Conference Book

EDUCATING THE EDUCATORS

2nd conference on international approaches to scaling-up professional development in maths and science education

7-8 November 2016
Freiburg, Germany

www.mascil-project.eu

University of Education Freiburg 2016

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Contents

Welcome by the Conference Chairs

Educating the Educators II

International approaches to scaling-up professional development in maths and science education

It is a great pleasure for the hosts, the European project mascil (mathematics and science for life!) and the DZLM (German Centre for Mathematics Teacher Education, funded by the Deutsche Telekom Foundation), to welcome you to the second Educating the Educators conference.

Educating the Educators II follows on the great success of the first conference we hosted on this topic in December 2014 in Essen, Germany in which almost 200 researchers, policy makers and practitioners participated.

This second conference serves as a researcher-practitioner platform for exchange focusing on research, policy and practice relevance and implications. Next to high-level keynote speakers, presentations by researchers and practitioners, a Materials Market, and an Early Career Researcher's Day the conference will also feature a company visit to reflect innovation in STEM education in the industrial context, a Policy Seminar and host a meeting of the Network of European STEM Professional Development Centres.

As the Conference Chairs we would like to thank the countless people, not least the DZLM and mascil project partners, the conference board members and all organisers, who have helped in planning and realizing this conference and who have contributed their wit, energy, commitment and time to make it the successful conference experience we wish every participant to have.

We hope you will enjoy Educating the Educators II and we look forward to insightful sessions and fruitful exchanges!

The Conference Chairs:

Katja Maaß, mascil | University of Education, Freiburg, Germany

Susanne Prediger, DZLM | TU Dortmund University, Germany

Diana Wernisch, mascil | University of Education, Freiburg, Germany

Foreword of the Rector

Dear conference participants,

I cordially welcome you to our institution, the University of Education Freiburg, and I am delighted that our call to participate in the *Educating the Educators* conference has brought you to Freiburg this year.

We are proud to have established *Educating the Educators* as a conference series in cooperation with the DZLM over the past years in the course of our work within the FP7-project *mascil*, mathematics and science for life!.

The project *mascil* is coordinated at the University of Education Freiburg and implemented together with a large group of renowned universities and stakeholders from policy and practice. The University of Education is a specialized university focusing on research, teaching and training the next generation of education researchers, and teaching and learning professionals. Through the Freiburg Advanced Center of Education (FACE) the University of Education Freiburg also joins forces with the University of Freiburg in delivering teacher education of the highest quality.

mascil is one of our research and development projects that fit into our profile of having a strong international outlook and role in improving scientific knowledge and school practices in the area of STEM (science, technology, engineering and mathematics) education. Successful international collaboration in European projects and a strategic focus on linking research and development in STEM education with dissemination and transfer (for example through in-service training of teachers) have in the past years established our university as a significant research centre and disseminator of innovative practices in STEM education. With the instigation of the new International Centre for Innovation in STEM Education at our institution, 2016 marks another step forward in this line of our work.

I would like to thank Prof. Dr. Katja Maaß and her team for the engaged work in building and strengthening these activities at our institution and internationally. Without our international partners we could never have been as successful. I therefore wish to take this opportunity to thank them for their collaboration and trust that we can strengthen our ties even more in future joint projects. In establishing Educating the Educators, our cooperation with the DZLM (German Centre for Mathematics Teacher Education, funded by the Deutsche Telekom Foundation) has been invaluable and we hope to continue this fruitful collaboration also in the future. Last, not least, I also wish to thank the Gisela und Erwin Sick Stiftung for a very generous donation supporting the conference.

I wish you a pleasant stay in Freiburg and a thriving conference experience!

Cordially,

Ulrich Druwe
Rector, University of Education Freiburg

Conference Hosts

mascil — mathematics and science for life!

Project mascil (www.mascil-project.eu) has received funding from the European Union's Seventh Framework Programme. During the four-year mascil lifetime (2013 – 2016), 18 partners from 13 countries are working together to achieve project goals.

Our aim is to promote a widespread use of inquiry-based teaching and learning in primary and secondary school science and mathematics classrooms. In addition, a key mascil focus is connecting mathematics and science education to the world of work. When doing inquiry-based tasks, students work like scientists and in the process, acquire competencies they need for their future professional and personal lives as active citizens.

