.

[II] Ccc depends partly on age. Therefore, how are the hypotheses above related to age?

[III] Ccc depends on available cultural tools, communicative practices and contexts, and therefore one might ask: How is ccc related to different speech genres, e.g. religious, scientific, educational, political and every

day language discourses? For example how is ccc related to different school subjects topics (e.g. the greenhouse effect issue treated in biology, social science, or in ethics)?

(5) Controversial conceptual change related to the (manmade) greenhouse effect issue – examples of test items in a pilot study

(6) Conclusion
Further steps have to be taken to show the validity of the model through analytical analysis and empirical research.

Interaction of cognitive and motivational factors in working with problems calling for conceptual change in number concept
*Kaarina Merenluoto and Tarja-Riitta Hurme, University of Turku, Finland

The aim of this presentation is to examine the problems of conceptual change in mathematics (e.g. Vamvakoussi & Vosniadou, 2004) from the viewpoint of dynamics between motivational and cognitive factors (e.g. Merenluoto & Lehtinen, 2004; Pintrich, Marx & Boyle, 1993). In reanalysis of our previous data, we pay attention students' cognitive and motivational profiles and to their level of metaconceptual awareness (e.g. Mason & Boscolo, 2000; Mason, 2001) which was shown while they worked with problems dealing with rational numbers.

The participants in the study were students on grades 7-9 at Finnish comprehensive school, grade 7 (n = 15), grade 8 (n = 17) and grade 9 (n = 15), the percentage of girls was 40 %, 18 % and 67 % respectively. All the students had the same teacher. Besides completing a 26 tasks rational numbers test and estimating their certainty at each task, the students were asked to fill in a questionnaire on own estimation of their self-efficacy and tolerance with difficult problems in mathematics. The teacher was also asked to estimate the same variables for each of her students and give students achievement level in mathematics.
Four distinctive cognition – motivational profiles were found. The answers of even the best students suggested mostly operational level of understanding indicating to an enrichment kind of learning (c.f. Vosniadou, 1999). Only in the answers of a few students there were some indications of deeper level of thinking suggesting a preliminary state of conceptual change. The high correlations between the cognitive and motivational factors refer to the importance of considering the motivational aspects in the research on conceptual change. But they also refer to the complex interaction of these variables in learning. The students' achievement level in mathematics had a significant relation to the high sensitivity to the cognitive demands and high tolerance of ambiguity that seems to be essential for the conceptual change. However, the moderate operational understanding of the concepts has a tendency to prevent the students' from noticing the cognitive conflict (c.f. Limón, 2001). The results also confirm that in the attempts to teach for conceptual change it is crucial to consider the cognitive distance between students' prior knowledge and the new phenomenon to be learned.

The results indicate how situations demanding conceptual change are also coping situations for the students. They need to give up their earlier confidence based on familiarity of natural numbers and move into a very different kind of mathematical thinking where different kind of rules and operations are dealt with. In order to success in this process, they need to tolerate the inevitable feeling of uncertainty (e.g. Sorrentino, Bobocel, Gitta & Olson, 1988; Efklides, Samara & Petropoulou, 1999) which comes from newly learned operations and concepts while enough certainty has not yet gained to deal in the new environment.

13.30 – 15.30 Paper sessions A

(Vårgårdsalen)

Chair and Discussant: Roger Säljö, University of Gothenburg, Sweden

Knowledge objects: flexible personal understandings constructed for specific contexts
Noel Entwistle, University of Edinburgh, Scotland

Background and aims

The research was designed to investigate the ways in which students develop their understanding as they prepare for final university examinations. A substantial body of research has established the importance of encouraging university students to adopt deep approaches to their studying (Marton & Säljö, 1997). Such approaches depend on the intention to understand evoking processes which, within a specific subject area, allow students to reach understandings that are in line with disciplinary conventions. However, the nature of those understandings had not been investigated to any great extent in higher education settings. A series of small-scale interview studies have been carried out in Edinburgh which indicate that students adopting a deep approach, when faced with the demands of a final examination, often construct understandings within individualistic structures that provide logical paths for the explanations they have to provide (Entwistle & Entwistle, 2003). The proposed paper would present a re-examination of the data collected in these studies to consider to what extent these constructed personal understandings take account of the specific contexts within which, and purposes for which, explanations have to be provided.

Research design

Two groups of students (N = 28) were interviewed about their experiences of preparing for, and taking, final university, essay-type examinations, mainly in psychology and social history. The interviews were carried out along phenomenographic lines (Marton & Booth, 1997) to follow students' experiences in considerable depth. The interviews were then transcribed and analysed to examine the processes of learning used during revision, and, in particular, the students' experiences of seeking and achieving, to their own satisfaction, conceptual understanding.

Outcomes

The analyses identified marked differences in the breadth, depth and structure of the understandings developed during revision, and in the ways in which students constructed their own flexibly-structured understandings or knowledge objects. The focus of the analysis to be presented in this paper would be the students' awareness of the demands of the task they were facing in preparing for the examination and how they used knowledge objects to produce explanations that were shaped to the specific requirements of the questions set with an alertness to the audience of examiners who would be reading and assessing the essays.

Theoretical and educational significance

The exploration of understandings constructed within a specific context for a particular purpose helps to indicate how the demands of a task shape the explanations provided from a mental model that had been previously committed to memory. Providing insights into the ways in which students seek to develop conceptual understanding is also important for both staff and students in higher education.

Conceptual change theories and their relation with the design of teaching – learning sequences
Gallegos, Leticia and *Garcia-Franco, Alejandra, National Autonomous University of Mexico, Mexico

Aim of the study

The design and implementation of teaching – learning sequences for specific topics in science has received a great deal of attention in the last years. However it is common that the theoretical assumptions which underlie these designs are not made explicit. The aim of this work is to provide a framework based on the different approaches and dimensions of conceptual change to design and analyze teaching – learning sequences.

Methodology / Research design

The way in which conceptual change is conceptualized has a profound impact in the design of teaching–learning sequences, because it determines the sequence of the concepts to be taught and the nature of the learning activities.
Some of the approaches to conceptual change are epistemological and some of them are more psychological / cognitive in nature, therefore, they tend to emphasize different aspects of knowledge construction.

