

## **Session 1a: Gender and Equity Issues**

Wed 4th June at 13.00-14.30, Exactum, room B120  
Chair: Anita Hussenius

### **1a/1: Making Matter Matter to Make Feminism and Gender Matter in Science Education**

*Kathryn Scantlebury, Anita Hussenius, Kristina Andersson, Annica Gullberg & Anna Danielsson*

While science education research has continued its focus on access, difference, and identity, gender research within the field has become confused, and possibly, lost, within other social categories. Gender is a social construction and is constituted within society's *structural*, *symbolic*, and *individual* levers. Most research in science education uses gender as an analytical category, is conducted at the structural or individual level without a critical theoretical framework. Complicating the issues is that feminist research and theories have ignored the role and influence of matter and materialism. Feminist research has granted language 'too much power' and ignored the 'matrix of domination' generated by science and technology. This paper introduces, and then using data from 120 pre-service teachers' essays about their in and out of school science experiences, discusses how material feminism may offer a framework for science education researchers to re-examine how engaging with the physical contexts for learning, teaching and practicing science would make gender matter using the concepts of *agential realism*, *agential cuts* and *apparatus*. Material feminism is producing new knowledge about how humans engage with the natural and physical world. By making matter matter, science educators would address how technology, history, physical space, apparatus and other phenomena influence their research.

### **1a/2: Interstitial Spaces – a Model for Challenge and Change**

*Anita Hussenius, Kristina Andersson, Annica Gullberg & Kathryn Scantlebury*

This paper introduces the concept of *interstitial spaces* to examine the boundaries of science, science education, pedagogy, caring, and gender to discuss the different cultures teacher students meet during their education. *Interstitial spaces* exist between and within boundaries. These spaces are possible sites within a defined context (a discipline, a practice, a culture) that may be occupied by an actor/agent working as a "carrier" of different cultural practices, knowledge and theories. A "carrier" can use the interstitial space to influence and challenge a "new" context and thus loosen up boundaries, but can also by experiencing new cultures and developing new knowledge integrate these new views into future practices. Thus, interstitial spaces establish a context for a carrier to act in ways to transform and change the cultures of disciplines. On an individual level, instead of feelings of alienation, of not fitting into a culture, the model offers a carrier the position as someone who has the potential and possibility to invoke a change, and this can be empowering.

### **1a/3: Love It or Leave It: Physics Choices in Norway**

*Maria Vetleseter Bøe & Ellen Karoline Henriksen*

In response to insufficient participation and female underrepresentation in physics education, this paper uses questionnaire data from Norwegian physics students in upper secondary education ( $N = 585$ ) to characterize the "physics choosers." An expectancy-value perspective is adopted to describe the motivations and expectations behind the respondents' physics choice. Three choice profiles were identified: the *intrinsic and extrinsic* profile, broadly motivated by interest-enjoyment,

expectation of success, and utility for university admission; the *extrinsic* profile emphasizing mainly utility; and the *intrinsic* profile emphasizing mainly interest-enjoyment. Girls were underrepresented in the *intrinsic* profile. Many students did not know what kind of job they wanted, but those who did, aspired to go into medicine (particularly girls) or engineering (particularly boys). The results imply that participation in physics may be improved by targeting students with a broader motivation than interest alone, through inclusive classroom practices including contexts and physics in society, and examples of physics applications and physics-related careers available.

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## **Session 1b: Technology, Power Relations and Sustainability**

*Wed 4th June at 14.45-16.15, Exactum, room D122*  
Chair: Claes Malmberg

### **1b/1: How Industrial Actors Engage in and Motivate Engagement in STEM Initiatives**

*Maria Andrée & Lena Hansson*

Many different actors, including government, academy and industry, are engaged in school- and recruitment-STEM-initiatives. The aim of this study is to shed light on industrial initiatives, what actors are involved and what different repertoires are being used when motivating engagement in STEM-initiatives. The data analysed consist web-material where industrial actors describe their engagement in STEM-initiatives and reasons for their engagement. The method for analysis is discursive psychology. The results show a variety of constellations of industrial actors and that the initiatives draw on a variety of discursive resources. In our analysis we identify the following interpretative repertoires: 1) The securing competent labour repertoire, 2) The developing specific job skills or competences repertoire, 3) The bright future repertoire, and 4) The general increase interest in science repertoire. The results are discussed in a perspective of previous research on cultural selection mechanism and students educational choices.

### **1b/2: Constructions of power and knowledge in the technology classroom**

*Maria Berge, Anna Danielsson, Malena Lidar, Leif Östman, Åke Ingerman & Maria Svensson*

The aim of this study is to investigate how knowledge and power are constituted in meaning-making processes in technology classrooms in relation to the teachers' enactment of a disciplinary discourse. By collecting video data from a Swedish technology classroom in grade 8 we explore interaction on a micro-level. Our examination of the teaching of technology is motivated by the fact that this is a key period for students engagement in technology and that many students are losing interest in the subject during grades 7-9. Our analysis is guided by an analytical framework based on practical epistemology, teachers' epistemological moves and the theory of didactical contract as completely implicit but highly powerful aspect of the relationship between teacher and student. Our analysis reveals that in the interaction between a teacher and her pupils both knowledge and power are mutually constituted in meaning-making processes, and are not possible to separate. It is therefore fruitful to use an analytical framework that includes both meaning-making and power in further research.

### **1b/3: Let the Right One In! Excluding and Including Effects in Swedish National Assessment in Chemistry**

*Marie Ståhl*

The aim of this study was to explore norms and values in the Swedish national tests in chemistry for grade nine in compulsory school. It is of importance to learn about the underlying evaluative meanings that come with science teaching, in this case, with the chemistry tests. They influence on whether students feel included or excluded from the science discourse and if they can identify with the subject. In order to overcome excluding effects, the science context has to be examined and norms and values attached to it highlighted. Critical discourse analysis and multimodal tools have been used to examine norms and values expressed in text and images. The chemistry discourse presented in the tests shows science from “the olden days” in the choice of issues and in the way women, men and youth are portrayed as well as how their interests either have been foregrounded or neglected. It is an elitist view that emerges and the gender as well as the age bias is clearly visible.

#### **1b/4: The West and the Rest – Constructions of Us and Them in Education for Sustainable Development**

*Claes Malmberg & Malin Ideland*

Education for sustainable development is a global project, with good intentions. One aim of the project is to rescue 'our common planet' in terms of social, ecological and social change. It is also a project that aims to include everyone. The aim of this paper is to problematize who is included in this inclusive project. It is done through an analysis of how good intentions in Education for Sustainable Development (ESD) construct and maintain differences between 'Us' and 'Them'. In other words, we are interested in exposing social constructions of normality and otherness in the taken-for-granted good intentions within ESD and question what the idea of a 'common world' implies.

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### **Session 2a: Collaborative Inquiry-Based Science Learning Supported by ICT**

*Wed 4th June at 13.00-14.30, Exactum, room B222*  
Chair: Veijo Meisalo

#### **2a/1: PROBLIT: An Example of Inquiry-Based Science Learning Enabled by Digital Technologies**

*Paul Lowe, Cathy Bunting, Fatheya Al Ahmadi & Darrell Fisher*

Inquiry-based approaches to learning science in real-life contexts has steadily been gaining prominence in curricular documents around the world, advocates arguing, for example, that such approaches engage students in relevant, meaningful learning; model scientific practices; and enhance students' scientific literacy. However, implementation of such curriculum aspirations is not straightforward, and exemplars of effective practice offer one way to support teacher change—although of course they are not, in and of themselves, enough. This paper outlines the history of one initiative, dubbed PROBLIT (Problem-based learning in teams), and the range of digital technologies that have been used to enable the programme to take place across large distances, and to scaffold and support teams of students' inquiry-based learning.

## **2a/2: Engaging GIS Inquiries: Examples of Inquiry-Based Science Learning Enabled by Digital Technologies**

*Paul Lowe, Fatheya Al Ahmadi, Alaaeldin A. Aly, Ahmed Yaqoub Yousif Alhammad & Pakrad Balabanian*

Inquiry-based approaches to learning science in real-life contexts has steadily been gaining prominence in curricular documents around the world, advocates arguing, for example, that such approaches engage students in relevant, meaningful learning; model scientific practices; and enhance students' scientific literacy. However, implementation of such curriculum aspirations is not straightforward, and exemplars of effective practice offer one way to support teacher change—although of course they are not, in and of themselves, enough. This paper outlines one initiative, based on GIS and a range of other digital technologies that have been used to enable the programme to take place and to scaffold and support teams of students' inquiry-based learning.

## **2a/3: Inquiry-Based Collaborative Learning in Virtual Laboratory Environment**

*Eija Yli-Panula, Mervi Hiilovaara-Teijo & Marja Vauras*

The study aimed to investigate, what are the students' capabilities to work collaboratively or build up hypotheses as part of the inquiry based collaborative learning in virtual environment how to develop this environment as learning and teaching tool. The study group consisted of the third year Finnish International Baccalaureate students (n=12) who worked either individually, in dyads or tetrads. True collaboration in and between the tetrads or dyads varied. Only in one of the three tetrads the students collaborated, in reality, preparing the study plan, and writing the application for funding. The power of collaboration was evident in that it clearly showed that they had learned both the cognitive issues and how to combine their forces to achieve their learning/research goals. As a whole, several aspects were identified how to develop the virtual environment to be more interactive, which was one of the most practical implications. An important finding was the students' opinion that besides the virtual laboratory also working at the laboratory desk is needed.

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## **Session 2b: Learning Science through ICT-supported Investigations in Primary School**

*Wed 4th June at 14.45-16.15, Exactum, room B120*  
Chair: Veijo Meisalo

### **2b/1: Learning Physics and Chemistry by Making Digital Stories about Investigations**

*Veera Kallunki, Johanna Ojalainen & Johanna Penttilä*

In this study, pupils learning in physics and chemistry in a project utilising ICT tools as a part of teaching are presented. The results are based on a pilot study, where fifth graders in two Finnish primary schools learnt physics and chemistry by shooting video clips about their investigations, and constructing digital stories of their video clips in a social mobile service MoViE. The aim of using the mobile service was to increase engagement and motivation of pupils, and in this way to promote learning STEM subjects. The results are based on pupils' mind maps of the subject to be

learnt, and on analysis of the digital stories describing their learning process. The results encourage designing and using different ICT tools in learning STEM subjects; the analyses uncovered development in qualitative understanding and showed how pupils performed their learning via their digital stories. The analysis also highlights the meaning of sharing and cooperation in the learning process.

## **2b/2: iPad-Supported Physics Investigations at the Playground**

*Ann-Marie Pendrill, Peter Ekström, Lena Hansson, Patrik Mars, Lassana Ouattara & Ulrika Ryan*

Playgrounds offer many possibilities to investigate fundamental physical phenomena. In this paper, we present investigations of friction and gravity by a group of 11-year olds together with their teachers. The sessions were planned by the teachers and supported by researchers, as part of a research-based development project where iPads are used in middle-school physics to enhance learning. The investigations were supported by students using iPads for measuring, documenting, and reporting. The discussions afterwards were videotaped to support the evaluation, performed jointly by teachers and researchers. This allowed us to analyse what aspects of friction and gravity were discerned by the students. Through the recordings, we could also observe expressions of different levels of understanding of nature of science, as well as the crucial role played by the scaffolding from the teachers, both during the investigations and the related classroom discussions.

## **2b/3: IKT som katalysator til økt bruk av utforskende læring i naturfag?**

*Jardar Cyvin & Anne Bonnevie Lund*

I dette framlegget vises noen resultater fra en case-studie der 5.-7.klassinger gjennomførte et undervisningsopplegg med bruk av dataloggere i naturfag. Utgangspunkt for undersøkelsen var følgende: Kan IKT være en katalysator for økt bruk av utforskende læring (IBL) i naturfag og vil økt innpass av utforskende læring (IBL) kunne føre til økt bruk av IKT i faget? En rekke prosjekter viser at IBL har potensial for å gi bedre læring og motivasjon. Vi mener potensialet for digitale verktøy er stort og uutnyttet i naturfag, selv om en rekke forskningsresultater viser konsentrasjonsproblemer for elevene ved mulighet for multitasking. «Stand-alone» verktøy som ikke er koblet til nettet kan være et alternativ, og det er ingen grunn til ikke å utnytte IKT-potensialet til aktiv utforskende læring der dette har mer-effekt.

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## **Session 3a: Science Classroom Discourse**

*Wed 4th June at 13.00-14.30, Exactum, room C123*  
Chair: Maria Andrée

### **3a/1: Consequences of Humour in Physics Education**

*Maria Berge & Per Anderhag*

Previous research in science education reveals that teachers and students use humour when they communicate with each other in a science education context. In this paper we explore consequences of humour for learning in two different contexts of physics education using video-

recordings: a physics classroom in year seven and a group of four undergraduate students learning basic mechanics together. The video data was analysed with practical epistemology analysis (PEA), which revealed several important conclusions. Firstly, in both practices humour in forms of playfulness and jokes successfully filled learning gaps in interaction. Secondly, the participants in both practices made content related jokes in order to (a) reduce strictness but also in order to (b) clarify content. Therefore, humour ought to be viewed as a significant resource for meaning making in the science classroom.

### **3a/2: Chemistry teachers' knowledge and perceptions about classroom oral questioning**

*Festo Kayima & Matthias G. Stadler*

The study focuses on establishing and assessing teachers' knowledge and perceptions regarding classroom oral questioning. The aim was to find out how chemistry teachers formulate and use oral questions, their expectations and experiences regarding students' reactions and learning. Semi-structured interviews were used to collect information from chemistry teachers from different schools in the Bergen region of Norway. Qualitative content analysis approaches were employed in the analysis to identify teachers' knowledge, practice and expectations. Results indicate that teachers can identify mainly two types of questions namely factual and thinking questions, they can also identify situations where they use each question type and give reasons for it. However the teachers seem to be unaware of other ways of categorizing questions used in research.

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## **Session 4a: Science and Technology in Preschool – Obstacles and Possibilities**

*Wed 4th June at 13.00-14.30, Exactum, room C124*  
Chair: Lena Löfgren

### **4a/1: Technology in Preschool – Staff's Understanding of Subject and Curriculum**

*Pernilla Sundqvist*

The study aimed to describe how preschool teachers and day care attendants understand technology and the purpose of introducing technology in the preschool. The aim was also to describe how preschool staff interpreted the technology goals of the curriculum. Previous research has shown that there is no consensual understanding regarding the subject's purpose and a scrutiny made by The Swedish Schools Inspectorate shows that preschools do not address the whole technology curriculum. The research questions were examined through a questionnaire that contained both open and closed questions. The findings showed many different ways to understand both technology and the purpose of technology education in the preschool. The understanding of technology has a wide range from almost no understanding to a nearly complete understanding. The fact that a large sample of the respondents has a very limited understanding of technology could be the answer to the shortcomings in the preschool.

### **4a/2: "Traditional" Science Renegotiated? – Examining Teachers' Understandings of Science for Preschool Practice**

*Sofie Areljung, Karin Due & Christina Ottander*

The Swedish curriculum has recently been revised, implying an expansion regarding the science content in preschool and a general shift towards the knowledge mission of preschool. This paper presents a study of ten video-stimulated group interviews in which preschool staff talks about science for preschool practice. The study draws on feminist critique of science, which has highlighted connections between perceptions of gender and perceptions of science, for example in the use of dualistic language. Three dichotomies have been used in the categorisation of the interview data, concerning ranges of “logic/intuitive”, “objective/subjective”, and “rational/emotional” understandings of science practices, which were then analysed in relation to the preschool staff’s perceived professional responsibilities. The results imply that the practices regarding science content intertwines smoothly with the everyday preschool practices, due to the staff’s comprehensive understandings of science for preschool practice. These comprehensive understandings are suggested to follow the “child-centred” teaching philosophy in Swedish preschool pedagogy. The results are discussed in relation to the profound question of what science in early childhood education could be.

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## **Session 4b: Science as Part of Everyday Activities in Preschool**

*Thu 5th June, 14.45-16.15, Exactum, room D122*  
Chair: Lena Löfgren

### **4b/1: Understanding Preschool Emergent Science in a Cultural Historical Context through Activity Theory**

*Christina Ottander, Karin Due, Sofie Areljung, Bodil Sundberg & Britt Tellgren*

This paper discusses how preschool cultures meet the reinforced learning goals concerning science in the revised preschool curriculum in Sweden. Qualitative data was collected from nine different preschools in the form of interviews with preschool teachers, observations of activities and stimulated recall discussions based on the recorded practices. Activity Theory (AT) was used as the theoretical framework for the analysis. Great creativity was displayed in each of the preschools’ science themes. They used a range of different approaches with opportunities to experience and learn about science. The educare culture is a main factor in the shaping of the science activities, and local epistemological beliefs and rules have a significant effect at a particular preschool. Aspirations to fit the activities to this culture also led to the science learning object becoming fragmented and elusive.

### **4b/2: Science Teaching in Preschool – Two Traditions on Collision Course?**

*Anja Alfredsson*

Currently much concern has been raised about students decreasing interest and results in school science. A solution to the problem of declining interest could be that students receive early positive experiences of the subject. More and more countries establish curriculum that includes science even for preschool. But science teaching in preschool seems to be a bit complicated. Research shows that even if the educators’ intention was to focus on science in an activity, it often turns out to be about something else. This study is based on a questionnaire with preschool educators to

investigate their attitudes to science and science teaching in preschool. The results indicate that educators in preschool tend to act differently, from how they usually teach, when science is in focus. When the respondents gave examples of activities with science contents, the majority of the examples were *non-contextualized*. However, in Swedish preschool the importance of contextualization is normally emphasized.

