Program & Abstracts

8th International Conference on Conceptual Change

September 1 to 4, 2012

University of Trier, Germany
**Program Overview**

<table>
<thead>
<tr>
<th>Day</th>
<th>Time</th>
<th>Event</th>
</tr>
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<tbody>
<tr>
<td><strong>Saturday, September 1, 2012</strong></td>
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<td>01:00 pm Arrival and registration (Library)</td>
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<td>02:00 pm</td>
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<td>Keynote lecture: Bethany Rittle-Johnson</td>
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<td>Welcome reception (1st floor foyer)</td>
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<td><strong>Sunday, September 2</strong></td>
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<td>09:00 am Keynote lecture: Stella Vosniadou</td>
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Sessions

2:30 - 4:00 pm, Library

Symposium: Supporting Conceptual Change through Multiple Texts and Multiple Representations

Organizers: Erno Lehtinen (Turku University, Finland), Patricia A. Alexander (University of Maryland, USA)
Chair: Margarita Limón (Autónoma University of Madrid, Spain)
Discussant: Barbara Moschner (University of Oldenburg, Germany)

There is ample evidence that achieving conceptual change in learners is a trying and often unsuccessful endeavor. Even when presented with compelling cases or counterevidence, learners seem able to resist and to retain unjustified beliefs. This symposium considers the question of what it takes to tear down the wall of student resistance by exploring the influence of multiple textual sources and multiple representations as, perhaps, one avenue to transforming students' knowledge and beliefs. This symposium will feature work from international scholars examining students' interactions with multiple texts and multiple representations of information to explore this possible road to conceptual change. Toward that end, this symposium will have two primary purposes. First, presenters will describe students' behavior in response to tasks and conditions that entail search or learning from multiple texts or multiple representations. Second, the findings from these investigations will be considered in light of the question of whether engagement with multiple data sources on a topic or multiple representations of data may facilitate deeper or richer processing of content—a critical step in changing what students know and believe about a topic.

Enhancing science teaching by combining laboratory and simulation activities

Tomi Jaakkola, Koen Veermans, and Erno Lehtinen (University of Turku, Finland)

Computer-based simulations and laboratory activities have been traditionally treated as substitute or competing methods in science teaching. Two experiments were conducted in the domain of electricity in order to investigate whether learning with the combination of laboratory and simulation activities can result in better conceptual understanding in science than learning with laboratory or simulation activities alone. During the experiments students worked in three different learning environments – 1) in laboratory they used real equipment, 2) in simulation virtual equipment, and 3) in simulation-laboratory combination real and virtual equipment simultaneously – and they had either a fixed number of circuits they could construct or a fixed amount of time in which to construct them. The participants were 117 10- to 12-year-old elementary school students from Finland. The students were first matched on their pre-test scores and then allocated randomly (from each matched set) to the learning conditions. In order to measure and compare how the learning environments affected students' conceptual understanding of electric circuits, a subject knowledge assessment questionnaire was administered before and after the experimentation. The intervention session of each student was videotaped in the second experiment, in order to obtain explanations for the learning outcomes. The results of the experiments showed that studying electrical circuits in the simulation–laboratory combination environment improved students' conceptual understanding of electrical circuits more than studying circuits in simulation and laboratory environments alone. Although there were no statistical differences between simulation and laboratory environments, the learning effect was more pronounced in the simulation condition where the students made clear progress during the intervention, whereas in the laboratory condition students' conceptual understanding remained at an elementary level after the intervention. Analysis of the video data revealed several theoretical explanations for the effectiveness of combining simulation and laboratory activities. 1) Both representations have unique affordances that help students to discover the properties of the domain. The representations are also complementary: 2) analogical encoding between two overlapping representations can activate deeper processing of the content, 3) help students to interpret and understand each representation, and 4) correct emerging misconceptions.

Students' source selections, justifications, and evaluations when responding to different question types

Alexandra List, Emily M. Grossnickle, & Patricia A. Alexander (University of Maryland, USA)

This study adopts a comprehensive view of multiple source use to consider students' selection, use, and evaluations of multiple texts in a digital academic context. Specifically, we focus on (a) students' purpose for using each text, (b) descriptions of text use, and (c) understanding of texts in relation to one another. Participants were asked to respond to two academic questions, one discrete and one open-ended, using a library of eight digital texts, varying in source
type (e.g., newspaper article) and reliability. Log data, as well as retrospective guided interviews, were used to capture students’ processing of multiple texts. Profiles of student source use were developed for each question type and categorized according to the extent to which students’ source use process was reflective of epistemic concerns. Further, profiles were examined for the extent to which students adopted an orientation toward multiple source use that likely would facilitate their conceptual learning and development. Implications for research and instruction will also be discussed.

Promoting conceptual change in history: influence of prior topic knowledge, epistemic competence and in-group identification

Margarita Limón (University Autónoma of Madrid, Spain)

Literature about reasoning has shown that evidence evaluation is often biased. Studies developed since the nineties have pointed out how individuals’ beliefs, goals, motives, feelings or mood influence their assessment of the evidence presented (e.g. Kunda, 1990; Stein & Miller, 1993; Kardash & Scholes, 1996; Klaczynsky, 2000). a) To study the influence of prior topic knowledge, epistemological understanding and in-group identification in how individuals select, interpret and evaluate evidences when they are presented an ill-defined historical problem. Both the main effects and the interactions among these variables will be studied. b) To study how individuals’ react to the presentation of data that confirm and contradict their initial position, that is, if they are sensitive to data or not. Spanish high school students (n= 30), and Spanish freshmen (n= 30) participated in the study. Students seemed to be rather sensitive to the data presented. Instructional implications of these results for history learning and teaching will be developed.

4:15-5:40 pm, Library

Paper Session: Conceptual Change in Physics

Chair: Ilonca Hardy

Starting at the beginning: Experiencing physics in preschool

Gertraud Benke (University Klagenfurt, Austria)

Much has been written about changing naive physics into more mature physical understandings (e.g. Vosniadou, 2010). At the core, many students display systematic misconceptions about natural phenomena stemming from their everyday interactional practices with the inanimate world. Can we change the acquisition of at least some of these understandings before they solidify? While participating in the Fibonacci- Project (an EU-RP7 project), a preschool in a small Austrian town set up a science lab in their preschool (in spring 2011), and later, seeing the enthusiasm of the children, science corners in all their classrooms for daily playful engagement. Through the Fibonacci project, the educators got professional development courses in inquiry science education, which they put to practice with their children. In this paper, I will present an exploratory study on student discourse during their engagement in their science corner and in the science lab, as well as their responses to questions trying to elucidate the nature (or complexity) of their understandings. Additionally, I will briefly present the preschool teachers’ perspective and experiences on bringing science into their classrooms (see also Duit, Treagust, Widodo, 2008). The paper is based on 10 weekly two-hour sessions of observation and videotaping in spring 2012, informal interviews with the students and their teachers.

Conceptual change of secondary students’ mental models of hillslope springs

Sibylle Reinfried, Sebastian Tempelmann (University of Teacher Education Central Switzerland Luzern, Switzerland)

Prior research has indicated that students on the K12 level show little understanding of hydrological processes. An analysis of 13-year old lower secondary students’ learning pathways concerning their mental model building of hillslope springs and spring water pollution was conducted to better understand mental model construction processes in learners and the difficulties related to them. The relevance for this research is given by the fact that it has become a socio-political and future-orientated necessity to constitute an understanding of “water knowledge” (UNESCO-IHE, 2007). Freshwater springs play an important role in the context of “water knowledge” because they are at the intersection of subsurface and surface water. To better understand students’ mental model building and conceptual change processes an explanatory in-depth investigation based on the case study method was employed. An instructional sequence embedded in a pre-posttest design provided quantitative and qualitative data. The instruction
used a constructivist learning environment that focused on model evolution and conceptual change and included worksheets, experiments, physical models, phases of co-construction and one-on-one tutoring interviews. The transcripts of the videotaped co-construction phases and the tutoring interviews, students’ annotated drawings and their answers to the questions in the questionnaire served as the database. The results of the analysis demonstrate that the students achieved significant learning gains through their work with the learning environment. Nevertheless, the students’ prior knowledge plays a dominant role in mental model construction and the conceptual change process. Students with no spring-related or science-related pre-knowledge constructed mental models that represent the scientific concept used in the teaching materials. Students with elaborated, experience-based but false pre-knowledge had difficulties to change their mental models.

Concept development in learning physics: The case of electric current and voltage revisited
Ismo T. Koponen (University of Helsinki, Finland)

In learning conceptual knowledge in physics, a common problem is the concept development and concept differentiation in the learning process. An important part of such a development process is the re-organisation or re-structurisation process, in which students’ conceptual knowledge and concepts change. Traditionally, such a learning process has been approached from a viewpoint of conceptual change, where the current views fall to two major camps: knowledge-as-theory and knowledge-as-pieces views. This study proposes a new view of concept development with explicit attention to concept development from the level of knowledge-as-pieces to the level of knowledge-as-theory, and where both aspects are acknowledged as appropriate descriptions but at different stages of development. The proposed new picture is based on the view that concepts are complex constructs essentially embedded in a larger system of knowledge. Three closely connected aspects need our attention: 1) conceptions of concepts, 2) conceptions of knowledge systems, and finally, 3) conceptions of the process of change. These aspects are approached taking into account that that concepts as elements of higher cognitive tasks can project differently in different situations. The theoretical part of the study is connected to empirical part. The empirical part shows potential advantages of the suggested new viewpoint, which are demonstrated through re-analysis of the concept development in the well-known case of electric current and voltage. The data of the analysis comes from interviews of groups of upper secondary school students. The results show that in the concept development process causal knowledge and coherence of the knowledge system both play crucial roles.