Conceptual change theories can also be differentiated according to their treatment of concepts. In some cases concepts are considered as stable, non-dynamic entities which can be replaced and in some other cases concepts are considered to be part of a complex, evolving system.
Even though these differences are not always clear cut, we consider that classifying theories of conceptual change according to their approach and their conception of concepts can be useful to analyze their influence on the design of teaching learning sequences.
We have developed a framework of analysis for teaching–learning sequences that comprises on one hand the epistemological / cognitive dimension, and on the other hand the concept replacement / complex system dimension.

Outcomes

We have used this framework to analyze different teaching–learning sequences already published in international journals and found out that it provides information that allows the comparison of different strategies according to their theoretical assumptions.
Using this framework for analysis also permits testing for consistency in the teaching – learning sequences, considering if the theoretical suppositions are in agreement with the actual activities. This framework makes emphasis on the recognition of the theoretical assumptions underlying the design of teaching–learning sequences which can be very important for its implementation in different contextual conditions.

Theoretical and educational significance

The design of research based teaching learning sequences is an important area in science education given it allows for the outcomes of research to become tangible in the classroom. It is important therefore to build these sequences based on frameworks that facilitate consistency and coherency between theoretical assumptions and actual activities.
By using this framework based on the different conceptual change dimensions it is possible to analyze already published teaching learning sequences trying to find out all the elements that are relevant if it is to be implemented in different contextual conditions. This framework also highlights different aspects that need to be considered in the design of teaching–learning sequences, allowing for the design of more theoretical-based teaching–learning strategies.

Pupils' Conception of the Greenhouse Effect as a Societal and Moral Phenomenon
Li Wang, Stockholm University, Sweden

China's prioritization of economic development over ecological and social considerations may have environmental repercussions. But the problem of greenhouse effect caused by particularly industry together with increasing number of cars appears as not only a Chinese regional problem, but one with global consequences.

Based on pupils' discussions regarding the responsibility to reverse environmental deterioration, which is elicited from discussions about greenhouse effect, the study aims at describing and exploring how they interpret the relationships among nature, society and individuals. The investigation is from the angle of seeing them as a dynamic inter-relationships woven among the three aspects.

The design of the study is composed of five assignments aiming at investigating how 14 year olds studying at Chinese Green Schools in the Beijing area interpret the concept of greenhouse effect in the practical situations by referring to pictures showing changes of life, and also by referring to pictures showing changes of landscapes. The paper describes students' conceptions of the roles of individuals, nature and society towards sustainable development and their inter-relationships. The preliminary findings show that the pupils' interpretations of the relationships vary depending on where their own standpoints are.

Contextual Variation and Conceptual Understanding in Higher Education
Max Scheja, Stockholm University, Sweden

Background: Research on the relationship between students' subject-matter understanding and memorization has stressed that conceptual understanding is dependent on the students' experiences of variation. For instance, by reading an academic text over and over again, but by varying the perspective used in reading that text, variation is created which enables the learner to discern critical aspects of the topic studied and enhance her or his understanding of that topic. In particular, if students focus on different aspects each time they read a particular text the understanding reached will become richer and more differentiated; and by contextualising the text in different ways it will become clearer how the text's theme differs from other ways of dealing with the same topic. However, while there is some empirical evidence for the proposition that certain forms of variation can enhance students' understanding this relationship is not as empirically straightforward and well documented as that between, for instance, repetition and rote-learning.

Aim: This paper addresses the question of the interplay of variation and understanding, and aims to contribute to the ongoing discussion on conceptual understanding in higher education by investigating what contextual variation, in terms of students' shifting contextualisations of learning material, imply in terms of opportunities for their developing conceptual understanding in a university setting.

Methodology/Research Design: Data were collected among students at a large Swedish university. A sample of 125 undergraduates taking a basic course in education were recruited for participation in a problem session presenting them with a task—initially introduced by Kahneman and Tversky in their well-known investigations into decision making—foregrounding the concept of probability. The students were asked to work on the task individually and write down their solutions, and were then given twenty minutes to discuss the task in groups of four to six. Apart from collecting the students' written answers, additional data were collected in relation to the students' group discussions. With the students' informed consent, eight of these discussions were audio-taped and later transcribed in full. The paper draws primarily on these transcripts. Analysis of the data was performed following the principles of intentional analysis, focusing on the students' intentions in approaching the given task.

Outcomes: The analysis of the data revealed a marked variation in the students' ways of relating to the concept of probability. More specifically, it is shown how different ways of contextualising the task yield different

interpretations of the concept of probability, and hence of the task as s problem to be solved.

Theoretical & Educational Significance: This research has it roots in a continuing interest in understanding what variations in students' ways of conceptualising learning tasks imply in terms of opportunities for learning in different subject areas. By focusing on the ways in which students interact with their learning environment and contextualise learning tasks the present work links research on learning in higher education with research on conceptual change, offering an integrative framework for exploring both cognitive and sociocultural aspects of the process through which students develop their conceptual understanding.

13.30 – 15.30 Paper sessions B

(von Kochsalen)

Chair and discussant: Lucia Mason, University of Padua, Italy

Can drawings be used to grasp children's conceptions?
Karin Ehrlén, Stockholm University, Sweden