#### **4b/3: Science Learning Starting in Everyday Situations – Preschool Teachers Evaluate Different Situations' Suitability**

*Lena Hansson, Lena Löfgren & Ann-Marie Pendrill*

This article takes a starting point in the idea that science in preschool would benefit from starting with children's questions and situations in preschool everyday life. In a previous study preschool teachers have collected such questions and everyday situations in their own preschool practice. A content analysis was performed resulting in a number of different categories describing the potential science content. With the present study we want to contribute to a deepened understanding of how preschool teachers view the possibility to work with science starting from different kinds of questions and situations in preschool everyday life. The data were collected in focus group interviews with preschool teachers who were asked to evaluate different questions/situations (collected in the previous study) in respect to the extent they could work as starting points for science learning situations. The results show that the preschool teachers put forward different kinds of reasons when discussing whether or not the questions/situations could work as a starting point for science learning. These reasons are discussed in relation to policy documents as well as earlier results in the research field concerning science and preschool.

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### **Session 5a: Education for Biodiversity and Sustainability**

*Wed 4th June at 13.00-14.30, Exactum, room C222*  
Chair: Irmeli Palmberg

#### **5a/1: Nordic-Baltic Student Teachers' Identification of Species and Understanding of Biodiversity and Sustainability**

*Irmeli Palmberg, Ida Berg, Eila Jeronen, Sirpa Kärkkäinen, Pia Norrgård-Sillanpää, Christel Persson, Rytis Vilkonis & Eija Yli-Panula*

Knowledge of species, interest in nature, and nature experiences are the factors that best promote interest in and understanding of environmental issues, biodiversity and sustainable life. The aim of this study is to investigate how well student teachers can identify common local species, their interests in and ideas about species identification and about the importance of species identification for biodiversity and sustainability. Totally 456 student teachers for primary schools were tested using an identification test and a questionnaire consisting of fixed and open questions. A combination of quantitative and qualitative methods was used to get a more holistic view of students' level of knowledge. The student teachers in Nordic countries identified species reasonably well, while the student teachers in Lithuania identified only up to four species. Experiential learning outdoors was suggested by the majority of students as the most efficient learning method, followed by experiential learning indoors, project work and experimental learning. They regarded the knowledge of species as 'important' or 'very important' for citizens today, for sustainable development and for biodiversity. Our conclusion is that teaching and learning

methods for education of biodiversity and sustainable development should always include experiential and project-based methods in authentic environments.

### **5a/2: Student Teachers' Interest in and Conceptions about Species and Species Identification**

*Pia Norrgård-Sillanpää, Ida Berg, Eila Jeronen, Sirpa Kärkkäinen, Irmeli Palmberg, Christel Persson & Eija Yli-Panula*

Humans are dependent on the service species and ecosystems provide. Being able to identify species is a key to understanding biodiversity. The purpose of this study was to clarify student teachers' (N=426) interest in and conceptions of the importance of species identification and the relationship between biodiversity and sustainable development. The data was collected by the aid of using a semi-structured questionnaire with fixed and open questions. Student teachers explained their interest in plants and animals in a pragmatic, cognitive or emotional and aesthetic way. Pragmatic, cognitive and educational views were used to explain the importance of species identification today and in the future. Few students had a professional view. The relationships between species identification and sustainable development were described with cognitive, pragmatic, conservational and educational views, whereas the relationship between biodiversity and sustainable development were mostly categorised in the no, cognitive, ecological and conservational views. The student teachers' conceptual framework related to biodiversity and the relationships between species identification and sustainable development were limited. The results are compared with related literature. This study increases and broadens researchers' and teacher educators', knowledge about the challenges of species identification in teacher education and at schools.

### **5a/3: Young Students' Meaning Making in an ESD School Practice**

*Annika Manni & Christina Ottander*

This paper presents the empirical results from an ESD, Education for sustainable development, Case study. Young students' meaning making processes in sustainability issues were observed and followed during a period of four months in the students' school practice. Wanting to explore even deeper the complex processes of learning as meaning making, the holistic approach of a Case study was chosen. Observations, field notes, logbook entries, interviews, school documents and pictures were gathered in order to get a rich picture of the case. From previous research were the emotional and cognitive integration in students' experiences on ESD highlighted in their reflections on activities and content (Manni, Sporre & Ottander, 2013; Manni, Ottander et.al, 2013). This study therefore sought to investigate the process of meaning making even deeper. The preliminary results reveal democratic approaches in practice, meaningful transactions with both the environment and artefacts as well as with peers. Cogni-emotional dimensions were to be found in the processes; in the phase of anticipation, the phase of transactions, and the phase of fulfilment. Learning in ESD illuminates the integrated process of cognition and emotion in students' meaning making processes and calls for educative approaches thereafter.

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## **Session 5b: Education for Climate Change and Understanding of Landscape**

*Wed 4th June at 14.45-16.15, Exactum, room B222*

Chair: Christina Ottander

### **5b/1: Ninth Graders' Perceptions about Climate Change**

*Linda Degerman*

Mitigation of climate change will be one of humankind's greatest challenges. Adequate knowledge is vital for a person to start acting in an environmentally friendly way. The purpose of the study is to learn which perceptions Swedish-speaking Finns in the ninth grade have about climate change, and thereby evaluate if the current education about climate change is appropriate. Totally 425 students from 9 schools, spread over the Swedish-speaking parts of Finland, were tested using a questionnaire with both closed and open questions. Data was analysed in SPSS and the open questions were categorized. The majority of the students considered climate change to be caused by humans, but many misconceptions were present. Students considered climate change to have a negative effect on species and on human health but not on their lives. To mitigate climate change the majority was prepared to do things that didn't affect their quality of life negatively. Girls were significantly more willing to act and felt more worried. In the light of these results it is clear that climate change education should focus more on the causes of climate change and strive to increase the students' preparedness to act.

### **5b/2: Teaching about Climate Change: Geography Teachers' Views**

*Mikaela Hermans*

It has been increasingly recognised that education plays a key role in addressing human-induced climate change. The ultimate goal of climate change education (CCE) is positive impacts on the climate through both individual and collective actions. Research concerning the implementation of CCE in school is scarce, but of great importance for the process of developing CCE. The aim of this study is to investigate geography teachers' views about CCE. Data was collected using semi-structured interviews with geography teachers (N = 13) at eleven secondary schools from all parts of Swedish-speaking Finland. The results show that there is considerable variation among the teachers' motives for teaching about climate change, ranging from wanting to inform the students about the topic to supplying them with action competence. Most teachers focus their content on the phenomenon itself, whereas only few focus on actions addressing climate change. Active learning is used to a smaller degree, whereas teacher-centered methods are more common. The geography teachers in this study thereby largely miss the ultimate goal of CCE, pointing at the need for more effort to be made in the process of developing CCE at secondary school.

### **5b/3: The Effects of Socio-Scientific Issue Based Inquiry Learning on Pupils' Representations of the Landscape**

*Sirpa Kärkkäinen, Seija Juntunen, Ilkka Rätinen & Tuula Keinonen*

Research has demonstrated that societal science issue based inquiry learning, has significant advantages for learning outcomes and students' motivation. For successful understanding of landscapes in environmental and geographical education, one also needs to combine informal learning environments with school education. This case study concerned the influence of societal science issue based inquiry learning, carried out in a school and Nature park context with primary school pupils' (n=36) representations of landscapes. The pupils were asked to draw and write about the landscape both before and after interventions; they were also asked to fill in a questionnaire concerning their learning during the intervention. The data was analysed qualitatively

to investigate the impact of the interventions on the representations that pupils used in their descriptions of the landscape. It was found that societal science issue based inquiry learning in rich learning environments, noticeably enriched the pupil's representations, leading to a multifaceted holistic understanding of landscape. In many cases, the pupils produced quite sophisticated representations.

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## **Session 5c: Outdoor Education and Field Courses**

*Thu 5th June, 10.45-12.15, Exactum, room B120*  
Chair: Irmeli Palmberg

### **5c/1: The Implementation of Fieldwork and Student Learning Processes during Preparation, Field Activity and Follow-Up Work**

*Kari Beate Remmen & Merethe Frøyland*

Fieldwork has a great learning potential in science education, but the practice of it lacks empirical research. In the context of geoscience in Norwegian upper secondary school, this study uses video observation to track how three teachers and their students implement classroom preparation, fieldwork activities and classroom follow-up work. Video data are analysed with respect to: (1) whether the fieldwork is implemented in accordance with prevailing recommendations for practice provided in the literature, and (2) whether students display surface-level or deep-level learning processes while participating in learning activities. Results indicated that although the teachers implemented fieldwork in accordance with literature-driven recommendations, student learning processes were predominantly surface-level. However, deep-level learning processes were more apparent in one class. Results from two classes are presented in greater detail, indicating that the nature of the learning activities was one main difference. Hence, the study suggests that recommendations for fieldwork need further specifications – particularly with respect to the quality of learning activities offered to support student learning processes before, during and after fieldwork activities.

### **5c/2: Objects Promote Scientific Activities among Learners in a Museum**

*Marianne Achiam, Bent Lindow & Leonora Simony*

Museums are emphasised as important contributors to science education. Because their collections of objects are what sets them apart, it is important to understand how museums can stage objects to promote science learning. To do this, we must look to the scientific community for whom the objects are sources of information to determine what constitutes valid scientific learning activities. In the case examined here, a museum programme involving the fossil *Archaeopteryx* and modern birds, we thus carry out an *a priori* analysis of the established modes of inquiry of the paleontological research community. We then use this analysis as a lens to examine the activities of secondary school students in the museum programme. Our results show that the students indeed do engage in scientific inquiry and interpretation of museum objects. We conclude by discussing the implications of the specific implementation of the programme for the students' activities, and argue how our findings have generalizability beyond the world of museums.

### **5c/3: Student Experiences of Geocaching: Exploring Possibilities for Science Education**

*Jenny Sullivan Hällgren, Kirsty Stewart & Kirk P. H. Sullivan*

Geocaching, or treasuring hunting using GPS technology, is an international phenomenon with science education possibilities. This potential is little researched or strategically used in teaching and learning contexts. Four school students were interviewed after a day's cycling trip that included geocaching. The interviews were semi-structured and focussed on the students' experiences of geocaching and how it connected with their classroom learning. We found that they enjoyed geocaching, made the connection between the coordinate system and GPS, and had ideas about how geocaching could fit into their education. It was apparent that the hunt for the geocache motivated the school students, and that this reinforced in an authentic practical way classroom learning. This suggests that purposefully selected geocaching activities can be used to support other educational outcomes including science education outcomes.

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## **Session 5d: Outdoor Science Education and the Sustainable Backpack**

*Thu 5th June, 13.00-14.30, Exactum, room B120*  
Chair: Christina Ottander

### **5d/1: Impact of Secondary School Outdoor Science Education on Students' Interest in Science**

*Jean-Philippe Ayotte-Beaudet & Patrice Potvin*

One of the most important questions in science education is how to generate an interest in science. Many research initiatives have found that hands-on activities practiced in authentic environments are among the activities that promote the most interest in science. However, science education does not often take place in authentic environments; instead, it usually occurs in artificial environments such as classrooms and laboratories. Thus, there is a need for research to provide a better understanding of outdoor science education in regular teaching contexts. This research addresses the question: How does outdoor scientific education that is provided in an authentic environment near a secondary school impact student interest? About fifteen secondary science teachers, each teaching two student groups, will participate in this research project. One student group will remain indoors for the duration of the study, while the other group will head outdoors during five to ten regular teaching periods. This poster reports on the context, theoretical framework, and methodology of our study still in development.

### **5d/2: The Sustainable Backpack – Implementation of Education for Sustainable Development in Norwegian Schools**

*Eldri Scheie & Majken Korsager*

This paper reports on how The Sustainable Backpack (Den naturlige skolesekken) has succeeded in implementing Education for Sustainable Development (ESD) in Norwegian schools. The Sustainable backpack was initiated by the Ministry of Education and Research and the Ministry of Climate and Environment in 2008, in response to UNESCO's International Implementation Scheme for the Decade of ESD and the Norwegian Strategy plan for the ESD 2005–2010, which was revised and expanded for the period 2012–2015. The aims of the Sustainable backpack are to influence attitudes toward, reconstruct ideas about and improve proficiency in issues related to

sustainable development among teachers and students in primary and secondary school. In the Sustainable backpack, ESD is supported in numerous ways, such as networking between teachers, schools and science education experts, Teacher Professional Development (TPD) courses and economic support to school projects. The aims of this study are to investigate how participation in the Sustainable backpack influenced teachers' engagement in and teaching for sustainable development. These issues have been examined through teacher questionnaires. The teachers report that participation in the Sustainable backpack has a positive impact on their engagement and understanding of sustainable development. They also report increased use of the schools' local environment when teaching. Less positive is that half of the teachers report that assessment is not incorporated in their ESD, despite this is a requirement for projects in the Sustainable backpack. However, the teachers call for good assessment practices of competencies for ESD.

### **5d/3: Key Factors for Education for Sustainable Development – a Case Study from a Rural Secondary School in Norway**

*Majken Korsager & Eldri Scheie*

In this paper we report on how a rural secondary school in Norway, supported by the Sustainable backpack (Den naturlige skolesekken, DNS: <http://www.natursekken.no/>) has implemented Education for Sustainable Development (ESD). The Sustainable backpack was launched in 2008 in response to UNESCO's International Implementation Scheme for the Decade of ESD and the Norwegian Strategy plan for the ESD 2005–2010. The Norwegian strategy is now revised for the period 2012–2015. The aim of the Sustainable backpack is to increase awareness, understanding and competencies in and for sustainable development for teachers and students in primary and secondary education. In this study we explore how a school in Norway has succeeded with ESD and try to identify factors central to implementing and making ESD viable in schools in general. This paper describes and discusses findings from interviews with the teachers, students and the school leader at a secondary rural school in Norway. The preliminary findings suggest that the school in many ways has succeeded with the aims of ESD, in terms of increasing awareness, understanding and competencies in and for sustainable development for teachers and students. The findings also indicate that there are three factors which seem to be crucial for this success. First, is a school-leader with a clear vision and ideas on how to integrate sustainable development in ordinary teaching. Secondly, are competent teachers who support and implement this shared vision into their curriculum and teaching. Finally, a factor which seems to be crucial is that the school's ESD work is strongly rooted in how to make the rural community sustainable for the future (local relevance). This factor illuminates the importance of having a local focus to make topics in ESD relevant and authentic to students.

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## **Session 6a: Assessing Inquiry-Based Science Teaching**

*Wed 4th June at 13.00-14.30, Exactum, room C323*

Chair: Regina Soobard

### **6a/1: Model for Evaluating Inquiry-Based Science Education in Teaching and Research**

*Steffen Elmoose & Martin K. Sillasen*

The object of this paper is to describe and discuss a three-dimensional model for evaluating IBSE-inspired teaching, where the goal for teaching is to develop science competences of the pupil. The characteristics of IBSE teaching in Danish public schools are described and these criteria for good inquiry teaching contribute to one dimension in a method of evaluating the teaching-learning relationship. The concept of science competence contributes to another dimension in the model for evaluation. Thirdly the concept of quality of a science competence is introduced and integrated in the model, which can be visualized as a three dimensional evaluation model. Finally this model and its theoretical foundation is discussed for its value as a research model for qualitative evaluation of teaching and learning, and as a tool for formative evaluation in practical teaching as to its ability to analyze relations between inquiry based teaching and competence learning.

### **6a/2: Strategies for Assessment of Inquiry Learning in Science in a Danish Context**

*Morten Rask Petersen, Thomas R. S. Albrechtsen & Claus Michelsen*

During the recent years there has been a change in teaching going from teaching content knowledge towards teaching skills and competencies. IBSE seems to be a powerful tool in that process. This paper describes how teachers from lower and upper secondary school approach an assessment of skills and competencies acquired through IBSE. The case study describes how 5 teachers (3LS, 2US) used lessons on UV-radiation (LS) and natural selection (US) as structures for assessing skills and competencies. We followed the teaching while doing field notes and video recordings. Afterwards we conducted follow-up interviews with the teachers. This material was analysed through qualitative content analysis. Teachers at both levels find it important, difficult, but useful to use assessment structures. But they also find that the largest hindrance for implementation is not from the curriculum but from a content-knowledge focused identity among science teachers. This area of teacher's culture could be a fruitful approach for further research.

### **6a/3: Examining Scientific Literacy Progression Using a Context-Based Test Instrument – A Comparison between Grade 10 and 11**

*Regina Soobard & Miia Rannikmäe*

This study was undertaken to investigate the change in cognitive components of students' scientific literacy during the gymnasium years. Scientific literacy is taken here to mean utilising science knowledge and skills, particularly with relevance to creative problem solving and making reasoned decision in real life situations. The instrument was compiled based on a review of relevant international literature plus competences emphasised in the Estonian curriculum. All tasks in the instrument were contextualized to relate to real life. Sample of students from 44 schools gave a data set with returns from 1111 10th grade students and 916 11th grade students. Preliminary findings suggested that there was no sufficient shift from one grade to another in components of scientific literacy identified as scientific explanation, problem solving and decision making. Although the expectation was that students did enhance their levels of scientific literacy gain more knowledge, but this was not reflected in their reasoning competences and in their competence to solve problems. This suggested there was a need to re-thinking science teaching and learning approaches and the manner in which science was introduced to students.