Promoting conceptual development in physics teacher education: Cognitive-historical reconstruction of electromagnetic induction law
Terhi Mäntylä (University of Helsinki, Finland)

In teaching physics, the history of physics offers fruitful starting points for designing instruction. I introduce here an approach, which utilizes the historical cognitive processes to enhance the conceptual development of pre-service physics teachers’ knowledge. It applies a method called a cognitive-historical approach introduced by Nersessian in the area of cognitive science. The approach combines the analyses of actual scientific practices in the history of science with the analytical tools and theories of contemporary cognitive sciences in order to produce knowledge of how conceptual structures are constructed and changed in science. Hence the cognitive-historical analysis indirectly produces knowledge about the human cognition. Here a way to use the cognitive-historical approach for didactical purposes is introduced. In this application, the cognitive processes in the history of physics are combined with the current physics knowledge in order to create the cognitive-historical reconstruction of a certain quantity or law for the needs of physics teacher education. A principal aim of developing the approach has been that it is valuable for pre-service physics teachers to know how the physical concepts and laws are or can be formed and justified. As a practical example of the developed approach, a cognitive-historical reconstruction of the electromagnetic induction law was designed. For evaluating the uses of the cognitive-historical reconstruction, a teaching sequence for pre-service physics teachers was conducted. The study reports of twenty-four and interviews of nine students were analysed through a qualitative categorisation of students’ justifications of knowledge. The results show a conceptual development in the students’ explanations and justifications of how the electromagnetic induction law can be formed.
Epistemic beliefs in children - Results of an empirical study using concept cartoons
Andrea Anschütz, Barbara Moschner (University of Oldenburg, Germany)

Research about epistemic beliefs is a steadily growing area in educational psychology and in the field of education. A large amount of published studies are based on questionnaire measures or interview data. Besides this, subjects in most of the published studies are adults or teenagers, only a few studies deal with young children. In our study we questioned if it is possible to assess epistemic beliefs with an instrument including concept cartoons. Moreover, we asked which epistemic beliefs do young children have and how do they vary between different school levels. For answering these questions we investigated the epistemic beliefs of 1273 3rd and 6th graders of German primary and secondary schools. Results of the data show that students were able to understand and get along with the new instrument with the concept cartoons. Factor analyses and reliabilities suggest that the instrument is a valid and reliable way to assess epistemic beliefs in young children. Results of the comparison between different school levels indicate that epistemic beliefs may not develop in a linear and stringent way as some theories and models assume. Our data rather provides the assumption that epistemic beliefs in children develop recursive and spiral like over time. It also seems that a critical step in the development of epistemic beliefs may be the shift from elementary to secondary school. Further results will be discussed at the conference.

Stop being a textbook-slave! Conceptual change in epistemological beliefs of future history teachers by learning how to design a page in a textbook
Nicola Brauch (Freiburg University, Germany), Albert Logtenberg, (Leiden University, Netherlands), Matthias Nückles (Freiburg University, Germany)

This paper deals with the question how future history teachers can be fostered in pedagogical choices by the challenge to design a cognitive activating task for teaching history in school. History textbooks do commonly not provide ill-structured problems and their narratives are mostly not understandable for pupils (von Borries, 2008). On the other side, history teachers to some extent are dependent on schoolbooks, because they don’t have the time to keep informed in current tendencies in historical science in each historical topic. They become nearly necessarily “textbook-slaves”. Thus, we believe that future history teachers should learn to design their own learning materials. The aim would be to enable future history teachers to develop task assignments adequate to the purpose of teaching history, that is to enable pupils to come to own historical reasoning and judgments (Schreiber, 2008, Van Drie & Van Boxtel, 2008). 61 future history teachers participated in one of four curricular standardized courses in teaching and learning history. Students were given conceptual texts representing current debates on theoretical and historical content, pedagogical content and pedagogical sciences. (e.g., Van Drie & Van Boxtel 2008). In the first half of the term students read and analyzed the text in order to use them for designing history lessons. Student reading and analyzing was structured by prompted learning journals (Nückles et al., 2010) in order to describe the process of learning. In the second half of the term the future history teachers constructed cognitive activating tasks for students in secondary education (Blömeke et al., 2008). These tasks are analyzed to describe the learning outcomes. The four courses dealt with the topics Holocaust, Piracy and Vikings. Students achieved best in the studies based on the curricular content “Holocaust” and by reading and reflecting a text-sample dealing very explicitly with the problems of text/task arrangement and the epistemology of historical sciences.

Does studying science make a difference? A comparison of epistemological beliefs of prospective science teachers during their academic education
Heike Brauer & Matthias Wilde (Bielefeld University, Germany)

Epistemological beliefs are personal beliefs about learning and knowledge. They have been found to have important implications for learning, for academic achievement and they predict teaching practices. This study examined the development of epistemological beliefs of 166 prospective science teachers in Germany. A self-reported questionnaire with the dimensions source, certainty, development and justification was used. Confirmatory factor analysis was applied and had had satisfactory psychometric properties; the explained variance is 58 %. The results show that students start their academic education with inappropriate epistemological beliefs and do not succeed in changing them. Neither there were no differences in three dimensions regarding to the semester studied; only the dimension
justification shows an inconsistent shift. Nor were correlations found between their beliefs and the courses the prospective teachers have been deepening before in school.

**Exploring epistemological beliefs and conceptual change in undergraduate psychology students**

*Armin Günther, Günter Krampen, Gabriel Schui, Anne-Kathrin Mayer, Johannes Peter, Nikolas Leichner (University of Trier & ZPID, Germany)*

Background of the presentation is a longitudinal study of learning processes among psychology (and computer science) undergraduates from a conceptual change perspective currently prepared at Leibniz-Institute for Psychology Information (ZPID), Trier. In our presentation we discuss theoretical assumptions of the study focusing on the interplay between domain specific epistemological beliefs and domain knowledge. We argue that “learning psychology” from a conceptual change perspective might not only involve changing psychological concepts but also changing the very concept of psychology as a science itself. Compared to their fellow students from disciplines like biology, physics or geosciences undergraduates starting to study psychology may face a more basic cognitive challenge: Not only their conceptions and lay theories of intelligence, personality, human development, mental health etc. may be questioned, but also their fundamental preconceptions and beliefs about the nature of psychology, psychological knowledge and psychological research, i.e. their (domain specific) epistemological beliefs. Approaching this distinction between “domain specific concepts” and “the concept of a specific domain” from an applied perspective some authors argue, that teaching psychology may succeed in changing psychology knowledge but fail in changing the more fundamental epistemological beliefs which are essential for critical thinking and “psychological literacy”. Additionally to the theoretical discussion we want to present first results of a pilot study, exploring domain specific epistemological beliefs for the field of psychology on different levels of expertise (undergraduates, graduates, and faculty).

**5:45 -7:00 pm, Graduation Assembly Hall**

*Keynote Lecture: Overcoming Misconceptions – Insights from Research on Understanding the Equal Sign*

*Speaker: Bethany Rittle-Johnson (Vanderbilt University, USA)*

*Chair: Lieven Verschaffel*

Integrating new knowledge with prior knowledge is foundational to learning, and this integration is particularly challenging when people have misconceptions that need to be addressed. For example, many students have the misconception that the equal sign means “get the answer,” so they make systematic errors when solving equations with operations on both sides of the equal sign (e.g., $3 + 7 = 5 + ___$). In turn, this misconception is a barrier to success in algebra. I will overview potential sources of this misconception, including primarily exposing children to equations in operations = answer format (e.g., $3 + 7 = 10$). I will also outline our construct-modeling approach to assessing knowledge of the equal sign, which identifies 4 knowledge levels, including transitional knowledge. Finally, I will describe research on several instructional methods that support knowledge change, such as exploratory experiences and self-explanation prompts.
**SUNDAY**

**9:00 - 10:15 am, Graduation Assembly Hall**

**Keynote Lecture: The problem of conceptual change in the learning of science and mathematics**

**Speaker: Stella Vosniadou (National and Kapodistrian University of Athens, Greece)**

Chair: Erno Lehtinen

Conceptual change research investigates learning processes that require the substantial revision of prior knowledge and the acquisition of new concepts. In this presentation I will discuss the major theoretical views on conceptual change and the kinds of instruction required to facilitate it. I will focus on the ‘framework theory’ approach that was developed to explain students’ difficulties in learning science concepts. I will argue that learners construct a naïve physics early on in childhood which is based on everyday experience in the context of lay culture. Naïve physics acts as a framework theory to advance but also constrain the learning of science. I will argue that both fragmentation and misconceptions can be the product of initial instruction and that many misconceptions are ‘synthetic models’ produced when constructive mechanisms are used to integrate scientific information with incompatible prior knowledge. I will then show how the framework theory can be used to predict and explain students’ difficulties in learning mathematics focusing on the learning of rational number.

**10:30 am - 12:00 pm, Graduation Assembly Hall**

**Paper Session: Metacognition and Scientific Reasoning**

**Chair: Patricia Alexander**

**Using evidence as a pathway to conceptual change: A study in the domain of elasticity**

Ilonca Hardy; Steffen Tröbst; Christin Robisch; Simone Stephan-Gramberg, Kornelia Möller (University of Frankfurt & University of Münster, Germany)

Learners’ coordination of their (naïve) theories with corresponding evidence has been repeatedly stated as a core goal of science education (Harlen, 2001; Duschl, 2008). An appropriate use of evidence refers to a person’s judgment of whether a presented piece of evidence is confirming, disconfirming or irrelevant to a given hypothesis. According to the conflict strategy, evidence disconfirming one’s prior belief should be related to conceptual change as new explanations need to be generated. The ability to use evidence in specific science content domains has rarely been examined. In the present study, we focus on young children’s capability to use evidence in the context of elasticity. We presume that children’s use of evidence shows developmental patterns found with content-lean tasks of deductive reasoning (e.g., Barrouillet et al., 2008) and that it shows systematic relations to three measures: domain-general scientific reasoning, working memory, and prior content knowledge. We tested children’s use of evidence following the scheme employed in the literature on deductive reasoning. In a cross-sectional study of four groups of children in preschool and elementary school age (total N = 142), we administered a test of use of evidence as well as the three above mentioned measures. As hypothesized, analyses showed a highly significant effect of age with regard to the frequency of six patterns of deductive reasoning (F (5, 134) = 53.96, p < .001). Similarly, children’s ability to coordinate and use evidence increased significantly with age (F (4, 134) = 1041.28, p < .001). Analyses with GLMM models of the contribution of domain-general scientific reasoning to performance on the domain-specific reasoning tasks showed a significant interaction with age, even after controlling for working memory capacity. Taken together, our results will inform instructional strategies in science education intended to promote conceptual change on the basis of empirical evidence.

**The development of conceptions of science in elementary school: understanding theories, designing experiments and interpreting data**

Christopher Osterhaus; Susanne Koerber; Beate Sodian; Daniela Mayer; Knut Schwippert (University of Education Freiburg, Germany)

Children’s understanding of the nature of science was investigated in two studies. Study 1 addressed the question whether distinct conceptions of science (i.e., naïve, intermediate and scientifically-advanced understanding) could be detected in a paper and pencil test. This paper and pencil test was developed based on standard interviews for assessing scientific reasoning (e.g., Carey, Evans, Honda, Jay, & Unger, 1989) and knowledge of scientific methods (e.g.,
Sodian, Zaitchik, & Carey, 1991) and thoroughly tested in various pilot and validation studies. So far, prior studies with this instrument affirmed its applicability in elementary school and, as opposed to traditional interviews, indicated an early understanding of science in children of this age group. In our present Study 1, 287 second-, third- and fourth-graders answered a set of multiple-choice questions regarding the nature of science and their understanding of scientific methods. Advanced concepts were more frequently accepted in grade 3 and 4 than in grade 2 with significant differences between the higher grades for only a set of questions. In Study 2, an adopted version of our paper and pencil test that only consisted of multiple-select items, for which each level of understanding of science needed to be accepted or rejected separately, was administered to 235 third-graders in order to investigate more thoroughly the structure of the instrument. Model comparisons revealed that the model that fitted the data best was a three-dimensional model with naïve, intermediate and advanced conceptions forming each a separate dimension.