Drawing is an often-used yet controversial method of grasping children's conceptions. The aim of this study was to investigate if drawings can be used for this purpose. The study compared the way children drew the earth to how they explained their conceptions of the earth. How children drew the earth was considered a matter of choosing between conventions for depicting in cultural contexts and children's application of conceptions was considered a matter of finding an appropriate conceptual framework in cognitive contexts. Both these kinds of contextualizing were related to the situation. Eighteen children, aged 6 to 9, were interviewed with a semi-structured method while they were drawing the earth. The children made one, two, or three drawings of the earth. The recorded interviews, drawings, and notes from the interview situation were analyzed to find the cultural and cognitive intentions behind the drawings. First the children's contextualizing of their drawings in cultural contexts was analyzed. Descriptions of how the children drew the earth were given, and indications of reasons for their choice of mode of depiction were scrutinized. Then the children's contextualizing in cognitive contexts was analyzed. What the children said about the earth was related to concepts in cognitive contexts and compared to earlier research on children's conceptions. Finally, the children's contextualizing in cultural contexts was compared to their contextualizing in cultural contexts. It was found that the explanations some of the children gave of their drawings of the earth were in line with alternative conceptions of the earth found in earlier research in this area and in research on children's geographical conceptions. However, these alternative conceptions were usually not revealed in the children's drawings. Moreover, the study gave support to a view of children's drawings as a process of connecting to conventions. This was concluded from that the children sometimes explicitly indicated the pictorial conventions they were trying to follow in their drawings and from that some children's comments indicated that they were aiming to draw as one normally drew the earth. These comments, together with the findings of differences between the children's drawings of the earth and their explanations of the earth indicated that what they drew was not out of their conceptions, but out of conventions and other pictures. Theoretically the results were explained by that choosing a drawing convention in a cultural context involves a different process than finding a cognitive context for a conception. Thus drawings in themselves are no appropriate means for grasping children's conceptions. Only if the meaning children themselves give to their drawings is considered, drawings may be useful in research situations when conceptions are investigated. The intention of the drawing child can be regarded as the bridge between the child's conceptions in cognitive contexts and the child's drawing in cultural contexts.

Mental models of the earth reassessed II: Children's models, drawings and explanations.
*Georgia Panagiotaki and Gavin Nobes, School of Psychology, University of East London, UK

Investigation of children's understanding of the earth provides important insights into the origins of children's knowledge, the structure of their concepts, and the development of scientific ideas. It is claimed (e.g., Vosniadou & Brewer, 1992; Vosniadou et al., 2004) that, under the influence of intuitive constraints and observations, children form naïve but coherent mental models of the earth: for example, they believe it to be flat, that people live inside a hollow sphere, or that there are two earths. An alternative view suggests that children's knowledge of the earth lacks the consistency and systematicity attributed to naïve theories or mental models (e.g., Nobes et al., 2005; Schoultz et al., 2001; Siegal et al., 2004). Even at the age of 5 years, many children demonstrate aspects of scientific understanding. In addition, when young children's ideas about the earth are not scientific, they are largely inconsistent.

This paper will discuss two studies. Both aim at testing the claim that children's knowledge of the earth

takes the form of coherent mental models such as the flat, hollow or dual earth.

In the first study, 59 children aged 6-8 years and 33 adults were given multiple-choice questions and a 3D model selection task. Questions concerned the shape of the earth, the location of people, the position of the clouds and whether there is anything that supports the earth. This approach addressed a number of methodological criticisms identified in previous studies. For example, by using multiple choice questions, it avoided the problematic open and repeated questioning used in Vosniadou & Brewer's studies. Results revealed that even the youngest children preferred scientific responses and so demonstrated some knowledge of the earth. Only 10% of the children showed any evidence of naïve mental models; other participants who gave non-scientific answers were inconsistent and unsystematic; and by the age of 8, children's patterns of responses did not differ from those of adults'.

In the second study, 85 6-7 year olds were asked to draw the earth and answer open questions about its shape and properties. The instructions and questions were similar or identical to those used by Vosniadou & Brewer, except that some were rephrased to minimise ambiguity and thus possible misinterpretation. Consistent with findings from the first study, children's responses about the earth were mainly scientific. When not scientific, their responses and drawings indicated fragmented knowledge rather than coherent misconceptions.

It will be argued that intuitive constraints have little or no influence on the development of children's ideas in this domain, and that emerging knowledge of the earth progresses from being fragmented to consistently scientific. In addition, children's apparent naive misconceptions reported in previous research may be methodological artifacts resulting from misinterpretation of ambiguous tasks and questions.

The Development of Knowledge about the Earth and the Day/Night Cycle in Blind and Sighted Children

Kalliopi Ikospentaki, Stella Vosniadou, and *Irini Skopeliti, University of Athens, Greece

The results of a study that compared sighted to congenitally blind children's knowledge in the area of observationally astronomy are presented. Our interest is focused on how congenitally blind children understand scientific information about the earth and the day/night cycle and how we can improve the teaching of science in this population. In prior research, Vosniadou and Brewer (1992, 1994) found that young children construct initial representations of the physical world based on everyday experience. These representations may then stand in the way of understanding scientific explanations of physical phenomena which often are counter-intuitive and require a major re-organisation of prior knowledge. We wanted to investigate whether blind children will go through a similar process in their understanding of scientific explanations in the domain of observational astronomy as sighted children do, or whether, given their lack of optical information, will find scientific information easy to understand. Twenty sighted and twenty congenitally blind children were interviewed individually. They were asked questions concerning the shape of the earth and explanations of the day/night cycle. Our results showed that the knowledge acquisition process possibly follows more or less similar path in blind and sighted children, as we found misconceptions and some synthetic models in blind children similar to those obtained in the case of the sighted children. In contrast, the congenitally blind children's answers indicate a lack of variety, comparing them with the answers of sighted children of the same educational group. Possibly the auditory and tactile information, which blind children get from their surrounding are sufficient to influence them in a way to construct initial representations, which may hinder them in understanding the scientific explanations.