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## **Session 6b: Assessment in Physics**

*Wed 4th June at 14.45-16.15, Exactum, room C123*

Chair: Ying-Yao Cheng

### **6b/1: Probing University Students' Pre-Knowledge in Quantum Physics with the QPCS Survey**

*Mervi Asikainen & Pekka E. Hirvonen*

The study investigated the use of Quantum Physics Conceptual Survey (QPCS) in probing student understanding of the basics of quantum physics. Altogether 103 Finnish university students responded to QPCS in the beginning of the course Quantum and Atomic Physics. The mean scores of the student responses were calculated, and the test was evaluated using to indices, Item difficulty and Item discrimination index. The results show that Finnish students' scores are quite low, 45.9%. The difficulty index showed that the test items were too difficult for the students ( $0.43 > 0.5$ ). On the other hand, the item discrimination was good, ( $0.34 > 0.2$ ). It seems that the QPCS can be used to probe student understanding of quantum physics after some careful modifications.

### **6b/2: Computer-Based Try-Out for Assessing Communication Goals in Physics**

*Maria Åström*

The Swedish science curriculum in compulsory school got a new component in the reform 2011 (Skolverket, 2011a). The new component consists of required communications skills that students should show in classroom discussions. In the work with national tests we did a try-out of a possible test item that could be aiming at those skills. The item consisted of two parts, the first was that students should use a number of recommended internet links to find information of the main topic in the item, namely if Sweden should continue to use nuclear energy. The second part consisted of a chat discussion between small groups of students that were done in a database environment where students should argue pros and cons the question. This pilot-test found that students were capable to use computers to search information and to discuss arguments with each other in a chat room. However, the number of students in the pilot test was small and the test item needed strongly development to fit the test frames to adjust to 35 000 students taking a written paper-and-pen test.

### **6b/3: Validation of the Figural Test of Scientific Imagination**

*Ying-Yao Cheng, Chia-Chi Wang, Hsiao-Chi Ho & Chih-Ling Cheng*

Based on the scientific imagination process (Ho, Wang, & Cheng, 2013), this study developed the Scientific Imagination test-Figural (SIT-Figural) for 5th and 6th graders. A total of 1256 students completed the SIT-Figural contained sample one ( $n=538$ ) and sample two ( $n=698$ ). This test was designed to measure pupils' scientific imagination, contained four items, A, B, C, and D which item covered two dimensions, Brainstorming and Association among scientific imagination process. The Rasch partial credit model was used to assess model-data fit. A differential item functioning (DIF) analysis was conducted to assess the consistency of the ratings provided by males and females. The results revealed that the two dimensions of the SIT-Figural showed good model-data fit. It was found that the two subtests had person separate reliabilities of .81, and .80. Finally, Suggestions for future research to revise and apply the SIT-Figural were proposed.

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## **Session 6c: Assessment Methods**

*Thu 5th June, 10.45-12.15, Exactum, room C123*

Chair: Jari Lavonen

### **6c/1: Formative Assessment and Increased Student Involvement Increases Grades in Biology**

*Martin Granbom*

By designing a topic in an Upper Secondary School biology course to be highly formative the effect on student learning was studied. The study was conducted on 6 classes of 20 students, 17 years of age and the sex ratio was 41% women and 59% males. Under supervision of the teacher students planned working methods and examination form within the topic of Gene technology. In the beginning of the topic students also phrased learning outcomes and grade descriptors later applied for examination. The design resulted in higher summative grades on the topic compared to traditionally taught topics within the same course. Reasons for the good results are further investigated by discussions out of a teacher perspective and also by focus group interviews with former students. Students were interviewed one year after graduation to investigate student perspective on the intervention. One important outcome was that students appreciate variation in teaching more than the content in itself, e.g. in phrasing grade descriptors. There was also a positive reaction to student-planned topics but students preferred the teacher to perform different kinds of controlling actions. Results are discussed in the context of formative methods and assessment with intention of improving practical teaching methods.

### **6c/2: Modersmålets betydelse för förmågan att kommunicera naturvetenskap i nationella prov**

*Maria Eriksson*

I den nya läroplanen för grundskolan i Sverige är det stor betoning på språkliga förmågor i samtliga skolämnen. Som en konsekvens av detta har bland annat kommunikativa förmågor testats i nationella prov i naturvetenskap i årskurs 6 från och med 2013. Krav på språkliga förmågor i nationella prov skulle kunna vara ett hinder för elever, med annat modersmål än svenska, att visa sina kunskaper i naturvetenskap. Syftet med studien är därför att undersöka hur elever i sjätte klass, med annat modersmål än svenska, presterar på det nationella provet i naturvetenskap. En datainsamling har gjorts av provresultat kopplat till modersmål i en kommun i södra Sverige. Intervjuer med elever, med arabiska som modersmål, har gjorts efter att det nationella provet genomförts och då har eleverna fått möjlighet att svara på samma provfrågor igen, men muntligt och med hjälp av arabiska om de behövde. Studiens fokus är att se om dessa elever är missgynnade på grund av att de inte har svenska som modersmål. Resultaten från studien kommer vara av vikt då det gäller bedömning av andraspråkselever och i konstruktionen av de nationella proven.

### **6c/3: Kamratbedömning i naturvetenskap – 11-åriga elevers samtal och uppfattning**

*Therese Granekull*

I svenska skolor har bedömning, både formativ och summativ, fått ett större fokus. Det finns studier som pekar på att formativ bedömning och bedömning för lärande kan leda till ökat lärande, ökad motivation och prestation hos elever. Samtidigt som bedömning genomsyrar skolan allt mer,

uppstår frågor och motiv till forskning inom området. Denna studie undersöker en del i formativ bedömning, som visat sig vara effektiv i tidigare forskning, nämligen kamratbedömning. 11-åriga elevers samtal under kamratbedömning med ett naturvetenskapligt innehåll, studeras just nu utifrån aspekter som är kopplade till kamratbedömning så som tydlighet, effektiv återkoppling och att ta del av andras alternativa lösningar. Kamratbedömningssamtalen studeras med hjälp av videoobservationer. Samtidigt ämnar studien ge en bild av elevers uppfattning och upplevelse av kamratbedömning, vilket kartlagts genom enskilda semistrukturerade elevintervjuer. Elevers svar på uppgifter av naturvetenskaplig karaktär samlas också in som underlag. Materialet har transkriberats och analysen är pågående. Hittills i analysen visar materialet på olika repertoarer av kamratbedömningssamtal, elevernas uppfattning av kamratbedömning är ofta positiv, men samtidigt pekar elever på aspekter som kan påverka kamratbedömningens utfall i negativ riktning. Implikationer av studien kan väntas bli att lärare kan få verktyg som gör att det lättare att komma förbi de hinder som eventuellt finns vid arbete med kamratbedömning.

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## **Session 6d: American Viewpoints**

*Thu 5th June, 13.00-14.30, Exactum, room D122*  
Chair: Jari Lavonen

### **6d/1: Equitable Access to Quality STEM Education through Identification of Closing-of-Achievement-Gap Schools**

*Motoaki Hara & Esperanza De La Vega*

Interest in providing robust Science, Technology, Engineering, and Mathematics (STEM) education continues to intensify. The stakes are high for both educational researchers and practitioners to facilitate a high quality science educational environment that would better prepare the current, and future, generation of students for an increasingly information/technology-centered society. Not surprisingly, a large segment of current research tends to be focused on the pedagogy within classroom. In contrast, the discussion on challenges educational practitioners face in providing equitable access to robust science education is less prominent. Despite wide recognition for the need to prepare all interested students for STEM careers, scholars such as Darling-Hammond (2010) and Montgomery (2008) highlight how a disproportionate number of students from traditionally disenfranchised backgrounds - due to immigration status, poverty, and/or ethnic/cultural background - continue to lack access to robust learning opportunities. Using a mixed-methods research approach, the current study illustrates how standardized achievement test, when coupled with a state-wide formative assessment process, facilitates a more equitable access to high quality science education for all students. The research demonstrates the critical need for the monitoring of student learning both at the classroom (micro) level, as well as at the school district and state (macro) level.

### **6d/2: How Does Finnish Science Education Compare to American?**

*Kathryn P. Elkins*

Middle school teacher from USA visiting middle schools in Jyväskylä region in Finland will present her comparison between Finnish and American science education based on her observations and interviews of teachers.

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## **Session 7a: Primary School Teachers' Collaboration with Researchers and University Teachers**

*Wed 4th June at 13.00-14.30, Exactum, room D122*  
Chair: Stefán Bergmann

### **7a/1: Students' Annotated Drawings of Sun, Moon and Earth Mediating Teachers' Professional Development**

*Birgitte Lund Nielsen*

A case study of a teacher examining her 4th graders' conceptual understanding of factors causing day and night, seasons, and the phases of the Moon is presented. The teaching example and the data-collection are sourced from the Danish continuous professional development (CPD) project QUEST. The study is framed referring to research from the two fields of CPD and students' alternative conceptions in science. Methods include categorizing and coding 160 pre and post annotated drawings, and analysing a semi-structured interview with the case-teacher using a previously developed meaning-making model. The pre-teaching annotated drawings reveal several alternative conceptions, but based on the post-teaching drawings the teaching must be seen as rather efficient in most areas concerning challenging students' alternative conceptions; however not in relation to the phases of the Moon. The teacher re-designed her teaching informed by looking through the pre-teaching drawings. She did not analyse the drawings in a systematic way, but later emphasized the insight gained from seeing the analysis presented here. Nonetheless, she questioned whether teachers would find time for such analyses. While there are promising indications that this teacher will continue using pre- and post-assessment, the collaborative analysis of the drawings was rather superficial.

### **7a/2: Primary School—University Action Research**

*Iiris Attorps & Eva Kellner*

This paper describes a longitudinal action research project between a primary school and a university in Sweden. Earlier research highlights the importance of combining research on professional development and pupil learning. The overall aim of the project was to stimulate teachers' professional development and pupils' learning in science and mathematics. The purpose of this paper is to answer the questions: How do we design and implement an action research project? What do we learn from it? Nine primary school teachers in collaboration with researchers were using Content Representation for planning, implementing and reflecting on lessons and pupils' learning in Learning Study inspired cycle. By using pre- and post-tests, the teachers acquired knowledge about the pupils' subject specific knowledge and learning. In this paper we are describing the design and implementation of our project and some examples of outcomes. This research design brings together university and school practitioners to work collaboratively and it seems to stimulate teacher professional development.

### **7a/3: Development of Geography Teachers' PCK – A Pilot Study**

*Søren Witzel Clausen*

A small case study of the impact of the professional development project QUEST on three Geography teachers' practice is presented. The focus is on the topic of weather formation and climatic change, and how the project might/or not effect the teachers' development of PCK. It appears that there is an immediately impact on these teachers' use of new didactical tools. At schools with a "weak" professional learning community, it is however rather difficult for the Geography teachers to make fundamental pedagogical changes in their professional practice.

#### **7a/4: Undersökande laborationer i tidigare år, att försöka falsifiera en hypotes ger nya möjligheter till lärande**

*Lars Björklund*

Som en del i en fortbildningskurs för lärare i naturvetenskap fick kursdeltagarna låta sina elever skapa egna experiment kring fenomen de själva var nyfikna på. Resultatet av experimentet behövde inte vara någon korrekt och bevisad hypotes utan motsatsen, en falsifiering, var fullt godkänt. I 25 skolklasser med elever mellan 6 och 12 år, genomfördes dessa experiment. Lärarna rapporterade att eleverna med entusiasm och kreativitet tog sig an uppgiften. Dokumentation och presentation fick ett större värde när varje elev ville visa resultatet av sitt eget experiment. Man upptäckte också att vissa elever inte vågar uttrycka idéer eller hypoteser de inte tror de är sanna och dessutom att det i klassen finns flera alternativa föreställningar om naturvetenskapliga begrepp och fenomen. I sin reflektion nämner många hur de själva fått en utvecklad syn på "den naturvetenskapliga metoden": *När jag frågade vad de hade lärt sig så svarade en kille: Jag har lärt mig att det går att undersöka vad som helst!*

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### **Session 7b: Lower Secondary School Teachers' Inquiry-Based Laboratory Work and Professional Development**

*Thu 5th June, 13.00-14.30, Exactum, room D123*

Chair: Stefán Bergmann

#### **7b/1: Negotiating The Meaning of Laboratory Work Addressing Inquiry-Based Science Teaching**

*Torodd Lunde & Shu-Nu Chang Rundgren*

The purpose of this study is to explore teachers' negotiation process between the key ideas of laboratory work existing in the Swedish teaching tradition and of inquiry-based science teaching discussed in the international literature. The participants were 15 lower secondary teachers who joined an in-service teacher training program. Two times of group reflections were audio recorded and one focused group interview were collected as data resources. The preliminary result, based on two groups of six teachers, indicated that the negotiation process turned out very differently in different groups dependent on how the participant challenged themselves and negotiated with each other. The reflections concerning the awareness of different purposes on doing laboratory work for science teaching and learning were successful reached in one of the groups, while limited for the other one, even though they were developing similar teaching activities during the program. The implication to inquiry-based science teaching for teacher training is presented.

#### **7b/2: How to Help Chemistry Teachers to Improve Inquiry Teaching Practice?**

*Jelena Volkinsteine, Dace Namsome & Jazeps Logins*

Since 2008, new secondary education standards in science and mathematics have been effective in Latvia. The standards require students' scientific inquiry as part of the learning process. However, lesson observation and the teachers' survey show that teachers experience significant difficulty practicing scientific inquiry. In order to help the teachers to improve their inquiry teaching practice, a learning team (as a new form for improving teachers' professionalism) was set up. During the school year ten teachers have monthly team meetings with an aim to seek a solution to an inquiry learning process problem situation. The efficiency of the learning team was analysed utilizing the Dictaphone recordings of the sessions, teachers' survey and student progress reports. The research shows that analyses of teachers' professional performance improves their awareness and sense of comfort about scientific inquiry and facilitates students' achievement in this area. The learning team leader states that this kind of professional development is even more efficient if teachers understand students' research and are capable of analysing and reflecting on their performance. In order to more extensively introduce the innovative form for improving teacher's professionalism, team leaders have to be prepared in advance.

### **7b/3: In-service Science Teacher Professional Development**

*Niclas Åhman, Gunilla Gunnarsson & Inger Edfors*

The aim of the present study was to explore teachers' professional development as they worked together with the tool Content Representations (CoRe) when planning a learning study in chemistry, which they also implemented and analyzed. The work of six experienced science teachers, all teaching at the 6<sup>th</sup> to 9<sup>th</sup> year (age 13 to 16 years), was followed at eight group meetings during one year. The teachers' discussions during the group meetings were audio and video recorded. Recordings were transcribed and a thematic analysis was performed. The preliminary results show that two main approaches to teaching emerged in the teachers' discussions, a pragmatic and a reflective approach, respectively. During the period, the content of the teachers' discussions changed, from a predominantly pragmatic approach to a predominantly reflective approach. The results indicate that the work with CoRe stimulated the teachers to express and discuss their knowledge, beliefs and attitudes towards teaching, i.e. promoted their professional development.

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## **Session 7c: Assessing Outcomes in Inquiry-Based Learning and School Competence**

*Thu 5th June, 14.45-16.15, Exactum, room D123*  
Chair: Maria Immaculata Maya Febri

### **7c/1: Assessing Schools' Competence to Work with Sustainability**

*Auður Pálsdóttir & Allyson Macdonald*

The purpose of this paper is to report on a development and use of a school self-evaluation tool designed to assess the competence of a school to work with sustainability education. Items for the trial version were selected from a literature review and from an analysis of two sets of interviews with teachers taken 24 months apart. Twelve schools took part in the trial survey. The results were

subjected to factor analysis and five factors were identified, three to do with the school culture, leadership and feedback and two to do with understandings of sustainability and sustainability education. A set of 55 items from the twelve schools was subjected to cluster analysis and multi-dimensional scaling. The results indicate that it is possible to sort schools and provide them with information on the current situation and indicators of feasible next steps (Rogan & Grayson, 2003), including need for mentoring, what to include in planning of continuous professional development (CPD) and revision of the school curriculum. The final version of the questionnaire was fully validated in a 13<sup>th</sup> school.

### **7c/2: Teachers' Experiences from In-service Education about Inquiry-Based Science Education**

*Mats Lundström, Anders Jönsson & Karin Nilsson*

Science teachers have often regarded in-service education as an ineffective way to improve their professional competence. At the same time a lot of resources are spent on in-service education, for instance in different projects financed by the EU. This paper reports from a project with the aim to develop science teachers' skills in inquiry based science education ("IBSE") and assessment. In-service teacher education is provided by a series of workshops (24 hours in total). In order to investigate how the teachers perceived their development as professionals during the workshops, the teachers answered a questionnaire individually in the end of each series of workshops. The majority of teachers reported that they consider themselves as more experienced in teaching IBSE after the workshops; something they state will make them use IBSE and assessment more in the future. The results also indicate that teachers' expectations of in-service education have been met by the workshops.