Osterhaus: The development of conceptions of science in elementary school: Understanding theories, designing experiments and interpreting data

Causes of goal misinterpretations during a lesson on experimental design
Stephanie Ann Siler, David Klahr, Bryan J. Matlen (Carnegie Mellon University, USA)
Learning to design and evaluate experiments are essential skills that enable one to learn about the world. Direct instruction in CVS (Control of Variables Strategy) has been shown to promote development of these skills and transfer to other domains across long delays in middle-SES students as young as third grade (Chen & Klahr, 1999). However, students from lower-SES populations typically fare much worse from this instruction in comparison (Klahr & Li, 2005). One reason is that lower-SES students more often misinterpreted the overall goal of the instruction as learning about the task-specific variables or as designing ramps to produce a desired outcome (i.e., engineering goal)—rather than as about learning a technique that serves the science goal of finding the causal status of a variable. Thus, conceptual transitioning from an engineering to a science goal orientation may be required to enable students’ learning of CVS. In this paper, we investigate potential causes of goal misinterpretations, guided by dual-process models of cognition (e.g., de Neys, 2012; Epstein, 1994; Evans, 2006). Two potential causes of misinterpretations in lower-SES students investigated and supported in our analyses are their weaker science-related goals and weaker metacognitive skills. If supported by future research, these results suggest that both science-goal knowledge and metacognitive skills should be targeted by CVS instruction.

10:30 am - 12:00 pm, Lecture Hall 1
Paper Session: Text and Discourse
Chair: Stella Vosniadou

Eye-Movements in Science Text Reading: Effects of an Introductory Refutation Passage
Erkki Anto, Marjaana Penttinen & Mirjamaija Mikkilä-Erdmann (University of Turku, Finland)
The aim of this study was to explore how the reading of an introductory refutation passage affects eye movements during the reading of a science text. In the study, 17 university students read an introductory refutation passage before reading a text on photosynthesis, whereas 14 participants directly began to read the science text. Pre- and post-test questions were administered. Eye movements during reading were recorded using a Tobii 1750 Eye Tracker. When a refutation passage had been presented prior to reading, the main eye-movement effect was the lengthening of the average first pass fixation duration during the first reading. This suggests that the cause of the refutation text effect may lie in, for instance, general alertness after a reader has been presented the possible presence of comprehension difficulties. In follow-up analyses, the finding will be explored together with results on the participants’ learning outcomes as well as other eye-movement measures, e.g., second reading of the text.

Why not disagree? Reasons for avoiding knowledge-related disagreement with experts
Salla Ahola (University of Helsinki, Finland)
Previous studies have unveiled several factors that are related to argumentativeness. However, less is known of why some individuals avoid arguments and thus the aim of this study is to gain a better understanding of these reasons. First, it is suggested that endorsing certain personal values might be one factor explaining why some individuals rather avoid disagreement. Second, individuals’ selfreported reasons for not having disagreed are analysed. While most
previous research has studied willingness to argue in general, the current study focuses more specifically on individuals’ disagreement with experts. The data of 304 randomly sampled Finns was gathered using a postal survey. Respondents filled in the Portrait Values Questionnaire and gave an account of a situation in which they disagreed with an expert about some knowledge or in case of having not disagreed explained the reasons for that. Those 68 respondents who had left the latter part unanswered were excluded from the analyses, which were done using logistic regression analysis and qualitative content analysis. Results of logistic regression analyses showed that endorsing self-direction, stimulation, power and rational truth values decreased the likelihood of avoiding disagreement, while endorsing security, conformity and tradition values increased this likelihood. Content analysis was used to categorise respondents’ explanations for not having disagreed. Only the seven most prevalent categories are reported here. The categories that were used most often were trust in experts, own characteristics, and unwillingness to quarrel or fight. Other categories which also received several mentions were the importance of the issue, practical realities, possible risks involved and seeing disagreeing as futile. It is concluded that personal values are one important factor in predicting individuals’ willingness to disagree or to avoid disagreement. Second, the analysis of respondents’ own accounts clarifies our understanding of the range of reasons for avoiding disagreement.

The effect of discourse style and human presence on conceptual change learning through argumentation

Christa S. C. Asterhan & Miriam Babichenko (Hebrew University of Jerusalem, Israel)

Research and theory on conceptual change indicates that socio-cognitive conflict can serve as a trigger for the restructuring of misconceptions, provided that students are given adequate opportunities and support to work through, understand and articulate the differences between conflicting explanations, for example through the use of argumentation (e.g., Asterhan & Schwarz, 2007; 2009; Nussbaum & Sinatra, 2003). However, students often avoid the direct confrontation and instead prefer to concede upfront or hold on to their initial standpoint without much cognitive engagement, therefore missing important opportunities for learning (Asterhan, in press). We propose that the reasons for these difficulties should be sought in the interpersonal dimension of peer argumentation: When the interaction between two disagreeing peer learners is regulated in a way that emphasizes collaboration (as opposed to interpersonal competition), students will benefit from the cognitive affordances that argumentative discourse has to offer. Moreover, interacting with a disagreeing peer is expected to be less threatening (and thus more beneficial to learning) when the peer partner is believed to be a computerized agent, as opposed to a human subject. These expectations were tested in a 2*2 experimental study in which 80 undergraduates learned about the topic of diffusion and then discussed their solutions to transfer items with a disagreeing peer confederate, who was believed to be either a human or computer agent. Peer confederate’s verbal behavior was tightly controlled and scripted to evoke argumentative discourse, while holding constant exposure to content but differing in rhetoric style (competitive vs. constructive). Argumentative discourse style was found to affect conceptual learning in the expected direction and in particular on those conceptual principles most resistant to change (i.e., the micro –molecular- level). The manipulated belief of interaction with a human vs. a computer agent did not affect learning, even though individual differences in perceived social presence were associated with learning.

A conceptual integration perspective on language and ontology in conceptual change

Tamer G. Amin & Bassem Malek (Lebanese American University & Greater Beirut Evangelical School, Lebanon)

Different lines of research on conceptual change have offered different, conflicting perspectives on the ontological classification of concepts in experts and novices. Analysis of language has figured prominently in this work. In this paper, we draw on the cognitive linguistic theory of conceptual integration to offer another perspective on ontological classification and its relationship to language. We suggest that this perspective accounts for broad differences between novices and experts but also accommodates flexibility within levels of expertise and within individuals. Two experts (university physics professors) and four novices (secondary school students) participated in interviews in which they reasoned about physical events drawing on the concept of energy. Analysis of the participants’ reasoning allowed for inferences about their ontological conceptualization of energy in the context of their reasoning about specific phases of the physical events being considered. In addition, the verbal predicates used to express ideas about energy were documented. The framework of conceptual integration was used to examine how conceptualization of energy emerges as an outcome of the integration of the conventional schemas associated with verbal predicates, the specific features of the physical event being considered and other background knowledge. The analysis provides evidence for broad differences between novices and experts in their ontological conceptualizations and use of verbal predicates. While the ontological conceptualizations of the novices varied more, experts also showed some variability in their
conceptualizations of energy. Both groups used verbal predicates literally and metaphorically. The implications of these findings for claims about the occurrence of ontological shifts as an aspect of conceptual change and their relationship to language are discussed.

1:30 - 3:00 pm, Graduation Assembly Hall

Symposium: Sensemaking, Answermaking, and Resource Coordination across the Undergraduate Physics Curriculum

Organizers: Mathew “Sandy” Martinuk (University of British Columbia, Canada), Eleanor C. Sayre (Kansas State University)
Chair: Paul W. Irving (Kansas State University)
Discussant: Eleanor C. Sayre (Kansas State University)

In university physics classes, students must coordinate multiple representations to make sense of physical phenomena and mathematical formalism. In this symposium, we look at students in three kinds of university physics classes - introductory algebra-based, intermediate classical mechanics, and advanced electromagnetism - working together to solve problems posed by their instructors. As they work, they must also coordinate and negotiate activities amongst themselves. In the first paper, *Epistemological Framing and Sensemaking in Collaborative Group Problem-Solving*, we argue that introductory students engage in both *sensemaking* as they figure out concepts and phenomena and *answermaking* as they try to understand and meet external requirements, and that these two behavioral patterns correlate well with two epistemological frames. In the second paper, *Epistemological Framing: Asynchronous Individuals in Group Problem Solving*, we argue that intermediate students in a group can flexibly and rapidly shift between epistemological frames and sensemaking/answermaking behaviors, coordinating mathematical resources as well as social and epistemological ones. In the third paper, *Representations in Physics as Material Anchors: Using Conceptual Blending Theory to Understand Sensemaking with Representations*, we argue that advanced students' sensemaking behaviors include coordinating complicated representations, and analyze their sensemaking in terms of Conceptual Blending. Although the papers are drawn from different groups of students, these three papers together suggest a developmental trend for physics students moving through the curriculum. Introductory students use mathematics for answermaking. Intermediate students blend mathematical and intuitive representations for both answermaking and sensemaking, a change in both framing and behavior. Advanced students coordinate multiple formal mathematical representations while sense-making.

Epistemological framing and sensemaking in collaborative group problem-solving

*Mathew “Sandy” Martinuk (University of British Columbia, Canada)*

In order to support the development of students' conceptual understanding we need to provide opportunities for students to engage in sensemaking as a part of their problem solving in physics. However, students may also engage in answermaking: the performance of instructional tasks without regard to their own judgments of what is sensible. The Resources and Framing theoretical framework provides a way of understanding these behaviors in terms of epistemological framing: the students' expectations about the nature of knowledge and learning in their current activity. Prior research has shown that these frames significantly affect students’ approach to their learning and may therefore influence whether students engage in answermaking or sensemaking. The current study uses epistemological framing to examine sensemaking in the context of collaborative group problem-solving in an introductory algebra-based physics course. Analysis of students' discourse shows that sensemaking behaviors are predicted by the epistemological frame of Conceptual Discussion and answermaking behaviors are predicted by the frame of Procedural Discussion. Instructional implications for promoting sensemaking via Conceptual Discussion are discussed.