Acknowledgements

This publication is part of a PhD dissertation which is supported by the Principle Investigator, General Secretariat for Research and Technology, Greece, 03 ?? 8.3.1, with the title "*A methodological approach for the Acoustic-Haptic Interaction design in the non-visual user interface, with emphasis to the accessibility of visually impaired persons – Homer"*

Conceptual Change by Means of External Representations

*Michael Schneider, Ilonca Hardy and Angela Jonen, Max-Planck- Institute for Human Development, Germany

Representational tools such as diagrams and graphs are commonly employed as reasoning tools which allow learners to derive conceptual insights by building on, refocusing, and extending initial conceptions. For instance, for a concept of density, learners need to simultaneously consider the two quantities of mass and volume, allowing predictions of objects' floating and sinking. The use of external representations may show the inadequacy of students' initial conceptions such as the concentration on objects' weight, and it may support students' construction of new explanations by focusing learners' attention on essential variables. Further, external representations may foster students' ability to make sense of new forms of representations such as graphs. In an experimental classroom study with 98 third-graders, we addressed the question which of two forms of representation, a balance beam or self-constructed forms, is more helpful for developing students' conceptual understanding of "floating and sinking," including their understanding of the proportional relationship between mass and volume in the concept of density. In a follow-up study five months later, we investigated whether experiences with the balance beam, which is structurally similar to the graph, will help children in interpreting line graphs displayed in a coordinate system. While the balance beam draws attention to the simultaneous involvement of mass and volume in determining material kind, and to their (constant) quantitative relation, a student may explicate his or her understanding of a situation directly in a self-constructed form of representation; often, this type of activity involves the qualitative representation of variables.

In the classroom study, we employed a curriculum of 11 lessons on floating and sinking which varied only in students' use of visual representations for density. Results revealed a significant improvement in conceptual understanding of floating and sinking for students of both experimental groups, as assessed by a test scoring both the correct rejection of misconceptions and the adoption of scientific explanations. The two groups' gains in proportional reasoning differed with regard to the domain (density, speed, or juice mixtures). In the follow-up study, 56 randomly chosen students from the classroom study were presented with coordinate systems depicting line graphs in a density and speed context during a structured interview (see Hardy et al., 2005). As hypothesized, students who had worked with the balance beam outperformed students who had worked with self-constructed representations in the context of density, but only marginally in the context of speed. As correlations with posttest scores on proportional reasoning indicate, these children interpreted density graphs in a quantitative way, as in determining the mass and volume of objects of different densities. In sum, this study supports the importance of the use of external representations for conceptual change in science domains, while especially highlighting the effect of quantitative representations such as the balance beam for transfer between representations.

16.00 – 18.00 Invited symposium

Epistemological Beliefs, Motivational Beliefs, and Approaches to Learning: Their influence on Conceptual Change Processes

Organizers: Lucia Mason, University of Padua, Italy, and Gale M. Sinatra, University of Nevada, USA

Chair: Lucia Mason, University of Padua, Italy

Discussant: Stella Vosniadou , National and Kapodistrian University of Athens, Greece

Presenters:
Barbara Moschner, Carl von Ossietzky University of Oldenburg, Germany
Gale M. Sinatra, University of Nevada, USA
Christina Stathopoulou and Stella Vosniadou, University of Athens, Greece
Lucia Mason, Angela Boldrin, and Alessia Vanzetta, University of Padua, Italy

Introduction
In their seminal article, Pintrich, Marx, and Boyle (1993) called for moving beyond cold conceptual change, that is, to consider affective, motivational, and situational factors that may affect knowledge change. With a very few notable exceptions (Dole & Sinatra, 1998; Gregoire, 2003), researchers in the field have yet to investigate these motivational factors. Among the motivational factors included by Pintrich (1999) and colleagues (Pintrich, Marx, & Boyle, 1993) are goal orientations, epistemological beliefs, personal importance, value, interest, self-efficacy, and personal control. This symposium aims to shed some light on the role of these, until recently, neglected variables in the process of knowledge revision. These processes are analyzed in students of different educational levels, ranging from elementary school to college, and considering different scientific phenomena. More specifically, in order to better understand how, and in what conditions, conceptual change is more likely to occur, we will mainly focus on crucial characteristics of learners. The key factors analyzed in all contributions are students' epistemological beliefs, that is, their beliefs about the nature of knowledge and knowing. Epistemological beliefs will be examined in relation to content knowledge (Sinatra's paper), achievement goals (Mason et al.'s paper), and approaches to learning and studying (Stathopoulou & Vosniadou's paper). A critical review of the role of these factors in the process of conceptual change will be also provided (Moschner's paper) at the beginning of the symposium to raise crucial questions that will be discussed throughout the session.

Contributions:

Epistemological Beliefs, Learning Motivation, and Learning Strategies as Predictors for Conceptual Change
Barbara Moschner and Carl von Ossietzky University of Oldenburg, Germany

Not only in classroom education but also in lifelong learning situations the question of prerequisites for conceptual change has become more and more prominent over the last years. Epistemological beliefs, learning motivation and self-regulated learning approaches are regarded as important variables which can facilitate or inhibit conceptual change processes. But so far only a few empirical studies have investigated, such as which epistemological beliefs, which motivational beliefs and which approaches to learning are positively related to long lasting conceptual changes. However it is supposed that more sophisticated epistemological beliefs, intrinsic learning motivation and deep learning processes may foster conceptual change. After reviewing current theoretical models and existing empirical data about the relation of these variables, some of the above mentioned suggestions will be questioned. Not believing in absolute knowledge but "being lost" in multiplism might have negative consequences for intentional conceptual change; intrinsic learning motivation without the ability to judge the quality of information might strengthen the old (mis-)conceptions and elaborated learning strategies might not be helpful for conceptual change if the new information is integrated in a network of

wrong or problematic prior knowledge. Consequences of these possible difficulties for instruction and intentional conceptual change will be discussed.

Epistemic Conceptual Change
Gale M. Sinatra, University of Nevada, USA

In our work on epistemological beliefs and acceptance of biological evolution (Sinatra, Southerland, Mc Conaughy, Demastes, 2003; Sinatra & Southerland, 2002; Southerland, Sinatra, & Matthews, 2001) we have argued that learning about evolution involves *epistemic conceptual change*. That is, conceptual change in the domain of science involves a change in students' beliefs about the nature of knowledge and knowing. In this presentation, I will present the results of a follow-up study to the Sinatra et al. (2003) study examining the relationship between knowledge, epistemological beliefs, and acceptance of scientific explanations of phenomena. Students with high and low levels of biology knowledge will be compared in terms of their acceptance of scientific theories and their epistemological beliefs. We predict, based on the results of Sinatra et al. (2003), that students with greater content knowledge will show more sophisticated epistemological beliefs, and greater acceptance of scientific explanations. We posit that epistemic conceptual change is a result of increasing appreciation of the epistemic and ontological assumptions of the nature of science. In addition to our study results, the presentation will include recommendation for instruction to promote epistemic conceptual change.