### **7c/3: Professional Development of A Teacher's Practice – A Case Study within PRIMAS Project**

*Maria Immaculata Maya Febri & Ragnhild Lyngved Staberg*

Reports from European expert groups have identified the necessity of a renewed pedagogy in schools to overcome deficits in science and mathematics teaching. Engaging students in inquiry-based learning (IBL) is seen as a solution. This paper describes a case study performed within the framework of PRIMAS, a project aimed at a large-scale implementation of IBL. Our case is a teacher that participated in an in-service professional development (PD) course. After 10 months of PD, our case teacher started to use more open tasks, he became more aware of the use of discussion, to play on student statements and he became familiar with formative assessment of students' efforts in IBL, as shown through our classroom observation and interviews.

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## **Session 7d: Teachers' Professional Learning Model and Collaboration within Networks**

*Wed 4th June at 14.45-16.15, Exactum, room C124*

Chair: Lars Brian Krogh

### **7d/1: How Science Teachers Learn to Reflect by Analysing Jointly Observed Lessons**

*Dace Namsonē, Līga Čakāne & Ilze France*

The aim of the article is to present a teachers' professional learning model, implemented within the project PROFILES of FP7 Science in Society, with an emphasis on teachers' collaboration within school networks. The article reveals the contribution of the joint observation in real-life classroom environment, and lesson analyses to the development of the capability of simultaneously teaching scientific inquiry skills, collaboration skills and reflection skills. The survey of teachers, conclusions of experts and teachers' feedback all demonstrate that the model enhances the development of science and mathematics teachers' reflection skills. At the same time the article gives guidelines to follow when this model is practiced with different groups of teachers.

### **7d/2: Engaging Science Teachers with Motivational Theory in An In-Service Teacher Training Program**

*Hanne Møller Andersen & Lars Brian Krogh*

The need to enhance science teachers' motivational practices is well established, and reviews have suggested that these should be informed by motivational theory. In this Design Based Research project we have developed an in-service Teacher Professional Development Programme (TPDP) addressing the issues of a) what motivational knowledge should be made available to teachers? And b) how can we facilitate the transformation of theoretical knowledge to practice, through appropriate strategies in the context of a TPDP? Literature study has guided the development of a motivational CARTAGO framework and the selection of core transformative strategies included in our TPDP design. The TPDP has been developed through two trials and subsequent refinements. Empirically, we have rich data related to teachers practice (data from teachers' "micro-research", their lesson plans, reflective writings, and classroom videos) along with teacher evaluation surveys and interviews. Using evidence across the cycles we will discuss how teachers engaged with and benefitted from the applied strategies. On this basis we will also critically consider further TPDP refinements and scrutinize the underlying theoretical conjectures.

### **7d/3: Science Teachers' Professional Learning in School Networks Using an Inquiry-Based Approach**

*Thomas R.S. Albrechtsen, Beth W. Andersen & Claus Auning*

In this paper we discuss the question about how an inquiry-based approach to science teaching can become a shared object of professional learning for teachers collaborating across school boundaries. The case we will discuss is part of a regional research and development project in Southern Denmark called *Project X*. In the case students from lower secondary school (5<sup>th</sup> to 6<sup>th</sup> grade) visited elder students in a vocational school, at the Department of Agriculture, to learn about different aspects of growing plants. The information the students attain from the visit they use in their own classrooms to make inquiries about the best conditions for growth. This scenario was designed in collaboration between the teachers involved who have first had an introductory course about inquiry-based science education (IBSE). Viewed as a professional learning process for the teachers we experienced a first phase with frustrations about how to teach students to "work like scientists". But as the design was developed in the second phase the teachers became increasingly clear about how to turn the ideas into practice. The results of the design for the teachers were positive as regard to learning about each other and how to do science teaching differently and not least did the new contacts established in the process create new networks that probably would not have been created without the project facilitating it.

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## **Session 8a: Facebook & Smartphones – New Approaches to Students' Interest**

*Fri 6th June, 13.00-14.30, Exactum, room D122*

Chair: Kalle Juuti

### **8a/1: Facebook in Biology: A Case Study of Students' Interest and Participation**

*Niels Dohn & Nina Bonderup Dohn*

Since the development of learning motivation related to science topics seems difficult within formal school context, one would expect students to find it easier and more motivating to communicate about learning issues if they involved Facebook activities because of their familiarity with and general positive attitude towards Facebook. This study aims at clarifying how students' engagement in Facebook activities in the context of upper secondary biology can trigger interest. Data were collected by a mixed method approach, based on observation, interviews and questionnaire. Data were analysed with the themes 'interest', 'affordances for participation', 'constraints on participation' and 'interaction of contexts'. The results suggest that Facebook as an 'everyday platform' tends to increase students' interest and participation. On the other hand, however, our study also reveals counteracting characteristics of Facebook as a learning platform: First, distractions are many on Facebook. Second, a number of students felt invasion of their privacy. Thus, our study serves to give some counterbalance to the optimism displayed in the literature concerning the potentials for learning of Facebook.

### **8a/2: What Do Ninth-Grade Students See, Think and Do in Science Lessons?**

*Kalle Juuti, Jari Lavonen, Janna Linnansaari, Katariina Salmela-Aro & Jaana Viljaranta*

The paper focuses on photos taken by 11 ninth-grade students in science lessons during a two-week period. Each student received a request to take a photo of what he or she was doing and answer a few open-ended questions about his or her activities and thoughts by smartphone. Students' photos in science classes were classified into seven categories: blackboards or screens, teacher demonstrations, notebooks, textbooks, worksheets, hands-on activities and friends. Students' responses about their activities and thoughts in the photo situations illustrated a rather traditional view of science teaching and learning: Students follow the lesson and think often about something else.

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## **Session 8b: Engaging Students by Authentic Tasks or Topics**

*Thu 5th June, 13.00-14.30, Exactum, room C123*

Chair: Lars Brian Krogh

### **8b/1: Student Affective Experiences of an Authentic Research Project**

*Jenny Sullivan Hällgren*

The aim of this study is to understand (i) how students experience taking part in an authentic research project that aimed to increase motivation for science and understanding of research, and (ii) how these experiences are related to the science content and scientific way of working introduced in the authentic research project *the Medicine Hunt*. Twenty-four students from three lower-secondary schools were interviewed. These students were selected to provide variation in motivation for school science. The analysis of the interviews shows that most students enjoyed taking part in the project, and that students referred mainly to reasons connected to science education; to the authentic nature of the task, the inquiry-based methods, and the opportunity to learn more science. It further showed that students with low performance goals in all three classes appreciated the inquiry-based methods more than the other students. Otherwise, it was found that even though the three teachers had different foci and the students were selected to get largest possible variation in motivation for school science, there were no large differences between responses from classes or students.

### **8b/2: Elevers attityder till klimatfrågor och ämnesintegrering**

*Jan Schoultz & Pia Larsson*

Detta är en enkätstudie med ca 400 elever i årskurs 9 från fyra kommuner i Sverige. Studien behandlar elevers attityder till skolans naturvetenskap, till klimatfrågor och till tematisk undervisning med flera samverkande ämnen. Eleverna har arbetat med temaområdet *Energi och hållbar utveckling* i ca 5 veckor på NO- och SO-lektioner och besvarat samma enkät före och efter arbetsområdet. Enkätfrågorna är inspirerade av ROSE-studien och innehåller både öppna och slutna frågor. Svaren har kategoriserats och bearbetats statistiskt. Utfallet av studien visar bl. att eleverna har en positiv inställning till skolans naturvetenskap och en hoppfull inställning till klimatproblemens lösning, och verkar vara mer hoppfulla efter arbetet med temat. Attitydförändringar och information är viktiga förändringsfaktorer. Tematiskt arbete betraktas både positivt och negativt. Argumenten mot tematiskt arbete dominerar. Det upplevs som stressigt, svårt att hålla ordning på, svårt att fokusera, svårt med prov och betyg. Man lär sig mindre. Men det finns positiva röster som betonar bättre kunskaper, sammanhang och helheter genom temaarbete.

### **8b/3: 'My Product from Home' – A Didactic Approach to Motivate Students in Chemistry**

*Camilla Christensson*

Many students consider chemistry unpopular, difficult and abstract. If chemistry is placed in relevant everyday-life contexts, more students are interested in chemistry and motivated to learn the subject. This paper describes an empirical research where a didactic approach to motivate 16-year-old-students in upper secondary school by relating chemistry to their everyday life has been tested and evaluated. The students chose a product from home, such as shampoo, toothpaste or deodorant, which they brought to the school. During ten to twelve weeks, the students investigated their product from home in parallel with their growing knowledge in chemistry. Investigations included conductivity and pH measurements, and theory included periodic table, ionic and molecular compounds, alkali metals, halogens, acids and alkalis, and hydrocarbons. The students evaluated the didactic approach either by written reflections or by a questionnaire. A majority of the students enjoyed investigating their product from home. They thought they learned more chemistry and liked chemistry more.

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## **Session 9a: Learning Science: Conceptual Understanding of Physics**

*Wed 4th June at 14.45-16.15, Exactum, room C222*  
Chair: Ismo Koponen

### **9a/1: ReleQuant - Improving Teaching and Learning in Quantum Physics through Educational Design Research**

*Ellen K. Henriksen, Carl Angell, Berit Bungum & Cathrine W. Tellefsen*

In the Norwegian upper secondary physics curriculum, the competence aims concerning quantum physics and relativity are demanding for teachers and students, but have the potential for students to experience physics as personally relevant and engaging. Project ReleQuant applies educational design research to improve teaching and learning in these topics. In this paper, we present the first cycle of development of a teaching module on quantum physics. Identification of relevant theory and previous research, together with three small pilot studies with students and teachers, form the basis for this cycle. We present results from these activities, pointing to the following design principles for the quantum physics teaching unit: 1) clarifying how quantum physics differs from classical physics; 2) using simulations of phenomena that cannot be experienced directly; 3) providing for students to use written and oral language in their conceptual development; 4) addressing challenging concepts like wave-particle duality and uncertainty; 5) supporting teachers who are inadequately prepared in these topics, and 6) presenting examples and applications that are relevant to students' life-world. We discuss the next phases of development and suggest how the teaching material as well as the theoretical and methodological insights developed may contribute to improving physics education.

### **9a/2: Orienteering in Conceptual Groundings – Electric Field in Physics Teacher Education**

*Terhi Mäntylä & Maija Nousiainen*

Electric field is an abstract and complex scientific concept, which is important to understand in the university physics. However, research has shown that the field concept is problematic and difficult to learn. In this study, we first introduce three conceptual groundings called force, energy and source grounding concerning electric field concept for purposes of gaining more coherent and organized view of the electric field concept. Then, the learning results of pre-service physics teachers' understanding of the conceptual development of electric field concept are discussed. The results are based on the qualitative graphical and content analysis of the pre-service teachers' concept networks presenting the development of electric field concept within and between the three groundings. The results show that students are most familiar with the force grounding and it forms a basis of introducing other groundings. The approach using conceptual groundings gives students structured surroundings to navigate towards learning the various aspects and complexity of the electric field concept.

### **9a/3: University Students' Understanding of DC-Circuits: A Systemic Approach to Conceptual Change**

*Tommi Kokkonen*

A problem in teaching physics is that students' concepts often differ quite much from scientific ones and they are difficult to change. The nature of students' concepts and the nature of the process of concept learning are however disputed. According to some studies, students' initial knowledge is best described as a coherent theory-like structure. On the other hand, some view the knowledge

as incoherent and consisting of “pieces” rather than theories. This study presents a system-like description of knowledge and the process of learning. This framework is applied to empirical data which consists of university students’ interviews about DC-circuits. The explanatory models student used in the interview are analyzed and presented by the means of directed graphs reflecting their system-like structure. The graphs are a good way to present different kind of models from simple to more elaborated ones. Furthermore, it is argued that this kind of approach brings different views closer together and helps to understand the relations between them.

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## **Session 9b: Learning Science: Chemistry, Biology and Earth Science**

*Thu 5th June, 10.45-12.15, Exactum, room C124*  
Chair: Ismo Koponen

### **9b/1: Learning to Apply Models of Materials When Explaining Their Properties**

*Tiia Karpin, Kalle Juuti & Jari Lavonen*

This is a quasi-experimental study of how upper secondary school students applied structure models when explaining the properties and behaviours of different materials. The topic is important to chemistry education at the upper secondary level but is considered one of the most difficult topics to learn. Students were guided to predict – observe – explain activities in four different experimental situations. It was intended that the structure models would encourage students to learn how to identify and apply appropriate models in predicting and explaining situations. The lessons, organised during a one week period, began with a teacher’s demonstration and continued with student experiments in which they described properties and behaviours for six household products representing three different materials. Most students in the experimental group (n = 27) learned to apply the models correctly, as demonstrated by significantly higher post-test scores. The control group (n = 18) showed no significant difference between pre- and post-test scores. The findings indicate that the intervention had a positive effect on learning outcomes.

### **9b/2: How Do Young Pupils Interpret Explanatory Pictures? An Investigation of Animated Illustrations in School Science**

*Anna Karin Westman*

The study presented here is a part of a larger project which focuses on the understanding of explanatory illustrations used for science education and mathematics in primary school. School textbooks and other teaching aids for young pupils today typically include a lot of visual information. The transparency of this information cannot be taken for granted and little research has been accomplished in the domain of young pupils understanding of visual information. This study sets out from research on “graphic literacy”, visual and multimodal literacy and understanding of the organization levels in natural science. The whole project takes a socio-cultural perspective and the units of analysis are interactions between pupils and between pupils and teachers. Data is collected by video recordings and field notes from classroom and small-group work. A first pilot study in is carried out at the time of writing and some tentative results are presented.

### **9b/3: Do Norwegian Textbooks for Compulsory Education Promote Geological System Thinking?**

*Pål J. Kirkeby Hansen*

Geology is one of many topics in the Norwegian curricula for science and geography in compulsory education. System thinking is a strategy to promote conceptual development. The purpose of this study is to investigate how geological systems are presented in Norwegian science and geography textbooks for grades 1-10. Do they promote geological system thinking? 14 best selling textbooks were examined. The geological system for oil- and gas-formation is explicit in the curriculum; the plate tectonic cycle and the rock cycle are not. This examination shows that single components of geology are introduced in the textbooks at grades 1-4. Elements and processes in rock formation and plate tectonics are introduced at grades 5-7, and further developed at grades 8-10. Oil and gas formation are given a short introduction at grades 8-10. The textbooks do cover the geology topics in the curriculum. Except for one textbook presenting the whole rock cycle, the elements and processes are not presented as holistic geological systems. However, if taught adequately, the textbook-presentations could foster system thinking among the pupils. A small number of texts contain errors, misconceptions or oversimplifications. If not corrected by the teachers, the pupils might develop misconceptions.

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## **Session 10a: Nature of Science and Teaching Practices**

*Thu 5th June, 10.45-12.15, Exactum, room D122*  
Chair: Meyvant Þórólfsson

### **10a/1: Teachers Discussing, Planning and Implementing NOS-aspects in Their Teaching**

*Lotta Leden, Lena Hansson & Andreas Redfors*

The inclusion of “nature of science” (NOS) in science education has for a long time been regarded as a crucial component in the teaching for scientific literacy. The aim of this study is to investigate how in-service science teachers plan, implement, and afterwards reflect on a NOS teaching session. The participants in the study are Swedish in-service science teachers (n=4) in grades 4-9. Sources of data are teacher-group discussions (before and after the NOS-session), classroom observations, and teachers’ reflective notes. The analytical framework used in this study is developed with a point of departure in the NOS tenets described by Lederman (2007). The preliminary results indicate that although the teachers in different ways explicitly address many different aspects of NOS during the teaching sessions, and they believe that their students are interested in the provided tasks, the teachers themselves are having a hard time coping with the clash between the implemented NOS-session and more traditional views of science teaching.

### **10a/2: The Influence of Textbooks on Teachers’ Use and Selection of Chemical Bonding Models**

*Anna Bergqvist & Shu-Nu Chang Rundgren*

Textbooks have played a necessary role in teachers' teaching. The focus of this paper is to reveal to what degree textbooks influence teachers' teaching practices. The study presented in this paper is part of a research project investigating chemistry teachers' knowledge of teaching chemical bonding and models of chemical bonding presented in chemistry textbooks at upper secondary level, related to students' difficulties in understanding and alternative conceptions. A total of ten teachers were interviewed. Multiple data recourses were used for the data analyses in this study including interviews with the teachers, the content of teachers' lesson plans as well as the content of the textbooks used by the teachers. Our result revealed that teachers were influenced by the textbooks to a various degree in their use and selection of representations of chemical bonding models. According to research, these representations might cause students' difficulties in understanding and alternative conceptions of chemical bonding. The implications to teachers' professional development are discussed.