In order to implement inquiry-based teaching and connect mathematics and science education to the world of work, mascil follows a holistic approach by carrying out a variety of activities, including the development of high-quality, innovative materials and running professional development courses. Vocational educational teachers and industry representatives support the professional development courses for pre- and in-service teachers. Within the mascil concept, IBL-trained teachers become mascil multipliers who in turn, offer courses to other teachers. Depending on the national context, we accomplish this aspect by supporting our courses through e-learning. The mascil national and European advisory panels are comprised of stakeholders charged with providing expert advice to the partners and are invaluable in supporting a maximized impact of the project in the countries across Europe. mascil also organizes workshops and publishes policy papers to inform and work with policy makers in order to improve education.

mascil is coordinated at the University of Education Freiburg and implemented in collaboration with partner universities and institutes in thirteen countries: Foundation for Research and Technology Hellas (Greece), Utrecht University (The Netherlands), University of Nottingham (Great Britain), University of Jaén (Spain), University of Nicosia (Cyprus), National and Kapodistrian University of Athens (Greece), Norwegian University of Science and Technology (Norway), Leibniz Institute for Science and Mathematics Education Kiel (Germany), Babes-Bolyai University (Romania), University of Hradec Králové (Czech Republic), Divulgación Dinámica SL (Spain), Hacettepe University (Turkey), Vilnius University (Lithuania), University of Innsbruck (Austria), Goethe University Frankfurt (Germany), Bulgarian Academy of Science (Bulgaria).

DZLM — German Centre for Mathematics Teacher Education

The German Centre for Mathematics Teacher Education (DZLM, www.dzlm.de) is Germany's first nationwide centre providing teacher training in mathematics and is funded by the Deutsche Telekom Stiftung (www.telekom-stiftung.de). The DZLM focuses on developing long-lasting, continuing professional development programmes for multipliers that are research-based and practically relevant. These multipliers are teachers themselves (from pre-, primary and secondary schools) who in turn, offer PD courses, advice and support to other teachers, e.g. by supervising professional learning communities. The DZLM also provides professional development courses and materials that target specific types of teachers and their educators, e.g. educators who teach mathematics out-of-field, i.e. outside their specialty area, as well as pre-school teachers. All courses are continuously improved based on empirical evidence and disseminated at a large scale.

Eight universities are involved in the consortium: The Humboldt-University Berlin, Free University Berlin, University of Bochum, TU Dortmund University, the University of Duisburg-Essen, the University of Potsdam, Paderborn University and the University of Education Freiburg. In addition, the DZLM cooperates with further partners in the fields of mathematics, mathematics education and educational research, as well as the educational institutes of the different federal states.

Conference Committees

Conference chairs

Katja Maaß (mascil | University of Education, Freiburg, Germany)

Susanne Prediger (DZLM | TU Dortmund University, Germany)

Diana Wernisch (mascil | University of Education, Freiburg, Germany)

Organisation committee

Elena Schäfer (mascil | University of Education, Freiburg, Germany)

Thomas Lange (DZLM | Humboldt University Berlin, Germany)

Kim-Alexandra Rösike (TU Dortmund University, Germany)

Programme committee

Bärbel Barzel (DZLM | University of Duisburg-Essen, Germany)

Karen Reitz-Koncebovski (mascil | University of Education Freiburg, Germany)

Bettina Rösken-Winter (DZLM | Humboldt University Berlin, Germany)

Marta Romero Ariza (University of Jaén, Spain)

Ragnhild Lyngved Staberg (University of Science and Technology, Norway)

Vincent Jonker (Utrecht University, Netherlands)

Committee for the Early Career Researchers' Day

Susanne Prediger (DZLM | TU Dortmund, Germany)

Michael Besser (University of Education Freiburg, Germany)

Kim-Alexandra Rösike (DZLM | TU Dortmund, Germany)

Katja Maaß

Diana Wernisch

Elena Schäfer

Zofia Malachowska

Anika Weihberger

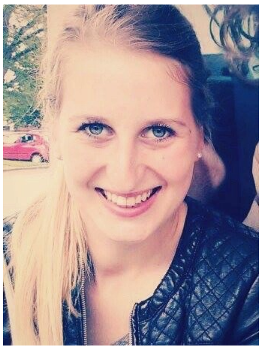
Karen Reitz-Koncebovski

Student Assistants

Theresa Gründler

Phaina Koncebovski

Franziska Bertram



Lisa Mayerhofer

1. 5th meeting of the European STEM PD Centre Network

Monday, 7 November 2016, 09:00-12:00, KA 106

(Internal meeting by invitation only)