The Influence of Physics-Related Epistemological Beliefs on Physics Understanding: How Do Approaches to Learning and Studying Intervene?
Christina Stathopoulou and Stella Vosniadou, University of Athens, Greece

The present study investigates the indirect influence of students' physics-related epistemological beliefs on physics conceptual understanding. It is hypothesized that physics-related epistemological beliefs may guide the adoption of a certain approach to physics learning and studying, i.e., superficial or deep approach, that in turn, may constrain or facilitate physics conceptual understanding. Interviews, think-alouds and observations of ten Greek 10th-grade students were analyzed in terms of their physics-related epistemological beliefs, approaches to physics learning and studying, and physics conceptual understanding. Preliminary results showed that all five students who were found to hold a constructivist physics epistemology and to have achieve in-depth physics understanding (in the area of Newtonian dynamics), adopted a deep approach to learning and studying. In contrast, the remaining five students who showed evidence of a less constructivist epistemology regarding physics and were far from having achieved in-depth physics understanding, adopted what may be considered as a superficial approach to learning and studying. Extensive examples are given to better illustrate the relationship between physics-related personal epistemology, the approach to studying and physics understanding.

Epistemological Beliefs and Achievement Goals in Conceptual Change Learning
Lucia Mason, Angela Boldrin, and Alessia Vanzetta University of Padua, Italy

The "non-cold" factors that Pintrich, Marx, and Boyle (1993) mentioned as potential resources or constraints in conceptual change also include learners' epistemological belief and goal orientations. Epistemological beliefs are representations about the nature of knowledge and knowing. It has been documented that beliefs in knowledge as complex, uncertain, and continuously evolving facilitates conceptual change more than beliefs in knowledge as simple, absolute, and certain (Mason, 2003; Qian & Alvermann, 1995; Southerland & Sinatra, 2003). Achievement goals have been distinguished in two primary goals, mastery and performance (Ames, 1992). Students who adopt mastery goals indicate that they do their work to learn and understand. In contrast, students who adopt performance goals indicate that they focus on demonstrating their ability, especially in relation to others. It has been documented that adopting mastery goals produces higher levels of knowledge

revision than adopting performance goals (Linnenbrink & Pintrich, 2002).

This study focuses on the effects of both motivational variables, which have been investigated separately in previous research, on the complex and dynamic process of learning from text by knowledge revision. A mastery or performance goal was randomly induced in seventy-nine fifth graders before reading a text on magnetism. Their epistemological beliefs were measured using the instrument by Conley and collaborators (2004). Their reading ability was considered as a covariate. Data analyses are still in progress. We predict that both motivational factors will affect conceptual change in favor of students with more advanced beliefs about scientific knowledge and students who adopt a mastery goal orientation. We also expect a significant interaction between the two factors, that is, their powerful combination that leads to attaining the highest scores for knowledge revision.

Saturday, June 17th

09.00 – 11.00 Panel discussion

(Vårgårdsalen)

Chair: Erno Lehtinen, University of Turku, Finland

Theoretical and Methodological Considerations for the Future

Gale Sinatra, University of Nevada, USA
Roger Säljö, University of Gothenburg, Sweden
Russel Tytler, Deakin University, Australia
Stella Vosniadou, University of Athens, Greece

11.30 – 12.00 Conclusions

(Vårgårdsalen)

Paul Cobb, Vanderbilt University, USA

Barbas....46
Bernhard....26, 38
Blajenkovia....39
Boldrin....59, 60
Bromme....24
Broughton....38
Bryant....14
Budde....46
Camilloni....23
Carretero....16, 27
Chou....16
Christou....31
Cobb....41, 62
Dal....13, 32
De Bock....9
Dochy....34
Ehrlén....56
Entwistle....52
Erkki....18, 39
Gallegos....53
Garcia-Franco....45, 53
Gikopoulou....16
Gillard....17
Gurlitt....39
Haerle....24
Haglund....13, 31
Halldén....6, 11, 14, 31
Hardy....19, 58
Humberstone....7
Hurme....51
Ikospentaki....57
Janssens....34
Jonen....19, 58
Jovchelovitch....11, 41, 43
Kariotoglou....19
Keiny....20
Kienhues....24
Kinnunen....18
Kozhevnikov....39
Krause....39
Larsson....11, 13
Le Maréchal....45
Leach....19, 42
Lehtinen....15, 44, 62
Levinas....23, 27, 48
Marton....32
Mason....14, 41, 56, 59, 60
Merenluoto....42, 51
Mevorach....29
Mikkilä-Erdmann....18, 39
Moschner....59
Mwakabungu....40
Möller....19

Niedderer.....27, 41, 44, 46
Nikolopoulou.....19
Nobes.....12, 56
Nunes.....14
O' Dowd.....27
Österlind.....48
Panagiotaki.....12, 56
Pang.....32
Pantsidis.....7
Penttinen.....18, 39
Petersson, G.....6, 13, 15
Petersson, K.....46
Pnevmatikos.....19
Potvin.....28
Psillos.....46
Puhl.....34
Reeve.....7
Reynolds.....38
Rouet..... 15, 34
Salonen.....39
Schaeken..... 17
Scheja..... 54
Schneider.....19, 58
Segal.....21, 29
Sinatra.....38, 59, 60, 62
Skopeliti.....13, 57
Solomon.....14
Stahl.....24
Stark.....34, 39
Stathopoulou.....59, 60
Stern.....19
Struyven.....34
Strömdahl..... 7, 46
Säljö.....6, 14, 52, 62
Säter.....49
Taber.....45
Tiberghien.....15, 23, 45
Toussaint.....35
Tsai.....16, 42
Tytler.....31, 42, 62
Vamvakoussi.....8, 41
van Dooren.....9, 17
Wang.....54
Vanzetta.....59, 60
Verschaffel.....9, 17
Witenberg.....36
von Ossietzky.....59
Vosniadou.....6, 7, 8, 13, 14, 16, 31, 48, 57, 59, 60, 62