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## **Session 11a: Teaching Methods in Science Teacher Education**

*Thu 5th June, 10.45-12.15, Exactum, room D123*  
Chair: Berit Bungum

### **11a/1: Creating Animations – A Way to Connect Observed Chemical Reactions to Atomic Processes**

*Astrid Berg, Daniel Orraryd & Alma Jahic Pettersson*

The purpose of this study is to investigate how primary teacher students learning and engagement in chemistry is supported when they are assigned to create their own animations to explain their observations of experiments in electrochemistry. The rationale behind the assignment - having a small group of students working together by doing practical lab work, creating animations of the processes at the sub-micro level and present the product to their peers - is double. Firstly, it brings the most critical aspects for learning chemistry into focus - the existence of as well as the relations between the macro-, micro and symbolic level of chemistry. Secondly, the assignment as such allows students to collaborate to solve an authentic problem, gives them authority to address the problem, holds them accountable to others and provides them with resources – attributes that are proposed to lead to productive engagement and meaning making. The learning activities were video recorded to capture students' interactions with other students, instructors and artefacts. The video recordings will be analysed, using a socio cultural perspective, during the spring of 2014.

### **11a/2: Learning, Collaboration and Socialisation – The Power of Technology in Pre-Service Teacher Education**

*Christine Lindstrøm*

In a flipped classroom (FC) approach to teaching, students receive their initial exposure to the subject matter before class, thus freeing up class time to work on concepts students find particularly challenging. In this project, 66 pre-service teachers took an FC physics course. In a Just-in-Time Teaching (JiTT) manner, the instructor used student feedback obtained from online pre-work to tailor every class. During class, relevant mini-lectures were given interspersed by student discussions on conceptual questions. For this, the instructional method Peer Instruction (PI) was used, delivering questions to students on their digital devices. Both online pre-work and in-class questions were delivered using the online platform Learning Catalytics. Based on the

concluded autumn courses, students were motivated to do their pre-work (62 % compliance, N = 36) and attend classes (88 %, N = 36), both of which were voluntary. In the course evaluation questionnaires, students indicated that of the different teaching methods employed, PI and JiTT were the two most valuable for learning (M = 4.46 and 4.00 out of 5 respectively). In summary, the FC approach with JiTT and PI was successfully enabled by technology, motivated students and was perceived to be very valuable for learning physics.

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## **Session 11b: Teaching and Learning Science in Teacher Education**

*Fri 6th June, 13.00-14.30, Exactum, room D123*

Chair: Berit Bungum

### **11b/1: Teaching Prospective Elementary Science Teachers: Perspectives, Orientations, and Strategies Promoting Development of PCK**

*Hildegard Urban-Woldron*

Findings of educational research suggest that many elementary teachers are indisposed to teach science and admit a lack of knowledge and confidence to teach it. Therefore, the role of teacher education is critical to developing high quality teachers in helping them to teach science effectively for understanding and to support science learning. The paper reports on the design of a science methods course for future elementary science teachers guided by the framework of PCK (Pedagogical Content Knowledge) and also addressing students' motivational orientations according to personal and teaching efficacy in science education. 158 pre-service primary science teachers took part in the study. Quantitative data were gathered from the STEBI-B and a content knowledge test. In addition, a set of qualitative data (portfolio, assignments, lesson plans, and reflection on teaching sequences) was used for answering the research question how the design of the course impacted the development of students' PCK and motivational orientations. Starting with descriptive analyses, analyses of variance, confirmatory factor analyses, cluster analysis, and regression analysis were conducted. However, extensive data analyses reveal a range of alternative conceptions held by the pre-service elementary teachers prior to the course. Generally, the pre-service teachers indicate positive self-efficacy beliefs regarding science teaching. In conclusion, no significant relationship between self-efficacy beliefs and achievement could be identified.

### **11b/2: Preparing Future Teachers to Teach Socio-Scientific Issues**

*Jan Alexis Nielsen & Robert Evans*

This presentation reports on the implementation of three-step teaching module for Danish pre-service science teachers on teaching socio-scientific issues. The implementation was part of a LLP/EU funded project – PreSEES – in which six European countries participate. The research question clarified by the present study was the following: To what extent does a short indoctrination to, and application of, socio-scientific issues influence pre-service teachers' self-efficacy and teaching practice concerning socio-scientific issues? The preliminary qualitative data analysis reveals some issues concerning how pre-service teachers balance factual and value-laden argumentative discourses in microteaching sessions. In the presentation, we will present the full results and compare the Danish results with results from similar implementations in six other European countries.

### **11b/3: Artskunnskap og biologisk mangfold – Erfaringer fra et undervisningsopplegg i grunnskolelærerutdanningen**

*Per Ivar Kvammen*

Experiences shows that the knowledge of species among teacher students has decreased the last twenty years, and recent research from different parts of the world shows the same: The knowledge of species is decreasing. As an introduction to their science teacher education 39 students followed a course over seven weeks, where they learned more about plant- and animal species in three different biotopes: forest, mountain and freshwater. The students replied to a questionnaire five weeks after the course. Both the three days field course and making their own collection of different plants and animals had great positive impact on the students learning of species. The students expressed that the practical work with plants and animals has increased their interest in science, will have positive impact on their work as science teachers and has increased their pleasure to be out in nature. The knowledge of species and biodiversity has a rather small space in science teacher education and, compared to other disciplines, the time spent on plant- and animal species in different biotopes is decreasing. If we want to promote understanding of environmental issues and sustainable life style, should knowledge of species and biodiversity take up a larger space in science teacher education?

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## **Session 12a: PISA Considerations**

*Wed 4th June at 14.45-16.15, Exactum, room C323*  
Chair: Svein Sjøberg

### **12a/1: OECD, PISA and Globalization – The Influence of the International Assessment Regime**

*Svein Sjøberg*

International organizations are to an increasing degree influencing also national educational policies. We may identify the emergence of a global educational reform movement, where the OECD through its PISA project has become the key driver. The paper will present examples of how PISA and its focus on league tables and rankings influence educational debates and educational policy in many countries, in particular the Nordic. The paper will also review background papers and critical accounts of this development with special focus on the Nordic countries. Since studies like PISA cannot identify causal relationships behind success and failure, the educational consequences of the studies are often not clear. In many countries, international studies are used to legitimize market-driven reforms, control of the teachers, publication of results, payment by test results for teachers and principals, erosion of the public school system, privatization and the introduction of more testing regimes. Examples of this development will be given, and it will be shown how this development runs contrary to other advice, also as given by science educators.

### **12a/2: Comparing Danish and Swedish Versions of PISA Scientific Literacy**

*Margareta Serder & Helene Sørensen*

This paper presents a comparison between the Swedish, Danish, English, and French versions of three scientific literacy test-units from the released PISA items 2006. More specifically it compares how different words and concepts have been translated in the Swedish and Danish tests, compared to the English and French original versions. Differences that occur as a result of the translation process concerning words' meaning are demonstrated. The possible consequences of such differences are exemplified by an excerpt from a situation in which Swedish 15-year-old students collaboratively worked with these three PISA units. In the paper we claim that in spite of detailed and strongly controlled methods for achieving translations of high standard used by the PISA, important and perhaps even decisive, differences between the four versions exist.

### **12a/3: Hva har PISA og TIMSS bidratt med i norsk grunnskole? Trenger vi både TIMSS og PISA, og i så fall: til hva?**

*Odd Valdermo*

«Forskning viser at ... Og hva så?» er en studie av skoleforskning, primært om dens betydning for skolens hverdag. Blir forskningsfunn fulgt opp i skolen, og ev. hvordan? Denne presentasjonen er første arbeid i prosjektet, og har fokus på de internasjonale studiene PISA og TIMSS. Verken PISA eller TIMSS kan forklare skuffende resultater eller foreslå forbedring basert på egen forskning. Men de prøver. Tre mulige områder er analysert: lekser (TIMSS), læringsstrategier (PISA) og læringstrykk (begge). Resultatene av analysene får stor vekt i presentasjonen og blir vurdert mht. oppfølging, kvaliteten, markedsføring mm. Det har vært lite kritikk av denne forskningen til PISA og TIMSS. Presentasjonen omtaler også kort en studie av frigitte PISA-/TIMSS-oppgaver i naturfag, hva som skiller disse, betydning for forskningsfunnene og samsvar med intensjoner i læreplaner. Det er rimelig å tro at OECD påvirket norsk skole rundt 1990. Imidlertid er det grunn til å tvile på at PISA (og ev. TIMSS) har påvirket norsk skole i særlig grad. Leseforskning er ikke med. Presentasjonen tar kort opp dette og gir eksempler på vanskene med å dokumentere at realfaglige funn blir fulgt opp av de ansvarlige. Neste PISA-/TIMSS-undersøkelse kommer i 2015 (PISA og TIMSS), 2018 (PISA), 2019 (TIMSS), 2021 (PISA), 2023 (TIMSS), ... Mot denne opplistingen spør vi hvem som trenger internasjonal sammenligning med så høy frekvens? Trenger vi både PISA og TIMSS? Til hva? Analysene handler mest om norske data, men arbeidet er like relevant for andre (nordiske) land.

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## **Session 12b: Curriculum Development**

*Fri 6th June, 13.00-14.30, Exactum, room C123*

Chair: Allyson Macdonald

### **12b/1: Science Education and the Null Curriculum**

*Meyvant Þórólfsson*

This paper draws on the author's doctoral study, based on a compilation of research articles on the transformation of the science curriculum in Icelandic compulsory schools from 1960 to 2010. The findings imply that natural science as a curricular field, proves to be dynamic in nature. Transient ideologies, traditions and curriculum models seem to mix regarding both policy and practice. Furthermore, the science curriculum appears increasingly as becoming a 'crowded place', where new ideas and information have an easy access, while prior ideas and systems tend to remain and

amalgamate with new ones, resulting in a curriculum that transforms into a mixture resembling a 'kaleidoscopic quilt'. Practitioners, especially teachers, seem poorly prepared to deal with such complex conditions, resulting in particularistic practices, where each teacher and each school develops its own specific way of organizing science learning and teaching, occasionally resulting in what Elliot W. Eisner labelled as a 'null curriculum'.

### **12b/2: Science in the 2013 Icelandic Curriculum: Production and Deliberation**

*Allyson Macdonald & Auður Pálsdóttir*

The development of a science curriculum is an important process in a modern society and the final product is read by many. It is of interest to reflect on the recent revision of the science curriculum in Iceland produced under new laws on education from 2008 and issued in 2013. A review of some key international trends indicates that a discipline-based approach to science education remains dominant. In Iceland the decision was made to revise the entire national curriculum with a competence-based approach in mind. In the final stages of the science curriculum revision a switch was made from a disciplinary to a thematic approach built on five areas of competence related to procedural themes and five related to topics of importance to society. The aim of this paper is to reflect on the different stages of deliberation, the roles of stakeholders and the move from incremental to radical change in the curriculum. The changes required in the practice of teaching and assessment are also discussed and with reference to the role of teachers in the revision.

### **12b/3: Finnish Upper Secondary School Biology Textbooks Have Outdated Gene Models**

*Tuomas Aivelo & Anna Uitto*

The genetics is a fast-developing field with important socio-scientific impacts. As the updating of the national upper secondary school curricula is about to start, we decided to study how the current curriculum manifests in Finnish biology textbooks. We studied the main four textbooks for gene models and definitions of genes. The textbooks seemed to express sometimes even strong genetic determinism and we found out extensive genetic determinism which we call 'weak determinism': the genes were depicted as more important factor than environment in relation to the expressed properties. We argue that genetics education in Finland needs to take into account the environmental effects and there's a need for more emphasis on gene expression to make sense current science news and the need to understand genetic phenomena for instance because of potential increasing use of genetic tests.

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## **Session 13a: Teaching Methods and Assessment in Science Education**

*Fri 6th June, 13.00-14.30, Exactum, room C124*  
Chair: Anna Uitto

### **13a/1: Peer Collaboration and Conceptual Understanding of Speciation among Primary Pupils**

*Karin Stolpe & Johanna Frejd*

This study aims to investigate how peer collaboration affects individual pupils' conceptions of speciation. Earlier research on evolution has primarily focused on children's conceptions using individual and/or written examination. In this study, individual interviews and group discussions have been performed with eight 9-years old pupils who lack formal education on evolution. The results show that the pupils develop their conceptions on speciation in group discussions compared to individual interviews. This result suggests that also younger pupils improve their conceptual understanding in peer collaboration.

### **13a/2: Science Teaching at Primary School in Mobile Technology -Supported Learning Environment**

*Seppo Salmivirta*

There have been essential changes in the way educators think about learning process. Progressive inquiry model is representing a novel way for learning through inquiry. Collaborative knowledge building is the central aspect of it. Mobile technology combined with progressive inquiry allows new characteristics for a learning environment for science learning, which has not been studied a lot. This design based research focuses on research on a learning environment, emphasising the use of mobile tablet computer and progressive inquiry, where three design cycles during one school year has been completed. The group of students was the same in all design cycles. Data was collected through a stimulated recall group interviews. Moreover, students' texts, saved in an e-learning environment, videotaped classroom activities and teacher interviews were used as data in the research. The stimulated interviews composed of nine code families. In the family of Advantages of mobile environment almost 24% of codes were under label of Flexibility of learning environment. First results of the study revealed that there is a positive connection between mobile learning environment and knowledge building practices. First conclusion was drawn that mobile devices support cooperation and knowledge building in the classroom in the progressive inquiry situations of studying science.

### **13a/3: Formative Assessment as a Communication about Pupils' Prior Knowledge**

*Ann-Catherine Henriksson*

Assessing pupils' prior understanding and knowledge is essential when you look upon learning from a constructivist point of view. Formative assessment is also an important factor influencing learning and making learning visible for the pupil and the teacher. This qualitative study focuses on how primary school teachers look upon communicating the pupils' prior understanding and knowledge in the science subjects. The teachers were interviewed in spring 2012. Many of the teachers find large heterogeneity when it comes to the pupils' prior knowledge. A discussion between the teacher and the pupils about the upcoming theme is usual in the classes. A more systematic assessment is not common. There are teachers who find the assessment unimportant while they think that they are aware of the knowledge level anyway. Teacher might even be afraid of communicating the prior knowledge while they feel unsecure about their own subject knowledge. Teaching science in very heterogeneous classes can be challenging. The teachers seem to need more knowledge about how to improve the quality of formative assessment and about what benefits you as a teacher and the pupils get from using formative assessment.

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## **Session 14a: Approaches in Current Science Education**

*Thu 5th June, 13.00-14.30, Exactum, room C124*

Chair: Matthias Stadler

### **14a/1: What Does the Teaching of Science Look Like?**

*Svava Petursdottir & Gunnhildur Óskarsdóttir*

What constitutes good science teaching, is a prevalent issue in research of science education. Icelandic national curricula are ambitious expecting practices to be varied, individualized and using a range of teaching resources. Using data from 21 classroom observations from the Research project on Teaching and learning in Icelandic schools 2009-2011, this paper explores what the teaching of science in Icelandic compulsory schools looked like. The results indicate that teaching is characterised by teacher led discussions, written tasks but limited practical work. Textbooks have played a major role in influencing teaching but that seems to be diminishing. The data presented here gives a snapshot of the surroundings and what happens in the classrooms but further work is needed to describe science teaching in Icelandic compulsory schools and giving valuable information on exemplary practices to lead school development.

### **14a/2: Upper Secondary Teachers' Views on the Role of Laboratory Work**

*Simon Holmström & Ann-Marie Pendrill*

Experiments are one of the fundamentals of physics, and also of physics education. Laboratory work is used with a number of different aims for student learning, often only tacitly assumed, but not communicated, nor evaluated. The recent curricular reform in Sweden has brought a larger emphasis on experimental skills, including planning and design, as well as assessment of these skills. In this study 11 physics teachers in 4 different schools have discussed their laboratory teaching in upper secondary physics in focus groups interviews. The collection of data was complemented with responses from 17 teachers to a questionnaire. Logic of events was used as an analysis tool for the data. Human action is then seen as intentional and action is steered by the four determinants: objective, ability, norm and opportunity. Statements by the teachers were analysed according to these determinants. The analysis gave insight into teachers' actions in the form of laboratory work, but also into the choice and design of laboratory work. In addition, the results provide a picture of everyday work of teachers, with an increasingly heavy workload.

### **14a/3: What Tasks in Norwegian Chemistry Textbooks Require Students to Do?**

*Matthias Stadler & Ole-Anders Øvstegård Bodal*

This paper analyses tasks in chemistry textbooks for upper secondary school in Norway. It focuses on what solving a task requires students to do and how this can influence learning. A category system was developed from a list of inquiry activities also named ways of scientific thinking and working. A sample of 500 tasks from three textbooks was analysed assigning the activities needed for solving a task. The results indicate that the textbook tasks mainly require routine procedures hence: the focus is on the consolidation part of the learning process. In addition, the vast majority of the tasks displays a low complexity. This shows that the tasks support exercising on tiny bits of knowledge and isolated skills. Cognitive challenges that could lead to new learning are almost absent in the tasks. Whether the findings point towards a serious challenge in Norwegian chemistry teaching is however depending on the actual use of the tasks and possible cognitive stimulation by other means.

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## **Session 14b: New Collaborative Approaches for Science Education**

*Thu 5th June, 14.45-16.15, Exactum, room DK116*  
Chair: Päivi Kinnunen

### **14b/1: Highlighting Multi-Level Processes in Science Teaching and Learning**

*Päivi Kinnunen, Veijo Meisalo & Lauri Malmi*

Gaining comprehensive understanding of instructional processes is a valuable goal for anyone interested in developing science education. This work-in-progress study introduces a new version of general system theory based feedback loop model, which highlights the role of feedback in the instructional process. The model visualises the instructional process from the viewpoints of students, teachers, teaching organizations, society, and even the international community. The feedback loop model can be used to analyse teaching and learning challenges. For instance, at which phase of the process difficulties arise and what role feedback - or the lack of it - plays in challenges. The strengths of the presented model are that it features the whole instructional process from goal setting to planning, teaching/learning acts, and to processing learning outcomes. It also represents the process from different stakeholders' viewpoints thus providing a tool to gain a comprehensive view of the instructional process. We conclude by relating the feedback loop model to science education.