Epistemological framing – Asynchronous individuals in group problem solving

*Paul W. Irving & Eleanor C. Sayre (Kansas State University, USA)*

Previous research (Scherr and Hammer, 2007) has presented the interplay between conceptual reasoning and views of knowledge by observing student behavior in the context of a collaborative active-learning environment in an introductory university physics course. A student may frame a learning activity as an opportunity for sense making or answer making depending on the student's conception of the learning activity. In the past epistemological frames have
been thought to be synchronous for a group of students for a period of time. An individual is not expected to be out of sync with the group epistemological frame for an extended period of time. In this study we applied an observational methodology to discern the dynamics of epistemological frames observed in a similar collaborative active-learning environment in an introductory university physics course to that of the original Scherr and Hammer study. It was discovered from the observance of a group of students solving problems on ficticious forces that an individual could be consistently asynchronic with the rest of their group in regards to their epistemological frame.

Representations in physics as material anchors – Using conceptual blending theory to understand sensemaking with representations

Elizabeth Gire & Edward Price (University of Memphis & California State University, USA)

Representations are used extensively for sensemaking in physics. Moving between different representations (such as graphs, equations, and diagrams) of the same concept or relationship can reveal new meanings. Further, specific representations often facilitate the performance of powerful operations that are difficult in other representations. For example, geometrical reasoning is easier with a graphical representation, while differentiation is easier with an algebraic representation. Developing students’ ability to use and coordinate different representations is an important goal of physics instruction, and understanding students’ use of representations is therefore an important area of inquiry. In this paper, students’ use of representations for sensemaking is analyzed through the framework of conceptual blending theory. In this treatment, the physical manifestations of these representations (drawings, diagrams, written equations) are understood as material anchors. Episodes are analyzed from an upper-division electricity and magnetism curriculum that includes small group problem-solving activities, kinesthetic activities, and activities that emphasize visualization. As students transcode between representations, they select input spaces consisting of the concept (presented in a specific representation) and the target representation, composing a blended space consisting of a specific instance of the original concept in the new representation. This process relies on students’ broader knowledge of mathematics and physics. The blended space supports elaboration, for instance, students’ creation of a graphical representation of a vector field and subsequent reasoning about symmetry. The physical features of the representation as a material anchor stabilize certain aspects of the concept, such the geometrical relationship between the coordinate points and the value of the vector field at those points, facilitating inferences about the concept (e.g., the geometrical structure of the vector field).

3:15 - 4:40 pm, Lecture Hall 1

Paper Session: Conceptual Change in Mathematics

Chair: Esther Ziegler

Spontaneous use of strategies based on the concept of commutativity

Robert Gaschler, Bianca Vatterodt, Claudia Godau, Sonja Hansen, Alexandra Eichler, Peter A. Frensch, Hilde Haider (Humboldt-University Berlin & University of Cologne, Germany)

A person can be said to possess integrated abstract conceptual knowledge when she is able to spontaneously identify task relevant information in order to solve a problem efficiently. The current study investigates the development and the relation of the use of two strategies derived from the mathematical concept of commutativity: (a) rearrangement of the addends within a problem in order to simplify calculation, and (b) avoiding calculation in case a problem contains the same addends in different order as a problem solved before. Children from grade two to grade six and university students solved addition tasks that allowed for the use of these two commutativity-based shortcut strategies which require completely different processing procedures. Data from paper and pencil tests (258 elementary school children and 76 university students) as well as from eyetracking sessions (46 children between age six and twelve) indicated that such shortcut strategies were used by children of all age-groups. However, transfer analyses and correlational analyses indicated that only after third grade, there was a link between using one or another commutativity-based shortcut. Furthermore, while spontaneous strategy application transferred across strategies and task material, a direct instruction only strengthened the use of the instructed strategy. The results are consistent with an iterative development of abstract conceptual knowledge and flexible strategy application.
Conceptual knowledge about the addition/subtraction complement principle – A source of children’s scarce use of subtraction by addition?

Greet Peters, Bert De Smedt, Joke Torbeys, Pol Ghesquière, and Lieven Verschaffel (KU Leuven & Leuven Education College, Belgium)

Subtraction problems of the type $M - S = ?$ can be solved by means of various strategies, including the subtraction by addition strategy in which one determines how much needs to be added to the subtrahend to get to the minuend (e.g., $75 - 43 = ?$ by “$43 + 30 = 73$ and $73 + 2 = 75$, so the answer is $30 + 2 = 32$”). Several studies have shown that adults use this strategy frequently, efficiently and flexibly. Children, however, hardly report using it. The lack of conceptual knowledge about the addition/subtraction complement principle (i.e., if $a - b = c$, then $c + b = a$) has been put forward as a potential source for children’s scarce (reported) use of this strategy. In line with the framework of Bisanz et al. (2009), we constructed an instrument consisting of three tasks to investigate the relation between children’s conceptual knowledge of the addition/subtraction complement principle and their procedural knowledge of the related subtraction by addition strategy. This instrument focused on two dimensions: the various ways in which children can demonstrate their understanding of the principle (i.e., application, evaluation, and justification/explanation), and the various ways in which problems can be presented (i.e., numerical and non-numerical). A pilot study in 40 fourth-grade children revealed that substantial changes had to be made to the instrument. A new version of the instrument was developed, in which we focus on the application of the complement relation and its association with the use of the subtraction by addition strategy. This instrument will be tested in April-May 2012 in 60 third- and fourth-grade children. The results of this new study will also be presented at the SIG meeting.

From non-symbolic competencies to symbolic skills

Sonja Maria Hansen, Alexandra Eichler, Hilde Haider (University of Cologne, Germany)

Mathematical concepts guide our daily lives. General concepts consist of procedural and conceptual knowledge. However, little is known how these concepts actually develop. Some researchers think that procedural and conceptual knowledge develop iteratively, starting on a pre-numerical level (Baroody & Gannon, 1984; Resnick, 1992). In this regard, Sherman and Bisanz (2009) demonstrated positive effects of non-symbolic material on second-graders’ procedural skills. Our study focused on the transition of pre-numerical to symbolic knowledge, using commutativity. Experiment 1 examined the effect of non-symbolic material on procedural knowledge with children who had just entered school. Even these young children showed a positive effect of non-symbolic material on procedural skills. In a second experiment with slightly older first-graders, we also assessed conceptual knowledge. Results replicated the positive influence of non-symbolic material on procedural skills, but indicated no benefit for conceptual knowledge. Instead, children who dealt with non-symbolic material first showed a liberal response bias in the conceptual task. To test this finding as well as the beneficial influence of non-symbolic material with older children who are expected to have more numerical experience and more conceptual knowledge, we conducted a third experiment with third-graders. Even those children profited by initially working with non-symbolic material but could not extend this benefit to conceptual knowledge. Instead, they showed a liberalization effect in the conceptual task again. Together, our findings suggest that the non-symbolic material just triggers a comparational strategy rather than the underlying concept. This remains to be addressed in future research.

3:15 - 4:40 pm, Graduation Assembly Hall

Paper Session: Conceptual Change in the Social Sciences

Chair: Peter Davies

Liberal liability – Understanding students’ conceptions of gender structures

Linda Murstedt, Maria Jansson, Maria Wendt, Cecilia Åse (Stockholm University, Sweden)

Drawing on research on both conceptual change and feminist pedagogy, the overarching aim of this study is to examine students’ understanding of gender. More specifically we focus on how students in political science make use of a gender perspective, as they are required to problematize gender relations and apply the perspective as an analytical tool when analysing a specific empirical material. Our data consists of sound recordings from the students’ group discussions during a seminar with the theme Gender and Media. Totally there were 14 students (6 women, 8 men) divided into 4 different groups, participating in the study. The students were instructed to read four newspaper
articles, each covering a portrayal of a leader of a party in the Swedish parliament. They were also instructed to discuss how different structures of power became salient in the articles. The results show different patterns recurring in the students’ discussions. Furthermore it is shown how underlying notions and assumptions generally associated with a liberal paradigm, such as justice, freedom of choice and equality, are present in the students reasoning. From a learning perspective, we see that the students do not differentiate between two explanatory contexts or levels of description; one where the unit of analysis is the individual and another where the unit is structure. An implication for teaching based on the results from this study could therefore be to explicate these two perspectives in teaching and also to openly discuss possible advantages and disadvantages with the two perspectives, for instance concerning agency and guilt/responsibility.

### Changing conceptualization of stability with increasing age

**Maida Mustafić & Alexandra M. Freund (University of Zurich, Switzerland)**

Two studies examined age-related differences in the conceptualization of developmental stability across adulthood. Study 1 (N = 119) found that, compared to younger (Mage = 23.38 years) and middle-aged adults (Mage = 38.68 years), older adults (Mage = 65.29 years) evaluate developmental stability more positively and prevention of loss less negatively across all life domains under investigation (subjective well-being, social relations, cognition, physical functioning). Study 2 (N = 182, age-range: 18 – 86 years) demonstrates that these age differences exist only on an explicit but not on an implicit level of evaluations. The results are discussed in relation to motivational orientation and expectations regarding developmental change.