Participants' List

Bernhard, Jonte, Linköping University, Sweden
jonbe@itn.liu.se
Broughton, Suzanne, University of Nevada, Las Vegas, USA
ksbro1@netzero.com
Bryant, Peter, Oxford Brookes University, UK
pbryant@brookes.ac.uk
Camilloni, Alicia, University of Buenos Aires, Argentina
acamilloni@arnet.com.ar
Carretero, Mario, Autonomous University of Madrid, Spanien
mario.carretero@uam.es
Chou Ching-Yang, National Kaohsiung Normal University, Taiwan
chouching@yahoo.com.tw
Christou, Konstantinos, University of Athens, Greece
kochrist@phs.uoa.gr
Cobb, Paul, Vanderbilt University, USA
paul.cobb@vanderbilt.edu
Dal, Burckin, Istanbul Technical University, Turkey
dalbu@itu.edu.tr
Ehrlén, Karin, Stockholm University, Sweden
karin.ehrlen@ped.su.se
Enghag, Margareta, Mälardalens University, Sweden
margareta.enghag@mdh.se
Entwistle Noel, University of Edinburgh Scotland, UK
Noel.Entwistle@ed.ac.uk
Erkki Anto, University of Turku, Finland
emanto@utu.fi
Garcia-Franco, Alejendra Ciudad Universitaria, Mexico
alegfranco@hotmail.co.uk
Gikopoulou, Rania, University of Athens, Greece
rgicop@phs.uoa.gr
Gillard, Ellen, University of Leuven, Belgium
ellen.gillard@ped.kuleuven.be
Gurlitt, Johannes, University of Freiburg, Germany
gurlitt@psychologie.uni-freiburg.de
Haerle, Florian, University of Nevada, USA
email@florian-haerle.net
Haglund, Liza, Stockholm University, Sweden
lizha@ped.su.se
Halldén, Ola, Stockholm University, Sweden
ola.hallden@ped.su.se
Hardy, Ilonca, Max-Planck- Institute for Human Development, Germany
hardy@mpib-berlin.mpg.de
Humberstone, Judi, University of Melbourne, Australia
judih@unimelb.edu.au
Jakobsson, Öhrn Harriet, Police academi, Sweden
harriet.jakobsson-ohrn@phs.police.se
Jovchelowitch, Sandra, London School of Economics and Political Science, UK
S.Jovchelovitch@lse.ac.uk
Keiny, Shoshana, Ben-Gurion University of the Negev, Israel
shoshk@bgu.ac.il
Kienhues, Dorothe, University of Muenster, Germany
kienhues@psy.uni-muenster.de

Kvateng, George, Linköping University, Sweden
georgekvateng@yahoo.com
Larsson, Åsa, Stockholm University, Sweden
asa.larsson@ped.su.se
Leach, John, The University of Leeds, UK
j.t.leach@education.leeds.ac.uk
Lehtinen, Erno, University of Turku, Finland
erno.lehtinen@utu.fi
Levinas, Marcelo Leonardo, University of Buenos Aires, Argentina
leo@levinas.com.ar
Lundholm, Cecilia, Stockholm University, Sweden
ceci@ped.su.se
Mason, Lucia, University of Padua, Italy
lucia.mason@unipd.it
Merenluoto, Kaarina, University of Turku, Finland
kaarina.merenluoto@utu.fi
Mikkilä-Erdmann, Mirjamaija, University of Turku, Finland
mirmik@utu.fi
Molander, Bengt- Olov, The Stockholm Institute of Education, Sweden
bom@lhs.se
Moschner, Barbara, University of Oldenburg, Germany
barbara.moschner@uni-oldenburg.de
Mwakabungu, Fika, Stockholm University, Sweden
fika.lutenago@ped.su.se
Niedderer, Hans, Mälardalens University, Sweden
Hans.Niedderer@mdh.se
Nilsson, Per, Växsjö University, Sweden
Per.Nilsson@vxu.se
Nobes, Gavin, University of East London,UK
g.nobes@uel.ac.uk
Nunes, Terezinha, University of Oxford, UK
terezinha@edstud.ox.ac.uk
O Dowd, Mina, Lund University, Sweden
mina.odowd@pedagog.lu.se
Österlind, Karolina, Stockholm University, Sweden
karolina.osterlind@ped.su.se
Panagiotaki, Georgia, University of East Anglia, UK
georgia@eul.ac.uk
Panahi, Homan, Stockholm University, Sweden
homan.panahi@ped.su.se
Pang, Ming-Fai, The University of Hong Kong, China
pangmf@hkucc.hku.hk
Pantsidis, Cristos, University of Athens, Greece
pantsidis@sch.gr
Papagapiou, Marios, University of Ontario, Canada
marios.papagapiou@mycampus.uoit.ca
Penttinen, Marjaana, University of Turku, Finland
mapent@utu.fi
Petersson, Gunilla, Stockholm University, Sweden
gunilla.petersson@ped.su.se
Petersson, Karin, Linköping University, Sweden
karpe@isv.liu.se
Pnevmatikos, Dimitris, University of Western Macedonia, Greece
dpnevmat@uowm.gr67