### **14b/2: Conceptual Understanding of Physics through Technology-Mediated Lessons in a Mauritian School**

*Yashwantrao Ramma & Ajeevsing Bholoa*

In its attempt to promote science education in Mauritius, the Government is investing massively into the education sector by providing schools with IT resources. However, the desired learning outcomes of students, in terms of motivation, satisfaction and performance are issues of concern as technology has permeated the education sector within the existing traditional learning environment. In this study, an attempt is made to adopt a novel model of technology integration in the learning environment by reckoning the affective domain in a process whereby teachers, students (age 14) and parents interact to enable knowledge construction of physics by the students. A pilot conceptual physics lesson, comprising a multitude of interactive activities, was designed and hosted on a website. The class teacher, who has undergone training, was responsible for facilitating students' acquisition of concepts during the process of interaction with technology. Parents had the opportunity to make structured monitoring at home. A questionnaire was administered to both the teacher and parents. Interviews were carried out with students, the class teacher and parents. From the study, evidence emerges that the involvement of the three stakeholders within a technology-mediated environment lifts teaching-learning transactions.

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## **Session 14c: Approaches to Support Chemistry Students' Understanding**

*Fri 6th June, 13.00-14.30, Exactum, room C222*  
Chair: Berit Kurtén-Finnäs

### **14c/1: Using Digital Technologies to Enhance Chemistry Students' Understanding and Representational Skills**

*Annette Hilton*

Chemistry students need to understand chemistry on molecular, symbolic and macroscopic levels. Students find it difficult to use representations on these three levels to interpret and explain data. One approach is to encourage students to use writing-to-learn strategies in inquiry settings to present and interpret their laboratory results. This paper describes findings from a study on the effects on students' learning outcomes of creating multimodal texts to report on laboratory inquiries. The study involved two senior secondary school chemistry classes (n = 22, n = 27). Both classes completed and reported on two laboratory based inquiry tasks using digital technologies. Data were collected using pre- and post-tests, student texts and interviews and classroom video-recording. Content analysis of student texts indicated that students were able to generate new knowledge and use multiple representations to make explanations on the molecular level. Student interviews and classroom video-recordings suggested that using digital resources to create multimodal texts promoted knowledge transformation and hence deeper reflection on the meaning of data and representations. The study has implications for inquiry learning and using digital technologies to enhance students' understanding of chemistry on multiple levels.

### **14c/2: Open-Ended Investigations in Chemistry Education and Student Learning**

*Berit Kurtén-Finnäs*

In this presentation results from two different studies is presented and discussed. In the first study students in a class in grade 7 in the comprehensive school worked with open-ended investigations in their first chemistry course. The students were given a problem in the laboratory and had to plan how to solve the problems in their laboratory groups and conduct the investigation according to their plan. The second study is a result of the S-TEAM (Science Teacher Education Advanced Methods) project. One of the goals for this project is to make it easier for teachers to use inquiry-based or 'investigative' methods in their science teaching. Students in one class in upper secondary school were within this project video-taped during the planning phase in an open-ended investigation. Their discussions were analyzed by conversation analyze (CA). The focus of this presentation is student discussions during their planning of how to solve the open-ended problem given by the teacher. The results from the two studies show e.g. a progression of the use of scientific concepts during the discussions. The students' alternative conceptions were challenges in the groups discussions and they and the opportunity to modify their conceptions in the dialog with their peers.

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## **Session 15a: Science Teaching and Learning at the University Level**

*Fri 6th June, 13.00-14.30, Exactum, room B120*  
Chair: Haydar Oztas

### **15a/1: PhD Students at Science & Technology Exploring Student Learning in a Collaborative Video-circle**

*Birgitte Lund Nielsen & Rikke Frøhlich Hougaard*

A teaching course for PhD students at Science & Technology working as Teaching Assistants (TAs) has been iteratively developed to have two consecutive modules. Role-plays at course days and a “teaching in practice” assignment between modules have indicated that the TAs struggle to facilitate students’ exploratory talk in small class teaching, lab exercises etc. A potential third module organized as a video-circle with collaborative analysis of the TAs teaching based on observation and video has therefore been tested. The TAs reflections and their enactments in own teaching have been examined using video, audio and questionnaires. The TAs reported a high level of outcomes and referred to the importance of the video as evidence supporting the discussions. The importance of the collaboration between peers and staff (educational developers) was emphasized: highlighting the benefit of seeing peers teach and getting feedback from professionals. In addition, they appreciated the equal atmosphere in the group. There are indications that the TAs focused on student learning by consciously supporting students’ exploratory talk in their new enactments. Parts of the TAs reflections are descriptive, concerning what they did as teachers and why, but dialogic reflections focusing on how to support student learning seem to be developing.

### **15a/2: University Students Reflections on Representations in Introductory Genetics and Stereochemistry**

*Inger Edfors, Susanne Wikman, Brita Johansson Cederblad & Cedric Linder*

Genetics and organic chemistry are areas of science that are regarded as difficult. Part of this difficulty is derived from them having representations as part of their disciplinary discourses. In order to optimally support students’ learning and meaning-making, teachers need to thoughtfully use representations to structure the learning experience in ways that open up the variation in students’ prior knowledge. For our study, university students’ reasoning on representations in genetics and organic chemistry was investigated using a focus group approach (8 groups, 4-8 students/group). This revealed how students can construct somewhat bewildered relations with disciplinary-specific representations. For instance, they stated that they preferred familiar representations, but without asserting the meaning-making affordances of those representations. Also, the students were highly aware of the affordances in certain representations, but nonetheless chose not to use those representations in their problem solving. The focus group discussions led the students to become more aware of their own and others meaning-making. At the same time, feedback from the students’ focus group discussions enhanced the teacher’s awareness of the students’ prior knowledge and meaning-making. Consequently, we posit that a design focus group methodology can be fruitfully used both to promote teacher development and progression, and student learning.

### **15a/3: Students’ Understanding of Photosynthesis: A Questionnaire for the Simultaneous Assessment**

*Haydar Oztas*

Photosynthesis is an essential concept in biology; the organisms rely on this chemical process for nutrients. However, this complex chemical reaction that occurs in the chloroplasts of plants is very difficult for students to understand. Therefore, there are numerous misconceptions that students have about the process of photosynthesis. For this the teaching photosynthesis can be complicated, as it is as process with components that cannot directly be observed. To address the misconception that plants obtain their nutrients from the soil, a teacher may want to have his or her students repeat van Helmont’s experiment, growing plants and measuring the mass of the soil and

the mass of the plants. Students will be able to observe the increase in the plants' mass and the consistency of the mass of the soil. Additionally, there are many laboratory exercises that display parts of the photosynthesis reaction, such as the observation of bubbles being produced on leaf surfaces, showing leaves' production of oxygen; covering part of a leaf to block it from light absorption; and other similar activities. However, many educators have wondered about the effectiveness of these activities in encouraging understanding. It has been suggested that when teaching complex concepts, such as photosynthesis, incorporation of a range of different modalities of learning may help students develop a deeper understanding. Modeling photosynthesis can increase conceptual understanding, in traditional teaching mostly photosynthesis instruction began with traditional lecture, they follow up with activities such as making a three-dimensional model of a chloroplast, acting out the photosynthesis reactions as a role-play activity. In this study we developed the cluster of questions used by asking open-ended versions of questions to undergraduates in large introductory biology classes. The common inaccurate responses were noted, and these were used to develop distracters for diagnostic multiple-choice questions. All revised multiple-choice items were administered an introductory biology course with enrollments of 45 students. We asked two levels of questions. The lower-level questions asked students to identify the inputs and outputs of the light reactions and Calvin cycle. The higher-level questions asked students to what they know about the matter and energy transformations of photosynthesis to explain phenomena in plants. The questions, all indicate that a student who makes a correct choice on question may have: reasoned as expected, held a mixture of accurate and inaccurate ideas. The results may indicate and identify students with heterogeneous understanding. Tracing oxygen through the equation indicates that this is not a simple substitution reaction in which elemental oxygen is stripped from carbon dioxide, released, and replaced with hydrogen and hydroxyl groups.

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## Session 16a: Socio-Scientific Issues – Environmental and Health Education

*Fri 6th June, 13.00-14.30, Exactum, room B222*

Chair: Veli-Matti Vesterinen

### 16a/1: Students' Roles in Saving the World

*Veli-Matti Vesterinen, Sakari Tolppanen & Maija Aksela*

In this study, 59 international students aged 15 to 19 were interviewed in order to investigate what kind of roles students take in making the world a better place. The interviews were analyzed using qualitative content analysis, in which three categories were created to highlight the variation in the roles students assumed as citizens: *Personal responsible action* is about an individual acting responsibly within his social and natural environment, *participatory action* is carried out as a member of a group or community, whilst *preparing for the future* describe the actions students feel they should focus on to be able to make a difference later in their lives. Most students had assumed several of these roles. Although many students saw that the impact of their actions alone do not make a big difference, they also believed that setting an example and inspiring awareness through small deeds was a prerequisite for bigger changes. As preparing for the professional life can play an integral role in students' effort to make the world a better place, the study concludes that especially advanced science courses should provide more opportunities for critical assessment on the way engineers and scientist can contribute to saving the world.

## **16a/2: Suitability of Secondary School Graduate Levels of Scientific Literacy for Studying Health Care**

*Inga Ploomipuu, Jack Holbrook & Miia Rannikmäe*

The literature suggests Scientific Literacy (SL) involves, among many things, scientific knowledge, ways of thinking, making evidence-based decisions, science awareness, metacognition and self-direction. Yet skills that are most relevant for 21st century citizens are closely related to SL and tertiary health care education requires a base in such SL qualities, often relying on secondary schools to develop these prerequisite skills. As SL levels of tertiary level students SL have not been studied in Estonia before, it is necessary to define the gap between the needs of higher education curricula and the students' abilities in terms of SL. This study focuses on determining tertiary level health care students' levels of SL on entering tertiary level education. The goal is to develop health-care courses and evaluate their effectiveness in further enhancing SL. In this study, 213 first year students were tested during the first week of studies using an Estonian developed SL instrument. Preliminary results show a lack of some important SL related skills seen as prerequisites for studies in Health Care. Pre and post course test scores are compared.

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## **Symposium 1: Towards a Sustainable Change of Teachers' Professional Development**

*Thu 5th June, 14.45-16.15, Exactum, room B119*

*Katerina Plakitsi & Norman G. Lederman (chairs), Judith S. Lederman (discussant)*

Teachers' professional development is an important domain in any educational innovation or curriculum reform. An emerged agenda in the field is about the professional role of the teachers based on the dialectics of being professionals and/or practitioners or teaching engineers. The relevant discussion also concerns about the key ICT competences that teachers have to achieve in order to meet the current societal challenges, demands and needs. This symposium opens up new theoretical perspectives and practical possibilities to analyze the learning opportunities in academic educational institutions and workplaces. International contributors draw on a range of ideas developed within constructivistic, socio-cultural and activity theory frameworks. The symposium focuses on development of Pedagogical Content Knowledge (PCK) for Science Inquiry (SI) and Nature of Science (NOS). Especially, it focuses on various professional development projects that provide teachers with sustained support

## **SY1/1: Project SLICE: Science Learning through Inquiry, Content and Engagement**

*Norman G. Lederman & Judith S. Lederman*

Project SLICE: Science Learning Through Inquiry, Content, and Engagement is a 5-year systemic professional development program to enhance US high school students' science achievement (as measured by standardized tests and internally developed assessments), understandings of scientific inquiry, and understandings of nature of science in biology, chemistry, and physics (grades 9-11) through the delivery of extensively revised curriculum and continuous on-site and off-site professional development support for teachers. A strong focus was placed on scientific inquiry and nature of science and the design of the project provided a natural context for the collaboration of science teachers, scientists, and science educators. Project SLICE involved all of the biology, chemistry, and physics teachers in 23 high schools. There were a total of 197 participant teachers

and over 30,000 students involved in the project. The project consisted of three essential elements. These were: 1) initial professional development for participating teachers, 2) monthly academic year professional development workshops (these are divided between the university and an informal education site), and 3) on-site academic year support from science coaches. A science coach was assigned to each school and this individual works closely with each of the teachers on a daily basis. Through a combination of standardized tests, open –ended questionnaires, and classroom observations it was found that the project was quite successful with respect to improvement in students' subject matter achievement, knowledge about scientific inquiry, and knowledge about nature of science.

### **SY1/2: Magnifying Effects of NOS: Professional Development and STEM Education**

*Katerina Plakitsi, Efthymis Stamoulis, Panagiotis Piliouras & Dorina Stamou*

Teaching the Nature of Science (NOS) in schools and creating relevant teacher training programmes has become an undeniable need for the science education research. This paper presents two research projects targeted to NOS teaching and learning in primary education, using cultural historical activity theory. The first project is about a “developmental work research” with four fifth-grade elementary school teachers who seek to improve their NOS understanding and increase their ability to effectively teach their students. The main approach of the project was to give the teachers the opportunity to analyse their teaching practice and identify on their own how their NOS teaching methods can become more effective. This approach is highly participatory, attributing a very explicit and reflective character in the context of socio-cultural approaches to STEM Education. The second project focuses on teaching young learners the NOS. A teaching sequence on electromagnetism was designed according to an expansive cyclic model integrating elements from the History and Philosophy of Science.

### **SY1/3: Improving Trainers' Competences through Design-Based Research**

*Jari Lavonen, Kalle Juuti, Tiina Korhonen, Minna Kukkonen & Kati Sormunen*

The collaboration and common action of trainers and researchers within two Design-Based Research (DBR) projects are analysed and discussed. Three trainers, who are active in DBR, were asked to evaluate the influence of DBR on their competences as trainers and their collaboration with researchers. We conclude that DBR supports researchers and teachers/trainers in sharing the same world. Common DBR developed trainers' competences to work as trainers.

### **SY1/4: How Researchers Can Support Teacher Change: Lessons from Swedish Secondary School**

*Per-Olof Wickman, Jesús Piqueras, Karim Hamza & Marcus Angelin*

In this presentation we show how contributions of researchers sustained teacher change in a professional development program in a Swedish secondary school. The program was part of a research project on how science education research can support science teachers' day-to-day work with inquiry-based learning. We collected video data from thirteen meetings between researchers and teachers during three teaching cycles. We video recorded all lessons. For analysis we employed Clarke and Hollingsworth's model of teacher professional growth. Here, we focus on how the researchers supported teachers' changed PCK and practice through (a) explicit commitments regarding the consequences of employing the research based knowledge and (b) providing the teachers with thorough analyses and attendant concrete suggestions for how to

change practice on the basis of this knowledge. These commitments on the researchers' part resulted in distinct teacher change, observable as the teachers (1) were acknowledging salient outcomes of the researchers' contributions, (2) took over the terminology of the researchers, and (3) consistently began to employ the associated concepts in their own planning, in talk with the researchers as well as in artifacts such as planning documents. Results have implications for understanding the role of researchers in professional development.

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## **Symposium 2: PROFILES: The Project in Practice**

*Thu 5th June, 14.45-16.15, Exactum, room B120*

*Tuula Keinonen (chair)*

PROFILES, Professional Reflection Oriented Focus on Inquiry-based Learning and Education through Science, belongs to the EU 7th FW Programme. In the Curricular Delphi Study, partners clarified stakeholders' views of desirable science education. Based on the results of these studies in different countries, exemplar study modules were planned. The study modules follow PROFILES Three Stage Model, which comprises of the scenario, the inquiry and the decision-making stages. These study modules were presented to teachers on Continuous Professional Development programmes who then, in their own teaching, used either these study modules or new ones which they planned themselves. They also collected data on students' motivation towards the Three Stage Model studies. Teachers' ownership became apparent during the second year of the Continuous Professional Development programme when the same teachers presented PROFILES three stage studying to their colleagues. At this symposium, we will firstly present the PROFILES project, which will then be followed by three examples of its different stages. We will start with the Danish Curricular Delphi study, next we will take the Finnish teachers' views of the Three Stage Model and finally, the Swedish Students Gains study which shows students' viewpoints of the Three Stage Model.

### **SY2/1: PROFILES - Promoting Inquiry-based Science Education**

*Claus Bolte & Tuula Keinonen*

PROFILES (Professional Reflection Oriented Focus on Inquiry-based Learning and Education through Science) is one of the European FP7-funded projects in the field of "Science in Society", promoting contemporary science education in order to enhance Scientific Literacy in Europe and other countries associated to the European Union. The PROFILES Consortium consists of 22 partner institutions from 21 different countries. PROFILES supports efforts for Inquiry-based Science Education by raising the self-efficacy of science teachers to take ownership of more student-relevant ways of teaching in consideration of stakeholders' views. The project is based on 'teacher partnerships', implementing existing, exemplary, context-led, inquiry focused science teaching materials, guided by long-term teacher training programmes, reflecting on challenges identified by participating teacher educators and science teachers to improve their professional skills in developing creative, scientific problem-solving learning environments. Besides science teachers continuous professional development (CPD) the PROFILES project focuses on students' intrinsic motivation to learn science and aims at enhancing students' competencies in scientific inquiry as well as in skills of socio-scientific decision-making.