### Teachers’ conceptions of gifted and average-ability students – A latent class approach

**Tanja Gabriele Baudson, Michael Schneider, Franzis Preckel (University of Trier, Germany)**

Do teachers hold different conceptions of gifted relative to average-ability students? And which factors besides students’ level of ability influence teachers’ implicit theories about the ones they teach? The present study used an experimental vignette approach and latent class analysis to address this issue. The goal was to expand on prior results by the first two authors, who had found teachers to distinguish between students described as gifted vs. average-ability along three dimensions: intellect/achievement, antisocial behavior, and creativity. Their findings were in line with the so-called disharmony hypothesis, with gifted students being conceived of as more intelligent, achieving at a higher level, and more creative, but also as more antisocial. For the present study, data from a sample of 246 primary- and secondary-school teachers will be analyzed together with data from a sample of prospective teachers to examine whether variables such as experience influence the structure of their implicit theories. All participants assessed brief vignettes of students described along three dimensions: (1) age—8 vs. 15 years old; (2) gender—male or female; and (3) ability level—gifted vs. average ability. Participants were randomly assigned one of the resulting eight vignettes and were asked to rate the described student along Likert-type items. The items comprised 65 characteristics and behaviors considered typical of gifted or non-gifted students, based on a literature research of the last 30 years and including items from the Big Five personality inventory. The items will be factor analyzed, with the resulting dimensions being used in subsequent latent class analyses to derive groups of teachers with homogenous answer patterns, which will be interpreted in terms of implicit theories of giftedness. The results are expected to offer interesting insights into teachers’ implicit theories and the factors that influence them, especially in the light of common stereotypes about the gifted.
MONDAY

9:00 - 10:15 am, Graduation Assembly Hall
Keynote lecture: A Differential Perspective on Conceptual Change

Speaker: Elsbeth Stern (ETH Zurich, Switzerland)
Chair: Michael Schneider

In the past decades, Psychology has made considerable progress in better understanding the process of meaningful learning. While the acquisition of skills and procedures has been understood quite well for a long time, learning that results in deep understanding and allows for transfer and analogical reasoning, has been a scientific mystery for a long time. Only thanks to the research paradigm of conceptual change we now better understand qualitative changes in knowledge construction that allow learner to take a leap in understanding complex content areas. By switching from characteristic to defining features of concepts, learners can almost all in a sudden understand abstract principles and rules and thereby get a deeper understanding of scientific explanations. However, although several trajectories of conceptual change have been ascertained by now, little is known about the sources of individual differences when it comes to the acquisition of broadly applicable conceptual knowledge. There is of course an impact of general intelligence on successful meaningful learning. However, as yet little is known about qualitative differences in learning trajectories between learners scoring at the upper end of the intelligence scale as compared to those scoring average. Given the progress in better understanding cognitive processes underlying psychometric intelligence, the time has come for integrating the differential and the universal perspective of meaningful learning. In my talk I will demonstrate perspectives for future research in this regard.

10:30 am - 12:00 pm, Lecture Hall 1
Paper Session: Mental Processes in Conceptual Change

Chair: Tanja Gabriele Baudson

The relation between conceptual change in physical science, Theory of mind and personal epistemology and implications for science instruction
Natassa Kyriakopoulou & Stella Vosniadou (National & Kapodistrian University of Athens, Greece)

We argue that common cognitive components underlie children’s ability to think about the mental world (Theory of Mind), their epistemic beliefs about the nature of knowledge and the process of knowing (Personal Epistemology) and their ability to reason about mental models of the physical world (Conceptual change). Two studies were conducted to test this hypothesis. In Study 1 forty-six fifth graders were administered measures of theory of mind ability, epistemic stance, and reasoning in observational astronomy. The results showed that children’s theory of mind ability and epistemic beliefs were significantly correlated with their ability to reason about different representations of the same external reality. Regression analysis showed that children’s theory of mind and epistemic beliefs were strong predictors for the ability to reason on different interpretations of the physical world. In Study 2 half of the students who participated in Study 1 received instruction that focused on understanding in all three domains taking into account the relations between them, while the remaining students received standard textbook-based instruction only for observational astronomy. The results showed positive effects for the experimental group compared to the control. The discussion will focus on the importance of building epistemological sophistication together with content knowledge as a means of promoting conceptual understanding in science. Lin: Students’ conceptual evolution in earth: An empirical validation of the “Conceptual Evolutionary Tree” approach

Students’ conceptual evolution in earth: An empirical validation of the “Conceptual Evolutionary Tree” approach
Jing-Wen Lin & Yu-Lun Wu (National Dong-Hwa University & Taipei Municipal University of Education, Taiwan)

It is generally acknowledged that students’ preconceptions are central factors to influence science learning. Accordingly, the information about students’ conceptions developmental pathway is helpful to frame the curriculum sequence. However, investigations of the pathway not only spend considerable time and efforts but also face the validation problem. Therefore, one of the authors was enlightened by evolutionary epistemology and cladistics to develop a “conceptual evolutionary tree” approach to construct hypothetical evolutionary pathways of pupils’ mental
models to solve these problems. Due to the approach is novel in science education, more empirical evidence is needed to support it. The first topic we selected was electricity. That study built a hypothetical tree, Tree70, and showed this hypothesis could explain 81.3% of the empirical data. The second topic, earth, was selected in this study for types of the mental model in earth are well-known to science educators. Then, the hypothetical tree, Tree 2, was constructed. It showed the conceptions developmental pathway in earth was: Root → the earth is not supported → 3-D → there is no edge with the earth → things that looked flat are not flat → the gravity is toward the earth’s center, and the range of the sky surrounds the earth → spherical earth. The major aim in this study is promoting the conceptual evolutionary tree approach in investigating students’ conceptual developmental pathway by empirical validation. This study adopted eight diagnostic test items to 360 students from grade 1 to 5 to obtain the across grader percentages of students’ cognitive characters and their statuses. The authors tested the predictions of Tree2 by comparing with the percentages of the across grades survey. The results showed Tree2 could explain 83.3% of the empirical data. It verified the feasibility of applying the conceptual evolutionary tree approach to science education again.

**The formation of epistemic stances of academic staff**

*Kathryn Bartimote-Aufflick & Angela Brew (University of Sydney & Macquarie University, Australia)*

The primary aim of this study of academic staff members’ epistemic stances is to understand how an academic’s current stance may have formed by examining the possibility of linkages to the cultural layers of gender, age, discipline, institutions of study and work, ethnicity, religion, and parents’ social class. In investigating the formation of an individual academic’s epistemic stance, not only the external influence of layers of culture will be considered but also the potential role of individual agency in belief formation. The study design has been informed by critical realist methodology. In order to construct a model or models that may provisionally explain mechanisms that influence the formation of academics’ epistemic stances, three central (and complementary) methods are being employed. The first is a questionnaire that draws on Cunningham and Fitzgerald’s (2002) framework for its epistemic stance items and also includes items on cultural layers. The second is an interview that explores (more deeply) the same issues as the questionnaire, but also explores belief change over time. The third is recursive model development using these data sources along with theory and case comparisons to enhance and test possible models. Preliminary pilot data suggests some patterns in relations between academic’s epistemic stance and the disciplines studied at high school and undergraduate university level, as well as religion. In addition to presentation of the newly available data at the conference, it is hoped that together we can discuss the utility of several belief change constructs, including conceptual change, in explaining the epistemic stance formation of academic staff.

**Context and structure in conceptual change – Students’ understanding of price**

*Peter Davies (University of Birmingham, UK)*

Previous research on conceptions in economics has focused exclusively on conceptions of a single phenomenon and has also ignored the effect of students’ conceptions of the context in which that phenomenon occurs. This study addresses both these gaps by investigating conceptions of price and cost and the context which students use to frame problems involving price and cost. Undergraduate students from three universities were asked to categorise a set of short problems and then they were asked to respond to each of three extended problems. The data reveal categoric differences between conceptual structures within a particular domain. These differences are marked by students’ use of different models which lead them to define problems in more restricted (as in ‘a price problem’ or a cost problem) or more expansive ways (such as ‘a market structure’ problem). These differences are reflected in the breadth of interactions which students take into account when they are considering problems. There are holes in the reasoning displayed by each of the students: their models are not, in that sense, complete or wholly systematic. The frame they use only partially determines how they see a problem because there are difficulties with their understanding of some of the ideas which their frame brings into play. The picture that emerges is one of frameworks and fragments, rather than one or the other. Another important aspect of the differences in students’ framing is the effect that perception of the context has on their thinking. Whilst some students see the context as an individual business, others see the context as a market involving a number of business whilst others see the context as interaction between markets.
Designing learning environments for teaching theory of matter in primary school  
*Rania Gikopoulou & Stella Vosniadou (University of Athens, Greece)*

The purpose of the present research was to design and implement a teaching intervention to facilitate conceptual change processes in young students’ understanding of aspects of the particulate theory of matter. The innovative component of this intervention was that it took into consideration not only students’ naïve theory of matter but also their epistemic beliefs. The intervention was based on the suggested learning progression of the macroscopic concepts necessary for the introduction of the particulate theory of matter and was also facilitated by relevant software and simulations of the microscopic model. Previous attempts for designing learning environments to facilitate the learning process have focused on some of these factors but not on all of them. The sample consisted of 36 fifth grade students divided into two groups, control and experimental. The results showed statistically significant differences between the two groups, with the experimental group attaining significantly higher average performance in all tasks than the control group.

Relationships between designs for socio-cognitive conflicts, peer discourse and conceptual change: The case of proportional reasoning  
*Baruch B. Schwarz, Noa Cohen and Christa S. C. Asterhan (Hebrew University, Israel)*

Recent studies showed that designs such as instructions for collaborative argumentation and deliberation or hypothesis testing have led dyads facing a socio-cognitive conflict to conceptual change. However research on the relationships between such designs, characteristics of peer discourse and conceptual change is still embryonic. The present study zooms in on proportional reasoning. We elaborated a task based on three design principles: invitation to collaboration, provision of a hypothesis testing device and paring students in dyads according to initial cognitive differences. 496 students were randomly assigned to 4 conditions (individual or dyadic work, with or without hypothesis testing tools). All students completed a pre-test and post-test individually and participated in the learning task. It was found that (a) the learning task resulted in conceptual change in proportional reasoning beyond all conditions, (b) working alone or in pairs yielded similar gains, and (c) hypothesis testing considerably improved learning. Moreover, proportional students did not benefit from interacting with non-proportional students, or from hypothesis testing. Among non-fully proportional students, both hypothesis testing and interacting with a “proportional” peer independently led to higher gains. Also, testing hypotheses helped, but for low-level students, the interaction with students with slightly better understanding was preferable. Analysis of 50 randomly chosen dyadic interactions revealed that although the initial situation was a state of socio-cognitive conflict, the students generally did not solve this conflict by engaging in argumentation. Rather, students with higher strategies overall dominated discussions and explained more than they reciprocally argued with their partners. This hierarchical situation is different from situations of socio-cognitive conflict in other domains in which differences of positions do not necessarily mean more or less developed explanatory schemes. It appears then that relationships between designs, characteristics of peer interaction and conceptual change are complex and should be coped with in different domains.