Potvin, Patrice, Université du Québec á Montréal, Canada
potvin.patrice@uqam.ca
Psillos, Dimitris, Aristotele University of Thessaloniki, Greece
psillos@eled.auth.gr
Reynolds, Ralph E, University of Nevada, Las Vegas, USA
ralph.reynolds@unlv.nevada.edu
Rouert, Jean-François, University of Poitiers, France
jean-françois.rouet@univ-poitiers.fr
Säljö, Roger, University of Gothenburg, Sweden
roger.saljo@ped.gu.se
Sæther, Jostein, Norwegian Teacher Academy, Norway
js@nla.no
Scheja, Max, Stockholm University, Sweden
max.scheja@ped.su.se
Schneider, Michael, Max Planck Institute for Human Development, Germany
mscheider@mpib-berlin.mpg.de
Segal, Sarit, Levinsky College of Education, Israel
segal@macam.ac.il
Sellbjer, Stefan, Växjö University, Sweden
Stefan.Sellbjer@vxu.se
Sinatra, Gale, University of Nevada, Las Vegas, USA
sinatra@unlv.nevada.edu
Skopeliti, Irini, University of Athens, Greece
eskopel@phs.uoa.gr
Solomon, Gregg, National Science Foundation, USA
gesolomo@nsf.gov
Stark, Robin, Saarland University, Germany
r.stark@mx.uni-saarland.de
Stathopoulou, Christina, University of Athens, Greece
chrp@otenet.gr
Strömdahl, Helge, Linköping University, Sweden
helst@isv.liu.se
Struyven, Katrien, Centre for Research On Teaching and Training, Belgium
Katrin.struyven@ped.kuleuven.be
Tiberghien, Andrée, Université Lyon, France
andree.tiberghien@univ-lyon2.fr
Toussaint, Rodolphe M. J, Université du Québec a Troi-Riviéres, Canada
rodolphe.toussant@uqtr.ca
Tsai, Chih-Wen, Yenchao Junior High School, Taiwan
tcw1203@ms29.hinet.net
Tytler, Russell, Deakin University, Australia
tytler@deakin.edu.au
Vamvakoussi, Xanthi, Xenia, University of Athens, Greece
xenva@phs.uoa.gr
Van Dooren, Wim, University of Leuven, Belgium
wim.vandooren@ped.kuleuven.be
Vosniadou, Stella, University of Athens, Greece
svosniad@phs.uoa.gr
Wang, Li, Stockholm University, Sweden
wang.li@ped.su.se
Wistedt, Inger, Stockholm University, Sweden
ingerw@ped.su.se
Witenberg, Rivka T, Australian Catholic University, Australia
R.Witenberg@patrick.acu.edu.aumailto:jonbe@itn.liu.se

PAPER SESSIONS - Overview

Wednesday 14 June 13.30 - 15.30 Vårgårdsalen
Chair and discussant: Helge Strömdahl

The role of external representations in the ordering of fractions
*Christos Pantisidis and Stella Vosnadou, University of Athens, Greece

Conceptual Changes in the Transition from Arithmetic to Algebra
*Judi Humberstone and Robert Reeve, University of Melbourne, Australia

Aspects of students' understanding of rational numbers from a conceptual change perspective
*Xenia Vamvakoussi and Stella Vosniadou, University of Athens, Greece

The over-use of proportionality: Erroneous conception or scholastic effect?
*Wim Van Dooren, Dirk De Bock, and Lieven Verschaffel, University of Leuven, Belgium

Wednesday 14 June, 13.30 – 15.30 von Kochsalen
Chair and discussant: Sandra Jovchelovitsh

Differentiation and coordination in conceptual change
Ola Halldén and Åsa Larsson

Mental models of the earth reassessed I: Adults' responses to children's tasks.
*Nobes Gavin and Panagiotaki Georgia, University of East London, UK

For developing successful learning strategies in teaching: the analysis of students' ideas
Burckin Dal, Istanbul Technical University, Turkey

Developmental Shifts in Children's Categorizations of the Earth
*Irini Skopeliti and Stella Vosniadou, University of Athens, Greece

Situated analysis of conceptual models
Gunilla Petersson, Liza Haglund and Åsa Larsson, University of Stockholm, Sweden

Thursday 15 June 10.30-12.30 Vårgårdsalen
Chair and discussant: Mario Carretero

Conceptual change based on the development of conceptual categories: The change in Taiwanese eighth graders' concept of mass
*Chih-Wen Tsai, Yenchao Junior High School, Taiwan and Yang Chou, National Kaohsiung Normal University, Taiwan.

Categorizations of Substances in Relation to Explanations of Changes in the State of Matter

**Rania Gikopoulou & Stella Vosniadou*, University of Athens, Greece

Proportionality as a conceptual obstacle: Considerations from a dual-process framework
*Ellen Gillard, Wim Van Dooren, Walter Schaeken, and Lieven Verschaffel, University of Leuven, Belgium.

Eye movement measurement as a method for tracing cognitive conflict in reading science text
*Mirjamaija Mikkilä-Erdmann, Erkki Anto, Marjaana Penttinen and Riitta Kinnunen, University of Turku, Finland

Thursday 15 June 10.30-12.30 von Kochsalen
Chair and discussant: John Leach

Patterns of Conceptual Change: The Development of Elementary School Students' Explanations of "Floating and Sinking"
*Ilonca Hardy, Michael Schneider, Angela Jonen, Kornelia Möller and Elsbeth Stern, Max-Planck-Institute, Germany

Children's conceptions about floating and sinking: A microgenetic approach
*Dimitris Pnevmatikos and Kariotoglou, P. University of Western Macedonia, Greece

Is there a Theory of Conceptual Change?
(Is CC a good label?)
Shoshana Keiny, Ben-Gurion University, Israel

Constructing Knowledge in Teacher Training By A New Institutional Organization of Knowledge
Sarit Segal, Levinsky College of Education, Israel

Thursday 15 June 10.30-12.30 Örnesalen
Chair and discussant: Andreé Tieberghien

Conceptual Change in the History of Science as a Tool in Physics, Astronomy and Cosmology Teaching
Alicia Camilloni, and *Leonardo Levinas, University of Buenos Aires, Argentina

Changing epistomolgical beliefs: The surprising impact of a short-term intervention
Dorothe Kienhues, University of Muenster, Germany

The Educational Model For Personal Epistemology Enhancement
Florian Haerle, University of Nevada, Las Vegas, USA

Conceptual labs – experiences from a decennium of design and implementation
Jonte Bernhard, Linköping University, Sweden.

Thursday 15 June 13.30-15.30 Vårgårdsalen
Chair and discussant: Hans Niddered

How different contexts can produce partial conceptual change: an example of a decisive crucial experiment
*Leonardo Levinas, University of Buenos Aires, Argentina, and Mario Carretero, University of Autónoma de Madrid, Spain.