## **SY2/2: Danish Stakeholders' Views on Scientific Literacy**

*Jan Alexis Nielsen, Klavs Frisdahl, Lærke Bang Jacobsen & Fie Lykke Hansen*

As a part of the EU-funded FP7 project PROFILES, we have conducted a Delphi Study on Science Education involving different stakeholders' views on which aspects of science education are most relevant for scientific literacy in the 21st century. The study solicits responses from upper secondary school students, upper secondary school teachers, university students, scientists, industry representatives, educational scholars, and educational administrators. The data in this Delphi Study are collected in three consecutive stages. In the first stage, the stakeholders' views were collected in individual statements. Qualitative analysis is used to identify the key emerging themes (categories) in the responses. In the second stage, the stakeholders are asked to assign a priority to the categories, and assess the degree to which a given category is realized in Danish science education. This leads to a data-driven construction of a number of assertions about science education. In the third stage, the stakeholders assess these assertions. In this presentation, we present the results of the Delphi Study and discuss these results against the background of findings from other countries using the same methods as well as against the background of the present curriculum of Danish upper secondary school.

## **SY2/3: Incorporation of the Three Stage Model – Teachers' Experiences**

*Tuula Keinonen & Kari Sormunen*

The instructional innovation of PROFILES project is a so-called Three Stage Model (TSM). It aims to arouse students' intrinsic motivation when undertaken in a student-familiar, socio-scientific context (the Scenario Stage), to offer a meaningful inquiry-based learning environment (the Inquiry Stage), and to use science learning in solving socio-scientific issues (the Decision-making Stage). Incorporating innovations such as TSM in daily work can be seen as one of the main components of teachers' professional development. In this presentation, we describe how incorporating TSM, was experienced by Finnish PROFILES in-service teachers. The group was made up of science teachers (N=16). As a follow-up, a focus group discussion was held for the teachers to determine their experiences. Teachers' experiences were not only positive, new ideas were also aroused with regard to improving their TSM teaching. Teachers perceived that changes were needed in the way they worked and felt that the scenario was important, but challenging. A shared experience was their students' enthusiasm; TSM had been suitable for different types of learners. These findings confirm that TSM could be one way of increasing students' intrinsic motivation and in order to achieve this, teachers need practice and guidance in the incorporation of TSM in teaching.

## **SY2/4: Students' Responses to an Inquiry- and Context-Based Science Teaching Module**

*Susanne Walan, Shu-Nu Chang Rundgren & Birgitta McEwen*

In Sweden, like in other developed countries over the world, there is a problem with young people's low interest in sciences. To solve this problem, research has indicated that inquiry- and context-based science education (IC-BaSE) could increase students' interests in learning sciences. During the past years, the European Commission has also pointed out that there is a need for change in teaching science subjects and the focus must move towards IC-BaSE. In addition to the low interests in learning sciences, recently, the Swedish results in PISA 2012 has also shown the worst performance among all the other OECD participating countries. Therefore, it is time and necessary for science educators to work on enhancing students' learning interests and their engagement to sciences in Sweden. This study was based on an EU FP7 project, PROFILES, to develop an IC-BaSE way of PROFILES 3-step teaching module (the theme was Crime Scene Investigation, CSI)

and to investigate students' responses to this module. A Likert scale questionnaire was developed for the data collection. A total of 105 15-years-old students answered our questionnaire. The results showed that the students were positive to the IC-BaSE teaching. The implications to science teaching and learning are discussed.'

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## **Symposium 3: Authenticity in Environmental Education: Possibilities and challenges in school science practices**

*Thu 5th June, 14.45-16.15, Exactum, room C122*

*Erik Knain (chair)*

Authenticity is a multifaceted notion in educational discourses. In this symposium, cultural authenticity means that students participate in activities in school that closely resembles activities in for instance specialized knowledge domains or participation in out-of-school practices. In addition, when a learning experience is said to be personally authentic, it is relevant and meaningful to the student in terms of the student's interests and identity. In teaching complex environmental issues, there will likely be tensions between different authenticities, some fruitful or even necessary, others problematic. In the individual papers, aspects of authenticity, relevant to students' inquiry into complex environmental issues, are investigated. The aim of the symposium is first to explore ways of operationalizing authenticity in science classroom practices, and second to examine tensions of authenticity emerging in 1) assessment practices between aims of assessing and cultural authenticity, in 2) students' deliberation involving ethical aspects of environmental issues, and 3) students deliberations on complex issues in an educational gaming environment in tension with school and gaming authenticity.

### **SY3/1: Principles for Designing Authentic Assessment of Scientific Literacy**

*Jens Anker-Hansen & Maria Andrée*

Science teachers in Sweden are facing challenges of teaching and assessing scientific literacy reflecting civic out-of-school endeavours. From a perspective of situated cognition, assessment of students' readiness for dealing with socio-scientific issues, needs authentic open-ended tasks focusing on student performance in action. The aim of this design based research project is to develop principles for designing authentic assessment of scientific literacy. We draw on three studies conducted in co-operation with science teachers in secondary schools. Data were collected from audio and video recordings and student written work. Data were analysed from how students and teachers negotiated cultural and personal authenticity in different phases of the assessment process. The results show that the negotiations of participation and reflections of quality proved pivotal for student authentication, whereas negotiating how to value and use student participation as evidence were challenging for teacher authentication of the assessment. The results are used to discuss and develop principles for authentic assessment.

### **SY3/2: The Political Subject: Student Discussions *about* and *in* Public Issues in Science Education**

*Iann Lundegård*

This study focuses on authenticity in education and problematizes on a comprehensive level, what is meant when one talks about classroom activities as being authentic for the students or not. The study analysed excerpts from three classroom discussions which started from questions that the students themselves had formulated concerning issues related to sustainable development. It examined how the students' participation in the discussions shifted between either a distanced discussion on a factual level and / or a discussion where they took a standpoint in the issues as a "political subject", on a personal level. The result indicated that students' experience in a discussion differed depending on which question initiated it. If the questions allowed the students to distance themselves from the subject matter, then one type of content was created. If, on the other hand, the questions gave the students an opportunity to establish emotional relations to current social issues, then the content became something else.

### **SY3/3: Negotiating Authenticities in an Educational Gaming Environment**

*Erik Knain, Mette Nordby & Anne Kristine Byhring*

In this study, the complexity of environmental issues are recreated in a school science context using the educational game The Energy Game. By combining case study approaches and a semiotic analysis of students' interactions, we investigate students' negotiations between personal and cultural authenticities involved in the topic of energy use and sustainable development in the game play. The complexity embedded in the game design was construed somewhat differently by two groups of students, as they foregrounded different authenticities: the action mode of gaming practices and a more reflective and cautious mode resembling "doing school". Use of hand-outs was important in helping students to establish connections between concepts on sustainable development defined in their textbook, and the complex dilemmas experienced in the Energy Game. In earlier research on educational games it has been pointed out that allowing students to discuss and reflect on their gaming experiences is important, and also that the pedagogical frame of the gaming is just as important to student outcomes as particular features of the game. Our research supports these conclusions. Furthermore, we show how students in the same pedagogical context negotiate different authenticities afforded by learning materials.

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## **Symposium 4: Transferring Cutting-Edge Research to Out-Of-School Learning**

*Thu 5th June, 14.45-16.15, Exactum, room C123*

*Marianne Achiam (leader), Hannu Salmi (chair)*

The teaching of sciences such as geology, biology, or physics in schools is based on the research disciplines that give them their name. However, the distance between the "living science" found in research institutions and the "taught science" found in schools is often large, making taught science seem de-contextualised or obsolete. Out-of-school research institutions are ideally situated for the dissemination of cutting-edge science because they have direct access to contemporary research, they have resources to present it in efficient ways, and they can operate independently of school syllabi. We explore several aspects of out-of-school disseminations of cutting-edge science. In paper 1, Laherto et al. present an approach for creating outreach activities that present contemporary research in an authentic and scientifically sound way. Importantly, this approach entails close collaboration between the institutions that produce the science in question and the institutions that develop the activities. In paper 2, Sægrov and Frøyland argue that the structure of teaching in schools is not optimised towards conveying authentic science. They explore how an

alternative way of structuring science teaching, in school-industry partnerships, may positively affect secondary school students' motivation for working with science. In paper 3, Achiam and Johannsen examine the effects of a rapid transition of science from research to education in a museum programme for secondary school. While this rapid transition ensured that the content retained its cutting-edge nature, important opportunities related to the teaching of science-in-the-making were lost.

#### **SY4/1: Research-Based Development of Out-Of-School Learning Environments on Contemporary Research**

*Antti Laherto, Frederike Tirre, Stefan Schwarzer, Ilka Parchmann & Lorenz Kampschulte*

Out-of-school settings such as science centres and visitor labs at universities can complement formal science education in schools by offering views on authentic contemporary research. Despite the importance of such settings for science education and the increasing amount of research on out-of-school learning, the development of those environments is rarely a research-based process. Here we suggest that the Model of Educational Reconstruction (MER) might be a useful methodological framework for this. We illustrate the suggestion by presenting our research and development project dealing with two out-of-school learning environments on the emerging field of nanoscience: a student lab for visitors at the University of Kiel and a public nanoscience exhibition. In the presentation we show how research on nanoscientists' perspectives (component 1 in the MER) as well as research on students' perspectives (component 2) were taken advantage of when developing out-of-school learning environments (component 3). The dual role of those settings in science communication and science education will be discussed too.

#### **SY4/2: The Way a School–Industry Partnership is Organized Makes a Difference**

*Stig Sæggrov & Merethe Frøyland*

This is a study of a science co-operation project between schools and companies. 299 students from 22 school-industry-partnership have taken part in a survey, answering questions about how this project has affected their attitudes to working with science subjects at school and how it has affected their attitude to further science studies in the future. The various projects are grouped in three different categories, each with different guidelines as to how the project is to be implemented. The projects that are run in the Energy Schools apply a teaching model with guidelines for types of assignments, organizing of preliminary work, implementation of project work and follow-up work. The model "multiple experiences in multiple settings" builds on Teaching for Understanding (ref). The findings of this study show that if the project work is carried out in accordance with this teaching model, as it is implemented in the Energy schools, it will motivate students to make more of an effort in their science classes at school and also increase their motivation for further science studies.

#### **SY4/3: When is the Transition from Research to Education Too Fast?**

*Marianne Achiam & Bjørn Friis Johannsen*

School science differs considerably from the science of scientists. This is because in order to become teachable, science is taken from its original research context, deconstructed and reconstructed, and implemented in schools. While this transition is both necessary and inevitable, it may cause school science to become disembodied from its purpose or even obsolete. Accordingly, we suggest that museums are ideal places for the dissemination of cutting-edge science because

they are not bound to school syllabi, they have immediate access to contemporary research, and they are already established as out-of-school resources. To examine this issue, we studied the museum programme DNA and Life that intended to engage secondary school students in authentic, cutting-edge research. Through observations, video recordings, interviews and questionnaires with eight participating classes, we identified characteristics of the programme that contributed to the authenticity of its activities, and also characteristics that detracted from it. We discuss these characteristics with regard to the rapid transition of the programme's content from the world of science to the world of education.

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## **Symposium 5: Finnish-USA Collaboration in STEM Education R&D: the Science of Learner Engagement**

*Thu 5th June, 10.45-12.15, Exactum, room B119*

*Eric Hamilton & Jari Multisilta (chairs)*

This symposium introduces a new network of eight research and development projects that bilateral teams of Finnish and US investigators carry out under support from Tekes and the Academy of Finland and the National Science Foundation (NSF). The network is referred to by the funding agencies as "Science Across Virtual Institutes" (SAVI). Although each bilateral team focuses on different R & D goals, all share interest in the areas of learner engagement in science, technology, engineering and mathematics (STEM) learning. The objectives of this paper are to introduce the SAVI; outline the framework for learner engagement taken by each project; and present a prospectus for future empirical and theoretical research. This Nordic Research Symposium 2014 proposal outlines the rationale for this effort, including methodological approaches for measuring engagement. It closes with an introduction to two key elements of the research prospectus.

### **SY5/1: Engagement in Inquiry-Based Learning with Mobile Videos**

*Jari Multisilta, Veera Kallunki, Johanna Ojalainen, Johanna Penttilä, Ariel Liu, Kareem Edouard & Roy Pea*

In the Video Inquiry Project (VIP) a teaching approach of using pupils' own video recordings as a part of learning STEM subjects at school is developed. In this design-based research pupils record videos as a part of their learning process both in formal and informal settings. The recordings will be uploaded to the MoViE platform where pupils can edit videos, add annotations and comment others' videos. The video recordings can also be joined together to form longer video stories. In this way, sharing and learning together are on the focus of the project, which is suggested to increase pupils' engagement of learning STEM subjects.

### **SY5/2: Students' Situational Engagement in Finnish Science Classrooms**

*Janna Linnansaari, Jaana Viljaranta, Kalle Juuti, Jari Lavonen & Katariina Salmela-Aro*

In order to inspire students to learn science, and to solve a problem with decreasing number of students who are engaged in science learning, we focus on the concept of engagement in an authentic science classroom situation. To have a better understanding of this phenomenon, 110 students (44 girls, 66 boys) at 9<sup>th</sup> grade of comprehensive school and first year of upper secondary

school participated in the study in the spring 2013. In order to receive information of engagement right away when it occurs, smart phones and Experience Sampling Method (ESM) – questionnaire were used for data gathering. Smart phones were adjusted to make a signal in every science lesson and otherwise randomly during the day (from 8AM to 8PM). The data collection included also background questionnaire which students were advised to fill before the actual data gathering period. The results have shown that Finnish students have high level enjoyment, self-conception and appreciation of the subject in science lessons. The results for students' situational engagement revealed four factors: *positive commitment*, *skills and control*, *excessive demands* and *importance of the subject*. Using these dimensions engagement in science lessons is compared to engagement in other lessons.

### **SY5/3: How Should We Measure Engagement in Science? Comparison of Four Established Scales**

*Julia Moeller, Jari Lavonen, Katariina Salmela-Aro & Barbara Schneider*

This presentation shows and discusses findings from the EAGER project, which is one of the SAVI projects and investigates engagement in science subjects among Finnish and U.S. American high school students. The previous research on engagement in schools has applied diverse definitions and measures of engagement. These definitions and measures overlap in many parts, but also differ from each other in many aspects. This has led to some confusion among researchers, because due to these terminological ambiguities, it is often unclear what exactly is meant when the term engagement is used. In order to systematize the usage of the term, several review papers have compared different definitions of engagement. In contrast, systematic empirical comparisons of measures of engagement are lacking. Therefore, this presentation compares several established measures of engagement in terms of their sources of variance. Two cross-situational measures of engagement are compared with each other and with two situation-specific measures of engagement in science lessons which were assessed with Experience Sampling Methods (ESM). On the cross-situational side, we compare the PISA scales for science engagement with the Schoolwork Engagement Inventory (Salmela-Aro & Upadaya, 2012). On the situation-specific side, we compare the engagement measure applied by Shernoff & Vandell (2007; defined as composite of the experiences concentration, enjoyment, and interest) with a measure applied by Schneider et al. (2013; defined as composite of the experiences of feeling skilled, challenged, and interested). We show to what extent the cross-situational measures of engagement predict the in-the-moment experiences. Finally, taking a look on the measure-specific sources of variance, we will report eventual differences between the four measures in terms of country (Finland versus U.S.), gender, and science subject (Physics, Biology, and Chemistry).

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## **Symposium 6: The Icelandic NaNO Programme for Science Education in the 21st Century**

*Thu 5th June, 14.45-16.15, Exactum, room C124*

*Allyson Macdonald (chair)*

Cooperation between teachers and scientists in adapting 21st century science to 'school science' can prove both fruitful and problematic. Ethical and controversial issues need to be tackled and the level of prerequisite knowledge for pupils to understand the content varies. The NaNO programme is funded for three years by the University of Iceland and focuses on upper and lower secondary level and is one of several initiatives to improve science education in Iceland. NaNO staff at the

School of Education cooperate with other specialists in designing and supporting courses, a resource bank, Science Plaza (Náttúrutorg) a community of science teachers and meetings (EduCamps) for teachers to exchange ideas. In this symposium we critically analyse some of the early developments (2013-2014) in the NaNO programme. A design-based research approach is being used to identify learning demands and the development of teaching sequences, drawing on place-based pedagogy and communities of learning to create a space in which the participants can work. Data was collected with a mixed methods approach, participant surveys, analysis of class discussions and interviews along with analysis of the resources collected. NaNO staff will discuss the development of two modules, one on nanotechnology and the other on climate engineering, as well as the support being provided for the community of science teachers.

### **SY6/1: Science Plaza – Professional Development in an Online Habitat**

*Svava Pétursdóttir*

Science Plaza is a project started to meet the need of science teachers for peer support and continuous professional development. The project consists of an online community on Facebook where science teacher meet to exchange knowledge and experience; a website with resources and a series of workshops and EduCamps. An evaluation of the activities shows that the project has provided science teachers with peer support and access to knowledge and expertise that teachers regard as valuable for their practice.