Strategies for conceptual change in school science  
*John-Paul Riordan (Canterbury Christ Church University, UK)*

This study explores how experienced science teachers promote conceptual change. It examines how instructional strategies, learning tactics (Darden, 1991) and conceptual change interrelate. Pupils construct new concepts while still having old ones (diSessa, 2006). Their evolving learning tactics are sometimes distorted by naïve techniques (Zimmerman, 2005). Instructional strategies, learning tactics and conceptual change are interrelated (Klahr, 2000). But how should the conceptual change literature inform teaching? Three research methods (expert microteaching, verbal protocols and retrospective debriefing) were used. Data was video-recorded and managed using NVivo. Six 11 year-old pupils participated (three girls and three boys) in each expert microteaching interview, led by a science specialist. A ‘Concurrent Verbal Protocol and Retrospective Debriefing’ interview (Taylor and Dionne, 2000) happened later with six teachers participating. Twelve hours of interview data were analysed using grounded theory methods (Corbin and Strauss, 2008). The interpretivist theoretical perspective (symbolic interactionism) was underpinned by social constructionist epistemology. Findings show teachers use nine ‘teaching instruments’, ten ‘skill stratagems’ and six
‘deception stratagems’. Pupils demonstrate three learning tactics. Failure is explored. What can be considered evidence is a function of the researcher’s methodological position. Appropriate criteria for evaluating the emerging grounded theory (Lincoln and Guba, 1985) were used. Interpretivist approaches for investigating conceptual change in school science are necessary to avoid unbalanced dominance by positivist literature, and help address the gap between research and practice (Duit, 2008). This approach, proved successful in other fields (Taylor and Dionne, 2000), is new to this context. Instructional strategy is not straightforward (Clement, 2008, p.445). Incorporating the teachers’ interpretation during analysis helps understand complicated interactions between participants whilst learning takes place. This study proposes a grounded theory for how experienced science teachers promote conceptual change and questions how instructional strategy is understood in the literature.

There is nothing more practicable than a good theory (Kurt Lewin) – Effects of situated learning approaches on conceptual change in teacher education

Martin Klein, Robin Stark, Kai Wagner (Saarland University, Germany)

Theory-based perception and theory-guided analyses of school situations, phenomena and actions are unanimously seen as highly important for professional actions in the classroom. Yet, studies present alarming findings regarding teacher students’ competences for theory based perception and interpretation in complex pedagogical situations. Many teacher candidates have difficulties analyzing pedagogical situations on the basis of scientific knowledge and reasoning, often rely on subjective theories and harbor unfavorable attitudes toward educational theories (Stark et al., 2010). These difficulties show that this specific kind of conceptual change in the sense of Vosniadou et al. (2008) has to be fostered systematically in teacher education. Therefore, our project "Theorizing in practice" strives to teach these competences to students in a specific teacher training program. A complex case based learning environment was developed aiming at fostering students' ability to notice and analyze complex pedagogical situations on the basis of scientific knowledge and theory articulation. A pilot study in 2010 tested the effectiveness of three training conditions (problem based learning, learning through error analysis, learning through error analysis and problem solving). Effects on scientific argumentation knowledge, quality of theory articulation and cognitive load were assessed. Results showed that the three conditions are equally suitable and provide significant learning progress in near transfer, while far transfer could not be fostered (Klein et al., 2011). A modified replication study tested the effects of a prolonged training period and optimized training materials. In addition, interview data were recorded on various motivational dimensions. First results show that learning progress was fostered substantially, including a significant effect in far transfer. Additional qualitative analyses of post-tests and interviews will provide more insights into constraints and affordances of conceptual change in teacher education.

1:30 - 3:00 pm, Graduation Assembly Hall

Symposium: Conceptual Change in the Social Sciences

Organizer: Cecilia Lundholm (Stockholm University, Sweden)
Chair: Peter Davies (Birmingham University, UK)
Discussant: Erno Lehtinen (Turku University, Finland)

Conceptual change research in social science can still be seen to be in its early stage, and in comparison, much of current and past research is carried out in natural science and mathematics. Carretero and Voss (1994) presented a volume entitled Cognitive and Instructional Processes in History and the Social Sciences nearly 20 years ago, which was an important contribution and a starting point for further enquiry into the field of conceptual change in the social sciences and humanities. However, further empirical work is still needed along with a focus and discussion of the theoretical implications with regards to different conceptual change frameworks. Although it is acknowledged that conceptual change research makes claims that transcend physics (Vosniadou, 2008) questions emerging relate to the ways conceptual change theories are domain general or domain specific (Vosniadou, Vamvakoussi and Skopelti, 2008), and what this difference means in the natural and social domains respectively. This suggest that further enquiry in to the social science domains can enhance our understanding in these domains; but also generate further enquiry into the generality of conceptual change theories. The symposia include papers and current work carried out in very different contexts, concerning different subject fields like economics and the concept of price along with studies on the concepts of gender, race and racism and nation. The research presented provides an important step in furthering our
understanding of conceptual change in the social sciences domains and furthermore provides discussions on educational implications – especially with regards to the dimensions of values that cut across the findings.

**Values and competing frameworks in conceptual change in social science**

*Peter Davies (University of Birmingham, UK), Thomas Philip, César López Rodriguez and Cecilia Lundholm*

This paper discusses conceptual change in the Social sciences, addressing in particular issues of values and implications for teaching. The paper is a product of a symposium organised in September 2011 in Stockholm where researchers in the disciplines of economics, politics and sociology presented and discussed empirical studies on conceptual change in these domains. The current paper is a theoretical discussion which draws on the empirical evidence presented in the symposium. We concentrate on evidence from two studies. First, a study by César López Rodriguez examined conceptions of ‘Nation’ held by students in Spain and their readiness or reluctance to shift from their initial conception in the course of instruction. A second study by Thomas Philip examined the willingness of trainee teachers in California to change their conception of the relationship between education and employability. In both cases, students’ sense of belonging and purpose appeared to be an important factor in resisting conceptual change. Our main focus is on the way in which both these examples may be understood as challenges to ‘Master Narratives’ in Social Science. These narratives combine sets of descriptions, explanations and judgements to provide a coherent ways of seeing the social world. Descriptive categories (such as ‘nation’ or ‘education’) carry within them implicit judgements about the worth of the category (for instance whether nationhood or education should be seen as intrinsically good/bad, problematic/unproblematic) as well as implicit explanations of how the social world operates. The challenge for conceptual change in these circumstances is a need for simultaneous change in description, explanation and judgement. We discuss this challenge in the light of evidence provided by these two studies and we conclude with some implications for teaching in social science.

**Students’ understanding of economics and the concept of price**

*Caroline Ignell (Stockholm University, Sweden), Peter Davies and Cecilia Lundholm*

This paper aims to explore upper secondary school students’ conceptions of economic pricing. Individuals’ learning within the social sciences has not been profound investigated compared to youngsters’ learning and learning within the domains of natural sciences. We present results from the first phase of a longitudinal study concerning students’ conceptual formation in economy and environmental issues. The longitudinal study applies mixed data collection methods and with a sample of 213 students attending ten different classes in their second year of upper secondary schools in Sweden. Students are followed during two years with a questionnaire handed out once a year and some students also participate in individual interview sessions once a year. This presentation focus solely the questionnaire and the preliminary results show that students tend to give explanations of why a particular good has a reduced price, as well as an increased price, by parallel referring to various causes. A number of the conceptions found are in line with earlier research concerning younger students, for instance the study shows that students in upper secondary school also refer to the characteristics of an object for explaining prices. It is further shown how students simultaneously refer to one of the market mechanisms of demand or supply or brings forth an interaction of the market mechanisms as causes to price. The theoretical relevance of this research adds to our knowledge of students’ conceptions of economical phenomena that students come across within social science as well as in their day-to-day life. From an educational point of view, it also adds to discussions of concern to teachers and educators on content matter and instruction in civics, economics and geography.

**Reconsidering the relation between acceptance and understanding: Student reasoning about gender and justifying gender-related statements in upper secondary school**

*Jonas von Reybekiel Trostek (Stockholm University, Sweden)*

The aim of this study is to contribute to the discussion of how acceptance of a theory relate to an understanding of it. Previously, the discussion has taken departure in quantitative studies, resulting in disagreement and contradictory conclusions: Some studies suggest that acceptance results in understanding, other suggest that understanding results in acceptance, and a third thesis is that there is no relation at all. The present qualitative study can be seen as presenting an alternative with its assumption that acceptance is inseparable from students’ understanding, that is their contextualizations of a task. Methodologically, the study relies on an intentional analysis, and it is argued that acceptance logically follows the intentionality of an action. Data consists of audio-recorded interviews with 21 students in upper secondary school who reason on the topic of gender, and justifying
gender-related statements. The paper focuses on one student that interprets gender and the grounds on which gender-related statements may be accepted in different contexts; a poststructuralist, and a biological. Since ‘gender’ is understood completely different in these contexts, it is doubtful if acceptance can be measured as separated from students understanding. An implication for further research on acceptance and understanding is that there is a need to investigate how and to what extent students actually choose to assume a particular theory as basis for understanding, rather than to note to what extent they explicitly reject or confirm it on a scale in a questionnaire.

3:15 - 4:45 pm, Lecture Hall 1
Paper Session: Conceptual Change in Biology
Chair: Paul W. Irving

Formation of the health concept: Fostering conceptual change by applying the teaching strategy “Ascending from the Abstract to the Concrete”
Hartmut Giest & Ksenia Hintze (Universität Potsdam, Germany)

International and national school performance tests point particularly to a lack of flexible, reflexive, applicable or transferable knowledge for German schools. Classroom, particularly in primary school, fails in fostering conceptual change, concept-formation in the direction of a scientific conceptual level. In a classroom intervention study (classroom experiment – 10 lessons – in grade 3 and 4) following a pre-post-post-post-design in two intervention classes (N=46) and comparing the learning results of the intervention classes with those of control classes (N=42 – traditional classroom) we asked for effects of a learning strategy (“Ascending from the abstract to the concrete” – Dawydov, Lompscher) on concept formation and conceptual change. We focused our study on the formation of the health concept (sensu Antonovskij) with respect to the fields of nutrition (diet) and exercise. The teaching strategy is characterized by a particular structure of the learning material (subject matter), instructional support of learning directed to the acquisition and application (knowledge transfer – de and re-contextualization) of knowledge on a theoretical level and pays special attention to foster self-regulation of learning (actions). The intervention classes showed clear effects in pre-post and post-test regarding the reached developmental level of concept formation, the sharpness of conceptual level and in overcoming dichotomies in conceptual thinking applying the health concept. And they outperformed the control classes here. Also in knowledge transfer (applying the health concept to problems of nutrition and exercise) and in health motivation we could state clear effects of our intervention in Pre-Post-Post-Test and comparing intervention and control classes. Differences between the two interventions classes could be explained by effects of classroom quality and the application of the teaching strategy (rated videotaped classroom). Mediating variables (gender, verbal intelligence, social status, school performance) showed only few effects because of the novelty of the subject (salutogenetic health concept) in schools and families.