Ways of Seeing, Conceptualisation and Conceptual Change: Theoretical and methodological considerations
Mina O'Dowd, Lund University, Sweden

From conceptual change to conceptual evolution: looking for invariants in the gradual understanding of the conversely proportional relation within F=ma
Patrice Potvin, University of Québec, Canada

Knowledge-Building Community: Applying the Third Approach in Education to Teacher Training
*Sarit Segal and Miriam Mevorach, Levinsky College of Education, Israel

Thursday 15 June 13.30-15.30 von Kochsalen
Chair and discussant: Russell Tytler

Learning History. An intentional analysis of student's meaning making based on a visit at a museum
Liza Haglund, Stockholm University, Sweden

Students' interpretation of the use of literal symbols in inequalities
*Konstantinos Christou and Stella Vosniadou, University of Athens, Greece

Approach to Learning in Geoscience Education : the practice of Rocks
Burckin Dal, Istanbul Technical University, Turkey

Phenomenography and conceptual change
*Ming Fai Pang, The University of Hong Kong, Hong Kong and Ference Marton, Gothenburg University, Sweden

Thursday 15 June 13.30-15.30 Örnesalen
Chair and discussant: Jean-François Rouet

Facilitating conceptual change in educational argumentation – conceptualization and evaluation of a problem-oriented learning enviroment
*Robin Stark & Thomas Puhl, Saarland University, Germany

On the dynamics of approaches to learning: the effects of student-activating versus teacher-directed instruction.
*Katrien Struyven, Filip Dochy and Steven Janssens, KU Leuven, Belgium

Appropriation of Knowledge through Conceptualisation, Modeling and Problematisation
Rodolphe Toussant, University of Québec, Canada

Beliefs about radical tolerance – experiential influences or structral development?
Rivka Witenberg, Australian Catholic University, Australia

Friday 16 June 10.30-12.30 Vårgårdsalen

Tematic paper
Organizer: Hans Niddered

Chair and discussant: Erno Lehtinen
General introduction of learning process studies (
Hans Niedderer, Mälardalens University, Sweden

Research methods in learning process studies
*Andrée Tiberghien and Jean-François Le Maréchа, University of Lyon, France

Learning processes and parallel conceptions – learning about the particulate nature of matter
*Alejandra Garcìa-Franco National University of Mexico and Keith Taber, University of Cambridge, UK

The evolution of students' conceptual "topography" during instances of a teaching learning episode
Alexandros Barbas and *Dimitris Psillos, Aristotle University of Thessaloniki, Greece

Some thermal phenomena revisited in a new perspective
*Karin Petersson and Helge Strömdahl, Linköping University, Sweden

Influences of taught content on student learning in quantum atomic physics
Marion Budde and *Hans Niedderer, University of Bremen, Germany

Friday 16 June 10.30-12.30 von Kochsalen

Chair and discussant: Stella Vosniadou

Emotional factors and conceptual change
Karolina Österlind, Stockholm University, Sweden

What Kind of Conceptual Change Paved the Way for the Scientific Revolution

Leonardo Levinas, University of Buenos Aires, Argentina

Controversial conceptual change described as action – A model proposal in the context of science education.
Jostein Säther, Norwegian Teacher Academy, Bergen, Norway

Interaction of cognitive and motivational factors in working with problems calling for conceptual change in number concept
*Kaarina Merenluoto and Tarja-Riitta Hurme, University of Turku, Finland

Friday 16 June 13.30-15.30 Vårgårdsalen
Chair and discussant: Roger Säljö

Knowledge objects: flexible personal understandings constructed for specific contexts
Noel Entwistle, University of Edinburgh, Scotland

Conceptual change theories and their relation with the design of teaching – learning sequences
Leticia Gallegos and * Alejandra Garcia-Franco, National University of Mexico

Exploring Learning about Greenhouse Effect in the Green Schools in China
Li Wang, Stockholm University, Sweden

Contextual Variation and Conceptual Understanding in Higher Education
Max Scheja, Stockholm University, Sweden

Friday 16 June 13.30-15.30 von Kochsalen
Chair and discussant: Lucia Mason

Can drawings be used to grasp children's conceptions?
Karin Ehrlén, Stockholm University, Sweden

Mental models of the earth reassessed II: Children's models, drawings and explanations.
*Georgia Panagiotaki and Gavin Nobes, University of East London, UK

The Development of Knowledge about the Earth and the Day/Night Cycle in Blind and Sighted Children
Kalliopi Ikospentaki, Stella Vosniadou, and *Irini Skopeliti, University of Athens, Greece

Conceptual Change by Means of External Representations
*Michael Schneider, Ilonca Hardy and Angela Jonen

TRAVEL DIRECTIONS

Vår Gård Saltsjöbaden is located 17 km south-east of down-town Stockholm. You can reach us easily by car, public transport or boat.

BY THE TRAIN SALTSJÖBANAN

From Stockholm Central Station/Underground, take the underground south to Slussen, then follow the signs on the platform towards the train Saltsjöbanan. The train trip to the end of the line at Saltsjöbaden takes 30 minutes. When you get off the train, you will be able to see the red brick buildings of Vår Gård Saltsjöbaden on the other side of the tracks from the station. The walk to the front desk takes only a couple of minutes.

BY CAR

If you are coming from the south, take road 222 (Värmdöleden) east to the exit to Saltsjöbaden, road 228. Once you have arrived in Saltsjöbaden, follow the signs to Ångbåtsbryggan (the Steamboat Dock) and Vår Gård Saltsjöbaden. From the north, first drive to Slussen and then take road 222 (Värmdöleden) as above.

BY BOAT

Vår Gård Saltsjöbaden has its own dock and we would be happy to help you book transport by boat. The boat trip from downtown Stockholm to Vår Gård Saltsjöbaden takes about an hour. Some regularly scheduled archipelago tours stop at the nearby steamboat dock, Ångbåtsbryggan, in Saltsjöbaden.

Cover design: B Adolfsson Design · Photo: Stockholm visitors board/Richard Ryan · Print: TB Alltryck Rydheims, 2006