### **SY6/2: Challenges in Educating Scientifically Literate Citizens: The Case of Nanoscience**

*Ester Ýr Jónsdóttir, Svava Pétursdóttir & Birgir U. Ásgeirsson*

How do we educate scientifically literate citizens using nanotechnology as a scaffold? Designing a course including well-chosen topics that are diverse and different but still linked together by many of their basics is important if we are to succeed. Here we describe how the course Science in the 21st century was designed using a design-based research approach. Data is being collected with a mixed methods approach and the course is still under evaluation and will be redesigned after this first semester. The intention is to offer separate modules as in-service training to schools.

### **SY6/3: Learning to Teach Climate Engineering in Secondary Schools**

*Birgir U. Ásgeirsson, Ester Ýr Jónsdóttir, Svava Pétursdóttir & Allyson Macdonald*

Scientific topics in the 21st century are interdisciplinary and complex. Many teachers are not prepared to teach about and discuss controversial socio-scientific issues like climate engineering with students. A climate engineering module in the course Science in the 21st century at the University of Iceland, School of Education, was designed where the approach is drawn on design-based research. Results are based on data from interviews, recordings from classes, online discussions and material prepared by participants. Preliminary results indicate an increase in participants' motivation and interests during the module. Also, results indicate some issues of concern. First, a gap in vocabulary used by specialists when talking to teachers and second, specialists do not realise the knowledge level of teachers they work with. This raises questions on how to approach continuing education for science teachers on controversial socio-scientific issues of the 21st century like climate engineering. A way forward seems to be to enhance the dialogue between specialists and teachers when aiming at a sustainable society.

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## **Poster presentation session P1**

*Thu 5th June, 10.45-12.15, Exactum lobby*

### **PO3/1: Kjennetegn på lærerstyring og faglig produktivt elevsnakk under utforskende praktisk aktivitet**

*Stein Dankert Kolstø*

Forskning finner mindre faglig elevsnakk i naturfagstimer enn ønskelig, samtidig som bruk av språk regnes som et grunnleggende redskap i læring. I denne studien undersøkes kjennetegn på elevsnakk i timer med utforskende arbeidsmåter i situasjoner som kombinerer styring og åpenhet. Basert på tilgjengelighet ble det samlet inn videoopptak fra fire grupper og samlet klasse fra fem naturfagstimer knyttet til et opplegg i bevegelseslære. Data ble analysert kvalitativt med den konstant sammenliknende metode. Resultatene viser bruk av beskrivende språk, blandingsspråk og begrunnende bruk av naturfaglige måter å forklare og å bruke språk på. Analysen viser at elevenes språk fokuserte på ulike aspekt ved forsøk og data gjennom arbeidsøktene. De viser også at språket hos mange gjennomgikk en endring fra beskrivende til mer forklarende språkbruk. Det viktigste funnet i studien er påvisningen av at hybriditeten i elevenes blandingsspråket beveget seg mot økt naturvitenskapelig autensitet parallelt med utfordrende veiledning og krav om forklaring av problematiske data.

### **PO5/1: Green Environment Education European Network**

*Paul Strehlenert*

Climate change represents one of the greatest environmental, social and economic threats facing the planet. Today's teenagers will be forced to address the issue and need to learn to live sustainably in order to counteract climate change and subsequent environmental problems. Schools can play a central role in providing young people with information and knowledge to help them understand climate change as early as possible. Apart from setting-up a sustainable European network, GREEN aims to integrate climate change related topics sustainably into (science) education in schools; promote teacher training on climate change education: basic concepts, trends and issues, educational implications of teaching about climate change etc.; foster the European exchange and transfer of experiences and good practices on climate change education among education institutes, teacher trainers, teachers, practitioners, NGOs and young people; identify learning materials, good practices and teaching and learning strategies on climate change education and enhance their dissemination through the GREEN platform and other means; increase the production of and access to information and innovative solutions for science education on climate change and sustainable development; promote closer linkages between science education and science working market emergent trends and opportunities.

### **PO5/2: The Use of Professionals as Guest Teachers to Create Interest for Science**

*Egil Olsen*

Science and Math are important subjects for any one in a modern society, but in school they are often looked upon as very theoretical and hard to access. To make the two subjects more easily accessible, one approach, which we have pursued, is to make the teaching more applied. We have

done this by involving professionals directly in the teaching of students. Teaching program is developed through collaboration between the teacher and the professional. Preliminary evaluation of the effect on the students is based on a questioner to be answered by the students. The results indicate a positive effect on students' interest in the subjects and their motivation to pursue them.

### **PO6/1: Student Science Performance on Process Items Compared to Knowledge Items**

*Ross Hudson*

Assessment items in science have traditionally focused on science knowledge. However, since literacy has become more important in science teaching and as a result science assessments have introduced a larger range of items that are able to assess science investigative skills and science understanding as well as science knowledge. This in no small part can be attributed to the influence assessments such as PISA and to a lesser extent programs such as the TIMSS. The shift towards investigative or science process items raises the question of how this change will affect student performance. This research explored a series of large scale international population tests (International Benchmark Tests; IBT), that used instruments containing a balance of both science process and knowledge items. The instruments were administered to nearly 22,000 students, both primary and secondary aged. Rasch DIF analysis and correlation analysis showed little difference between the performances on the two item types. The conclusion from this study suggests that regardless of the students' ability they will perform equally well on science items regardless of whether the items have a process or knowledge focus. This result though somewhat surprising suggests that students are not disadvantaged by the changing focus of different questions

### **PO7/1: Validation of Scientific Imagination Theoretical Model: A Rasch Measurement Approach**

*Hsiao-Chi Ho & Chia-Chi Wang*

The study aims to validate the Scientific Imagination Theoretical Model (SITM) through the Rasch measurement. The SITM illustrated three crucial factors in the process of scientific imagination, including personality, picture in mind and surroundings. Participants were 1765 elementary and high school teachers recruited from Kaohsiung and Pingtung City in Taiwan. The Teacher Scientific Imagination Scale (TSIS), General Self-Efficacy Scale (GSS) and Runco Ideational Behavior Scale (RIBS) were administered to the participants. Multiple dimensional Rasch techniques were applied to assess model-data fit, provide the multiple validities evidences of the TSIS. The results indicated that TSIS exhibited good mode.

### **PO11/1: Supporting Pre-Service Chemistry Teachers in Technology-Enhanced Inquiry**

*Simo Tolvanen & Maija Aksela*

Data-logging technology can be used to support students' learning during inquiry activities. However, learning to conduct technology-enhanced inquiry activities is difficult for teachers. Pre-service chemistry teachers require support with both developing their own inquiry skills and learning to use the supporting technology. This poster presentation offers a model for chemistry education course designed to enhance pre-service teachers' skills in technology-enhanced inquiry teaching. Design-based research methods are used. Based on empirical problem analysis and on suggestions from literature, model for the course was designed. The model was then tested to evaluate the effectiveness of the design solution. Data was generated via a questionnaire and

observation of course participants, who include 21 pre-service teachers. Analysis of the data was continuous. Based on the analysis, a model will be proposed for the course.

### **PO11/2: Teacher Students' Experiences from Nordic Exchange – The ALKA Project**

*Mats Lundström, Anne Pellikka & Anja Gabrielsen*

This paper discusses students' perceptions from one international exchange; the Nordic network ALKA. The network organizes an intensive course week every year. The purpose was to make a pilot study about how students use the subject content and network connections established during the ALKA intensive course week in their teaching. A questionnaire was sent out to 22 former teacher students that have participated in the course during 2010–2013. All informants are very satisfied with the course content, the experiences from the intensive course and the contacts established during the course. However, none of the participants express that the intensive course have generated in co-operation with some of the colleagues from other countries. Instead, all of the participants in the study have used the course content in their teaching or teacher training. The meeting with new landscape, animals and plants has been used in geography or biology lessons. Also the didactical discussions during the course have inspired some of the students in their teaching. Particularly the out-door education situations have inspired the teacher students to move their science lessons outside the classroom

### **PO11/3: Preparing New Science Teachers for Promoting Student Engagement**

*Shirley Simon & Paul Davies*

Increased student engagement in science has positive effects on perceptions of science, academic achievement and the continuation of studying science after compulsory school. This study reports on initiatives in an initial teacher education (ITE) programme to support pre-service teachers (PSTs) in developing approaches that foster student engagement and motivation. The study involves a critical examination of three initiatives that aim to support the PSTs' acquisition of skills and approaches for promoting student engagement. It includes an analysis of the literature to establish theoretical principles that underpin the potential effectiveness of the initiatives and of how they are integrated into the programme. The study also includes a survey of PSTs to establish their views of which experiences promoted students' interest in science; the results show that these are – using technology, providing challenge and having relevance to students' lives. The study reveals the importance of theoretical considerations in education design and its potential impact on future teachers.

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## **Poster presentation session P2**

*Thu 5th June, 13.00-14.30, Exactum lobby*

### **PO8/1: Students' Motivation toward Practical Work in Physiology Education**

*Niels Dohn*

The laboratory has been given a central and distinctive role in science education. In tertiary physiology education, although time consuming and expensive, educators report that laboratory work motivate students. However, very little empirical evidence based on motivation theory seems to exist. The purpose of our research is to investigate how students view the laboratory work in terms of experienced interest and role for learning, as well as their willingness to engage (effort) and self-reported confidence in understanding (self-efficacy). First-year biology students (n = 132) from a university physiology course responded to a questionnaire with open and closed items on relevance of laboratory work, interest, effort, and self-efficacy. The outcome is correlated to academic performance (exam results). Implications for physiology education will be highlighted

### **PO8/2: Motivation, Self-Image and Developmental Tasks Influence Students' Science-Related Career Choice**

*Nina Bertels & Claus Bolte*

We examined in which way chemistry lessons influence students' intended career choice. Based on different theoretical approaches we are interested in answering the following question: Are the variables motivational learning environment, developmental tasks, self-to-prototype matching and self-concept connected to the career choice? For this purpose we developed a questionnaire which includes the variables motivational learning environment, self concept, self-image and prototypes and developmental tasks. The questionnaire was given to students of German schools (Hauptschule) and trainees of the chemical industry. A regression analysis showed that the variables partly influence the choice of career.

### **PO8/3: Occupational Orientation in Chemistry-Based Learning Environments**

*Michael Albertus & Claus Bolte*

The research presented in this paper summarizes the German project Science Career and Science Navigator (CSN). This project ties in with previous studies which indicate that it is necessary to include occupational orientation more strongly into science education. For this purpose, the CSN project developed a specific conception of learning environments. These learning environments are implemented into practice and then evaluated with the help of a questionnaire based on a career choice model which has proven useful in earlier research. The CSN intervention was able to bridge the gap between chemistry education and the area of occupational orientation. It thus contributes to supporting young people in finding a meaningful perspective for their lives. Additionally the CSN conception offers a way to make science lessons more attractive to young people by directly referring to the students' everyday and future life.

### **PO8/4: Multimodal Presentation of Student Laboratory Work: Comparison with Traditional Laboratory Reports**

*Johanna Lundström, Fouzieh Hassankhali & Maud Ragnarsson*

Experimental work and student's analysis thereof is a major source to teachers about student learning. Written reports are commonly assessed and constitute a significant part of the information that teachers use to grade students. The present study reports on a teacher initiated attempt to a) utilize multimodal presentation techniques in laboratory reports b) identify criteria for student learning in the multimodal form. Effective expressions and the use of informal language were identified to be significant indicators of learning. These affective parameters cannot be identified in formal written laboratory reports. In conclusion multimodal laboratory reports may provide a useful

tool to enhance learning and provide a useful platform for formative assessment. We also provide limited data showing that multimodal laboratory reports are inferior or at best equal to written lab-reports in summative grading of individual students performances.

### **PO12/1: What Brings Brand-New Topics and Subjects into Established Science Curricula? – Enlightened by Two Norwegian Cases**

*Pål J. Kirkeby Hansen*

The Knowledge Promotion Reform in 2006 brought Technology and design and Geosciences as brand new topic and subject into science curricula. This study sheds light on how that could happen and how individual persons influenced the curricular processes. Documents, notes from the processes, written comments and interviews of the most central persons in the curricular groups are analysed. In both cases the initial idea came from the top-leader of a big and reputable organization. Both had a vision of the “need” for something “brand-new” in the school to bring technology and science education and recruitment forward. The executive leaders of the curricular processes were dedicated and charismatic. Their groups were enthusiastic and loyal, but also critical partners. Lobbying key persons in Ministry and Parliament was essential for bringing Technology and design through because this was a “bottom-up” project from an organization outside school politics. Geoscience was a “top-down” project from Education Ministry. The mentioned common features could be crucial for bringing brand-new topics and subjects into science curricula. The two cases had also some quite different features: One being “bottom-up”, developing over ten years, involving very many persons. The “top-down” project was developing over less than two years, involving only a handful of persons. In both cases some individual persons had a substantial influence on the resulting curricula.

### **PO14/1: How to Teach Science Creatively? Construction of SIMST Model**

*Chia-Yu Liu & Wei-Wen Lin*

Since the variation of science teaching situation, instructional innovation is more important. However, while they know the importance and benefits of instructional innovation, novice teachers often face the difficulty of developing their own creative teaching practice in their careers. If they were scuffled by a model which aims at developing an innovative teaching program, their creative teaching behaviors could be more efficient, and students could benefit from their teaching. Hence, the purpose of this research project was to construct a Systematic Innovation Model for Science Teaching (SIMST). Nine Taiwanese creative science-teachers were interviewed and the verbatim and their creative science-teaching designs were analyzed. We adopted the pattern of the Theory of Inventive Problem Solving (TRIZ) (Altshuller, 1997) to develop SIMST’s matrix and inventive principles. Results showed that SIMST contains seventeen inventive principles (e. g., multiple assessments, connect teaching to daily life, group creativity, and interdisciplinary connections) to deal with different dilemmas and difficulties which novice teachers often encountered in their careers. This model could be a useful tool for novice teachers and other teaching groups, reducing their frustration brought by the exhausting trial-and-error process and facilitating the development of creative teaching behaviors.

### **PO14/2: Is It Useful Students’ Wrong Answers for Designing Learning Experiences?**

*Fulya Oztas*

The transition to conceptual understanding often sounds simple, but reality it presents significant challenges in theory and in practice. The aims of science teaching are simply creating an understanding of major concepts within a scientific discipline. During this procedure mostly students can be considered beginning with a little knowledge, awaiting the accept of present scientific understanding. In fact the finding out what students already know and, what they do not know, what they are confused about is hard issues for teachers and instructors during education period. In this point it could be vital point to sort out explore key ideas associated with teaching for understanding, including conceptual change, the role of alternative conceptions, and practical implications. An explicit confrontation between pre knowledge and new knowledge is the critical element in teaching toward understanding. In other words, students may have multiple and layered explanations of a single concept, the complexity of which may not surface in response to an assessment strategy that requires only that students have memorized the right answer. Perhaps for this reason, use of concept mapping at regular intervals is a popular method for documenting and understanding students' knowledge frameworks and how they may or may not grow in structural complexity. In biology education explicitly uncovering and addressing students' prior and alternative conceptions is essential if students are to integrate new ideas into existing conceptual frameworks about how the natural world works as a result of instruction. The understanding the students 'wrong answers nature in designing learning experiences and assessments may add more vulnerable assessment for development of a framework for making sense of the prevalent alternative conceptions that students harbor.

#### **PO16/1: Exploring Web Design Principles for Joint Meaning-Making in Health-Related Issues**

*Jonna Wiblom, Carl-Johan Rundgren & Maria Andrée*

Beginning with an overview of different aspects of scientific literacy in relation to an expanding media landscape, this poster proposes a broader definition of the concept of scientific literacy, also including scientific media literacy. The aim of the poster is to formulate and test a number of design principles for creating meaningful online learning situations in science education relating to health-related issues. The principles are characterized by collaborative problem-solving, informal mentorship, online interactions and working with as authentic and up to date topics as possible, e.g. socio-scientific issues. Through the joint creation of a web-based platform for participation in health-related reasoning, both Swedish upper secondary students and their science teachers are involved in the meaning-making process. Data will consist of audio recordings of students' reasoning during media production, uploads on the website (e.g. texts, images and wiki-threads) dealing with health-related dilemmas. The results from a pilot study will be presented and discussed, focusing on an evaluation of the design principles.

#### **PO16/2: Interdisciplinary Learning and Collaboration through Exploration of Claims from Food and Cooking**

*Erik Fooladi & Anu Hopia*

Science communication is today seen more as transaction between different stakeholders rather than one-way transmission of knowledge from academia to society and the relationship between academic institutions and various stakeholders is more relaxed and interactive than ever before. This change has generated new challenges such as desire for new approaches and tools for science communication. The project described herein represents an effort towards these challenges by using everyday matters, more specifically claims and specifications from cooking procedures, to stimulate inquiry and science learning (e.g. "one cannot make jelly containing fresh kiwi because then the jelly will not set"). The project spans a number of educational levels including

life-long and informal learning, as well as interdisciplinary scientific collaboration. This is sought accomplished within a network including not only pupils/students, science teachers, teacher educators and educational researchers, but also food devotees, professionals with interest in food, cooking and culinary heritage, researchers from various disciplines and so forth. Examples are given from formal education and informal learning contexts. Theoretical aspects including epistemic perspectives and the role of science in education and society are discussed. Also, prospects are outlined for learning, research and collaboration in the interplay between sciences, people's everyday lives and society.