Third graders’ conceptions about the origin of species before and after instruction
Anna Emilia Berti, Valentina Barbetta, Laura Toneatti (University of Padova, Italy)

This study examines how third-graders’ conceptions about the origin of species are affected by formal instruction and whether children can learn not only about “evolution as such”, but also about natural selection. We interviewed the same group of third-grade children (8-9 years old) twice, before and after instruction about “Earth before man” in keeping with the Italian National Syllabus for third grade. In addition we devised an “enriched curriculum” that was implemented in one class. Creationist answers were very rare at both pre- and post-test. The number of evolutionist answers increased significantly after instruction. However, children learned about evolution in a piecemeal way; they gave evolutionist answers for only some of the animals they were asked about, and made several errors when putting classes of vertebrates on a time line. Children who received the enriched curriculum performed better than the others, although only a minority of them learned something about evolutionary mechanisms. They said that newborn animals can be different from the parents because of mutations, but did not mention differential survival. No children showed “Lamarckian misconceptions” whereas many of them seemed to construe the evolution of a species (i.e. horses) as growth occurring during an individual’s life. These results challenge the views according to which 1) cognitive biases (i.e., essentialism, teleological and intentional thinking) make children unreceptive to evolution as such; 2) “Lamarckian” misconceptions, commonly found in secondary school or university students, start and become entrenched in childhood (e.g., Evans 2008; Kelemen 2011).
Exploring how motivation in game-based learning influences conceptual change

Cathy Tran, Katerina Schenke, Farhan Siddiqi, AnneMarie Conley (University of California, Irvine, USA)

Using the design-based research model, we are developing an interactive iPad game to address causal misconceptions and to teach systems thinking skills to 8-to-12-year-olds. First, we review the literature on causal misconceptions and systems thinking and address why this is an important area to target. Systems thinking refers to the capacity to conceptualize a framework made of interacting parts rather than a collection of isolated parts. Unfortunately, most children lack a basic understanding of systems and processes. For example, they fail to perceive how changes in one system (e.g., fuel usage) can influence a seemingly unrelated system (e.g., greenhouse gases) through an indirect web of causation. Overcoming these misconceptions requires conceptual change. Second, we discuss how the motivational characteristics of game-based learning are appropriate for addressing the challenge of changing strongly held misconceptions. Our design is influenced by the “warm” conceptual change model, which posits that learner motivation matters in the conceptual change process. Our definition of motivation comes from the expectancy-value framework, which posits that individuals will be motivated to engage in a task if they feel they can be successful at it (expectancy) and if they perceive the task as being important to them (value). Finally, we discuss our preliminary research plans to advance the theory of how motivation—particularly through game-based learning—can address cognitive misconceptions. Our game tackles common misconceptions of cause and effect by addressing them in a setting that requires players to make decisions about the production of food from the farm to the fork. For example, children decide which crops to grow, how much water and pesticide to use, and how to rotate crops to maximize production and minimize carbon footprint. We analyze gameplay data and interview six participants to investigate how motivation influences the process of conceptual change.

Achievement goals, argumentation and conceptual change in science

Shira Soffer-Vital, Baruch B. Schwarz and Ruth Butler (Hebrew University, Israel)

Argumentation can enhance conceptual learning, but it rarely occurs and when it occurs, it is often not productive. However, even in this problematic situation, it is worthy to ways to trigger argumentation since gains from argumentation are stable. The present study is about one possible inhibitor for emergence and productivity in argumentation, the achievement goals people set when engaging in dyadic interaction. We examine how achievement goals affect conceptual learning in science in students invited to participate in dyadic argumentation. Ninety University students participated in on-line dyadic discussions on photosynthesis and global warming. Before and after the e-discussions, individuals solved problems on photosynthesis and expressed written arguments on issues related to global warming. Each dyad was assigned one of three achievement goals: mastery, ability-approach or ability-avoidance. We found that among students in the ability-avoidance condition, conceptual change on photosynthesis and global warming could not be detected. Students in mastery and ability-approach learned from their interaction. No significant difference could be detected between students in the mastery and the ability-approach conditions. The findings of this study confirm the findings of a growing number of studies that show that proper designs foster conceptual change through short-term dyadic interactions. It also shows the relevance of goal orientation for productive peer argumentation.

3:15 - 4:45 pm, Graduation Assembly Hall

Paper Session: Context and Conceptual Change

Chair: Sibylle Reinfried

Conceptual distribution and the problem of conceptual change

Alexsandro P. Pereira & Fernanda Ostermann (Federal University of Rio Grande do Sul, Brazil)

In this paper, we outline a particular approach to conceptual change based on the notion of “conceptual distribution”. This proposal aims to reconsider the problem of conceptual change from a sociocultural perspective by focusing on how cultural tools, especially explanatory texts, mediate its functioning. According to the model of conceptual distribution, both naïve and scientific conceptions are viewed as distributed between agents and the textual resources they employ, especially textual resources in the form of explanation – both written and spoken. From this perspective, students’ conceptions are view as being distributed in two related, but analytically distinct senses: (1) socially, in small group interaction, and; (2) instrumentally in the sense that it involves both people and instruments of knowledge such as graphs, maps and language. The model of conceptual distribution differs from classical and re-
framed approaches to conceptual change in suggesting that different groups can have quite different accounts of physical reality, even within science community. From this perspective, conceptions are viewed as an active process that often involves contention and contestation among people rather than a structured body of knowledge they possess. In order to illustrate a case of contested distribution, we quote the controversy about the interpretation of quantum mechanics in science community and then we discuss the implications of scientific oppositions for the problem of conceptual change.

Do contextual features of items influence item difficulties in written tests of evaporation?
Judith Pollmeier, Steffen Tröbst, Kornelia Möller (Westfälische Wilhelms-Universität Münster, Germany)

Contextual features can influence which explanations will be used by students for a specific natural phenomenon. Conceptual change thus might be regarded as an adequate reassignment of conceptions to contexts. In this vein, the present paper examines how contextual features (i.e. physical location, visibility of a water surface, presence of a heat source) influence students’ responses to items pertaining to the phenomenon of evaporation in written, closed-format tests of knowledge of science. In a first cross-sectional study, responses of 1820 second-, third- and fourth-graders to 36 items covering the topic of evaporation as an aspect of knowledge of science were investigated. Explanatory item response models revealed that the location of instances of evaporation (inside vs. outside) exerted a marginally significant influence on item difficulty. For instances of evaporation located outside children experienced particular difficulty in consenting to correct conceptions and in dismissing incorrect conceptions. However, the items had not been designed specifically to investigate the issue of context effects on student conceptions. In a subsequent experimental study with 158 third-graders contextual features were varied systematically and conceptions covered in items were held constant across contexts. None of the inspected contextual features showed a statistically significant effect on item difficulty. However, the specific conceptions featured in items explained 35% of the variance on the item level. Items containing the conception of an active agent relocating water were most difficult to solve correctly, whereas items entailing the conceptions of change of location and false change of matter were particularly easy to respond to. In summary, these results suggest that children, if not asked to generate explanations of their own but to rate given explanations as either true or false, pay primarily attention to the actual conceptions presented and judge them rather independently from contextual features.

Coherence and contextualization in the process of conceptual change
Åsa Larsson & Ola Haldén (Stockholm University, Sweden)

In research there has been a search for the crucial event that should make conceptual change to come about. Here, it is argued that there are no specific conceptions that are of primary importance for conceptual change to occur. Twenty-nine preschool children were interviewed about their conceptions of the earth once a year during a three year period. They were interviewed from the year they were four to the year they were six years old. Conceptual change appears to be a non-linear and unpredictable process. The children took into account an amount of different information in their reasoning about the earth. In the process there were interwoven conceptions of different dignity involved that had to cohere simultaneous. The children changed their ideas of the earth when they realized incoherencies or conflicts within the model they embraced. However, there does not appear to be any specific conflict that causes conceptual change. What pieces of information that are actualized and have to be accounted for by the individual child seems to be unpredictable. Furthermore, conceptual understanding is related to contexts for applicability and it is argued that cognitive conflict is a relation among three entities, that is, two or more different facts or conceptions that conflict when related to specific contexts of applicability. Conceptual change involves a simultaneous processing of information and complex conceptions as well as revisions and changes at a model level, and all of this processing is related to contexts of applicability.

A coordination class theory lens on disciplined perception
Mariana Levin & Andrea A. diSessa (Michigan State University & University of California, Berkeley, USA)

Understanding the nature of technical competence and how it develops is a central goal of educationally oriented research. Drawing upon Goodwin’s influential work on professional vision (Goodwin, 1994), Stevens & Hall proposed that experts in a domain have disciplined perception—specific visual practices that are characteristic of their disciplines (Stevens & Hall, 1998). In their analytic work introducing disciplined perception, Stevens and Hall exclusively focused on the ways in which it is materially mediated and socially shaped through interactions with those more expert in a domain. In this paper, we use a theory of conceptual change, Coordination Class Theory (diSessa & Sherin,
to reformulate and extend Stevens and Hall’s notion to include key conceptual issues involved both in having and developing disciplined perception. In order to cleanly illustrate the way in which coordination class theory extends the treatment of disciplined perception and its development offered in the analyses of Stevens and Hall, we re-analyze the same data and episodes explored in a case study they presented in their original paper. The data include a series of eight episodes from a corpus of videotaped interactions between a tutor (“Bluma,” a mathematician) and a tutee (“Adam,” an eighth-grade pre-algebra student). The episodes under consideration came from six hours of video with Adam and Bluma as Adam reasoned about tasks concerning the connections between equations and graphs of linear functions using a computer environment that presented graphs of functions on Cartesian representations of the plane both with and without gridlines. What Stevens and Hall cast as Adam and Bluma’s differentially “disciplined” visual practices can be understood more systematically as a general class of learning issues predicted by Coordination Class Theory: the need for increasing the span and alignment of determining strategies across (representational) contexts.
TUESDAY

9:00 - 10:15 am, Graduation Assembly Hall

Keynote lecture: Relational Reasoning and Conceptual Change – Coupling Percept and Concept in Complex Understandings

Speaker: Patricia A. Alexander (University of Maryland, USA)
Chair: Wim van Dooren

That naïve conceptions exist or that such conceptions persist even in the face of compelling evidence has long been established. What is less apparent, however, is how or why such notions take shape or what stands as a barrier to their dismantling or reformation. Within the literature on misconceptions there are those who attribute these circumstances to fundamental ways of seeing and reasoning about the world. Others within the conceptual change literature look more at students’ existing mental models as explanatory factors. In this session, we will explore relational reasoning as an alternative perspective for understanding how rudimentary concepts arise and then potentially develop into more sophisticated understandings. At its simplest, relational reasoning pertains to discern meaningful rule-based patterns within informational arrays or between mental representations, and entails the coupling of both perception and conception in human learning and development. While such processes may be inherent to human cognition, relational reasoning abilities can vary significantly within a population and can be differentially leveraged to promote learning and expertise development especially for tasks or within fields that typically rely on perceptual-conceptual couplings such as science, mathematics, and engineering.

10:30 am - 12:00 pm, Graduation Assembly Hall

Symposium: Mind the Gap! Studies on the Development of the Rational Number Concept

Organizers: Erno Lehtinen (Turku University, Finland), Lieven Verschaffel, Wim Van Dooren (University of Leuven, Belgium)
Chair: Wim van Dooren (University of Leuven, Belgium)
Discussant: Patricia A. Alexander (Maryland University, USA)

Many authors have argued that number sense develops very gradually and to a large extent implicitly. This symposium focuses on one case where research identified a gap in this gradual development: the transition from natural numbers to rational numbers. Research in cognitive-developmental psychology and mathematics education has repeatedly shown that a major source of difficulty in the learning of rational numbers is the interference of natural number reasoning. Students implicitly or explicitly assume that the "behaviour" of natural numbers also applies to rational numbers, which leads to systematic errors. The paper by McMullen et al. will present a study describing how an increasing tendency to spontaneously focus on quantitative relations predicts success in conceptual change from early numeracy up to rational numbers. Second, Van Hoof et al. will describe the results of a study on the natural number interference in various domains of numerical reasoning in a wide age range. Finally, Depaepe et al. will present their findings on future primary school teachers’ pedagogical content knowledge with respect to the difference between natural and rational numbers.

Spontaneous focusing on quantitative relations in the development of mathematical skills

Jake McMullen, Minna M. Hannula-Sormunen, Satu Katajisto, Milla Laaksonen, & Erno Lehtinen (University of Turku, Finland)

The present study investigates the role of Spontaneous Focusing On quantitative Relations (SFOR) in the development of mathematical skills of primary school children. Previous studies of Spontaneous Focusing On Numerosity (SFON) have shown that SFON tendency at 6 years predicts conceptual knowledge of rational numbers at the age of 12, but SFON tendency at 12 does not. This indicates that a progression of spontaneous focusing tendencies may contribute to the development of mathematical knowledge. Those children who more readily spontaneously focus on quantitative relations may gain more self-initiated practice with relational concepts. These individual differences in self-initiated practice with relational concepts may contribute to the conceptual change involved in learning rational number concepts such as density. In the first part of the present study, 84 5-9 year olds completed tasks measuring SFOR
tendency and a measure of mathematical skills. Results indicate that there are individual differences in SFOR tendency evidenced by these tasks. Furthermore, SFOR was found to be related to mathematical skills after controlling for age. These results suggest that SFOR tendency is relevant for the study of mathematical development and that there may be a progression of spontaneous focusing tendencies which contribute to the development of mathematical skills. In order to test whether SFOR tendency does contribute to the development of conceptual knowledge of rational numbers, a longitudinal study of SFOR tendency in 10-12 year olds (N≈300) will be reported on in the presentation.

Looking for a developmental in rational number sense: Towards a comprehensive test instrument
Jo Van Hoof, Lieven Verschaffel, and Wim Van Dooren (University of Leuven, Belgium)

Before entering school, children have already formed an initial concept of what a number is, which is mainly based on the properties of natural numbers (Gelman, 2000; Smith, Solomon, & Carey, 2005; Vamvakoussi & Vosniadou, 2010). Relying on the conceptual change theoretical framework as developed by Vosniadou (1994), it is well-known that once the mathematical concept of rational numbers is introduced in the classroom, problems and misconceptions occur, because the rules counting for natural numbers are not always applicable for rational numbers (Gelman, 2000; Smith et al., 2005; Vamvakoussi & Vosniadou, 2010). The research literature points out different aspects on which natural numbers differ from rational numbers, while students often treat them similarly. These aspects are density, operations, representation and size. While there has been quite some research about each of these four aspects, there is - to our knowledge - no single study or test that combines all of them. Based on an extensive literature review and an analysis of the Flemish school curriculum, a comprehensive paper-and-pencil test was created that included the four aspects. Students from the fourth, sixth, eighth, tenth and twelfth grade will be tested (200-300 students for each age group). Each age group will get the same tasks, but adapted to the suspected knowledge for that particular age. Results will be analyzed using IRT models (De Ayala, 2009) to obtain an overview of the development of rational number reasoning. Three questions will be answered. The first question looks at which age levels students make progressions in rational number reasoning, the second one investigates if these progressions differ for the four aspects and finally an answer is sought at the question if rational number understanding as such can still be considered as a one-dimensional construct or rather as a multidimensional one.

Measuring preservice teachers’ content and pedagogical content knowledge in the rational number domain
Fien Depaepe, Joke Torbeyns, Nathalie Vermeersch, Dirk Janssens, Lieven Verschaffel, & Wim Van Dooren (University of Leuven, Belgium)

For most primary and secondary students the transition from natural to rational numbers is problematic: They incorrectly ascribe characteristics of natural numbers to rational numbers, a phenomenon known in the research literature as the “natural number bias”. To properly address this conceptual gap between the natural and the rational number domain (prospective) teachers need relevant content knowledge (CK) (i.e., Do they have profound conceptual and procedural knowledge in the rational number domain?), and pedagogical content knowledge (PCK) (i.e., Can they anticipate which misconceptions students will have and do they have appropriate representations at their disposal to prevent and remedy these misconceptions?). There is, however, evidence that the CK and PCK of elementary preservice teachers in mathematics, and especially in the domain of rational numbers, is limited. This paper documents on a new paper-and-pencil test that is especially designed to investigate preservice teachers’ CK and PCK in the rational number domain. The test consists of 48 items belonging to the following subcategories: (1) the concept of fraction (8 items), (2) the concept of decimals (8 items), (3) operations (i.e., addition, subtraction, multiplication, and division) with fractions (16 items), and (4) operations with decimals (16 items). Half of the items in each subcategory are devoted to the measurement of teachers’ CK and half to the measurement of teachers’ PCK, including two aspects: (1) teachers’ knowledge of students’ (mis)conceptions regarding fractions and decimals, and (2) teachers’ knowledge of representations that can be used to teach fractions and decimals. We already conduct a pilot study in which the CK and PCK of 30 preservice elementary teachers is measured using this test. In May 2012, a large-scale study on (the relation between) preservice elementary teachers’ CK and PCK is planned. During the SIG meeting, we will present the results of the pilot study and discuss the results from the large-scale study.
1:45 - 3:15 and 3:30 - 5:00 pm, Graduation Assembly Hall

**Post-Conference Workshop: Latent Variable Analyses (not only) of Conceptual Change**

Host: Jan R. Böhnke (University of Trier, Germany)

See the conference homepage for details.
Important Addresses and Phone Numbers

<table>
<thead>
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<th>Address</th>
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<tbody>
<tr>
<td>Taxi Zentrale Trier</td>
<td>+49 651 12012</td>
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<tr>
<td>Conference venue Bischöfliches Priesterseminar Jesuitenstraße 13 54290 Trier</td>
<td>+49 651 94840</td>
</tr>
<tr>
<td>Conference chair Prof. Dr. Michael Schneider Educational Psychology University of Trier Building D, Office 203 Universitätsring 15 54296 Trier</td>
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<tr>
<td>Emergencies (fire, ambulance, police)</td>
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<td>Tourist Information Trier An der Porta Nigra 54290 Trier <a href="mailto:info@trier-info.de">info@trier-info.de</a></td>
<td>+49 651 97808 0</td>
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<td>Main Station Trier Hbf Bahnhofsplatz 1 54292 Trier</td>
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<tr>
<td>Hospital Mutterhaus Feldstraße 16 54290 Trier</td>
<td>+49 651 9470</td>
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</table>

Welcome Reception

The Welcome Reception takes place on Saturday, Sept. 1, starting at 7 pm in the conference venue. We can celebrate the start of our bi-annual meeting with sparkling wine and hors d’oeuvres sponsored by the Psychology Department of Trier University. The Vice President of our university will attend the meeting and would like to welcome you.

Conference Dinner

The conference dinner starts on Sunday, Sept. 2, at 7 pm and takes place at the wine-estate G. F. von Nell (Im Tiergarten 1, 54295 Trier, +49 651 32397). Participants who would like to take a 35-minute walk to the wine-estate meet at 6:20 pm in front of the conference venue. Participants who would like to take the vineyard’s old-timer bus meet at 6:35 pm in front of the conference venue. The evening includes a dinner, a tasting of wines from the vineyard, and a tour of the wine cellar.
### Restaurant Suggestions

<table>
<thead>
<tr>
<th>Restaurant</th>
<th>Type (prize range of main courses)</th>
<th>Address (time to walk from the conference venue)</th>
<th>Phone number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weinstube Kesselstadt</td>
<td>Perfect for sitting outside and enjoying the view of the cathedral (3-10 €)</td>
<td>Liebfrauenstraße 10 (7 min)</td>
<td>+49 651 41178</td>
</tr>
<tr>
<td>Kartoffel-Kiste</td>
<td>Mostly typical German potato dishes, also soups and salads (3-15 €)</td>
<td>Fahrstraße 13-14, (2 min)</td>
<td>+49 651 9790066</td>
</tr>
<tr>
<td>Wine Restaurant Cumvino</td>
<td>Good selection of wines (6-27 €)</td>
<td>Weberbach 75 (2 min)</td>
<td>+49 651 97940940</td>
</tr>
<tr>
<td>Bitburger Wirtshauser</td>
<td>Traditional regional German food, open kitchen, drawn local “Bitburger” beer (4-15 €)</td>
<td>Kornmarkt 2 (5 min)</td>
<td>+49 651 4361880</td>
</tr>
<tr>
<td>Der Italiener</td>
<td>Nice Italian restaurant with an open pizza kitchen (6-19 €)</td>
<td>Dietrichstraße 3 (10 min)</td>
<td>+49 651 978240</td>
</tr>
<tr>
<td>Astarix</td>
<td>Typical student pub, seasonal menu, homemade pizza and casseroles (3-12 €)</td>
<td>Karl-Marx-Straße 11 (10 min)</td>
<td>+49 651 72239</td>
</tr>
<tr>
<td>Sushi Trier</td>
<td>Excellent sushi; however, often crowded and with long waiting times; closed on Sundays (9-20 €)</td>
<td>Neustraße 33 (10 min)</td>
<td>+49 651 9943637</td>
</tr>
</tbody>
</table>

And many more...

### Acknowledgements

The conference received funding from
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- EARLI,
- Institute for Psychology, University of Trier, Germany.

We thank our sponsors, and we thank all presenters for sharing their research with us.