In 2014, the first conference on "Educating the educators - International approaches to scaling-up professional development in maths and science education" served as a platform for connecting Professional Development (PD) centres across Europe: in the course of the conference the first meeting of European Professional Development centres involved in math and science education took place. Hosts of the conference as well as of the first PD centre meeting were the European project mascil (mathematics and science for life!) coordinated at the University of Education Freiburg, and the DZLM (German Centre for Mathematics Teacher Education, funded by the Deutsche Telekom Foundation).

The European STEM Professional Development Centre Network grew out of the idea that these national centres should be connected and work together at the international level since have similar aims and agendas, namely: investing in teacher professional development to substantially improve STEM education as it happens day-to-day in schools. Despite different national circumstances, foci and structures the national PD centres across Europe encounter similar concerns and challenges. Therefore, bringing together and connecting these centres seems essential. This will ensure knowledge exchange to improve local practices in STEM professional development as well as strengthen the voice of practice when it comes to shaping innovation in STEM education in Europe.

Owing to the resonance the first meeting, now, two years later, the network organizer are pleased to host already the 5th meeting of these professional development centres.
In addition, we are very happy to announce that the network now received funding and is based on an Erasmus project called STEM PD Net. This is a next essential step to set up, promote and strengthen the network, its aims and activities. By now, the network consists of more than 20 STEM professional development centres and other organisations with similar aims and foci like educational authorities or Ministries of Education from 13 European countries. The University of Education Freiburg who has acquired a renowned standing in Europe in the field of promoting innovative practices in STEM education serves as the Network Coordinator.

More information on the participants and results of previous meetings and planned future meetings, as well as on our future aims and activities on the network website:
www.ph-freiburg.de/international/STEM-PD-Centre-Network

2. Policy Seminar

Tuesday, 8 November 2016, 10:00-13:00, KA 106

(Internal meeting by invitation only)

Strengthening collaboration between research, practice and policy is one of the main intentions of the "Educating the educators" conference. Therefore, national and European policy makers are invited to the Policy Seminar to collaborate with STEM educators, researchers and practitioners, in particular representatives from teacher associations and the fledging PD Centre network. The Policy Seminar is part of the "Educating the educators" conference and is to be held on 8 November, 2016. Its topic is “Scaling-up STEM teacher professional development: Overcoming challenges through a research-policy-practice dialogue”. The main aims are to

- Present the latest research on teacher professional development and its scale-up: Effective models, key principles and discussion on implementation, shortcomings and challenges in the European context.
- Discuss recent trends and innovations in Europe: The work and experiences of newly established STEM PD Centres; scope and focus of the European PD Centre network initiated by project mascil and ways to further strengthen the voice of practice at all levels.
- Propose action to overcome challenges to scaling up STEM teacher professional development by drafting “next steps in Europe! – on the basis of mutual exchange between policy makers, researchers and practitioners.

The seminars workshop format will ensure that every participant will leave the seminar with concrete ideas on improving STEM teacher education and professional development at the local or European level.

3. Keynotes: Abstracts and Speaker Information

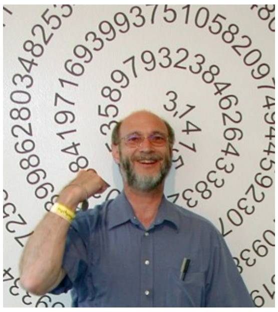
Keynote 1: What Counts in Professional Development, and Can We Conduct PD at Scale?

Alan Schoenfeld
Professor at the University of California, Berkley, United States of America
Monday, 7 November 2016, 13:30-14:30, Aula

There are at least two major challenges in building professional development programs intended to support large numbers of teachers. The first is the question of what teachers should know, in order to be able to help students become effective mathematical thinkers and problem solvers. The second is the question of how to go to scale – how to create opportunities for large numbers of teachers to experience the kinds of support that will make a difference.

In this talk I present a theoretical framework for professional development, called Teaching for Robust Understanding (or, TRU). I argue that there are five dimensions of importance when examining learning environments. All five dimensions are important, in that any one is lacking, students will not learn well; and all five together are sufficient to produce powerful learning. The challenge, then, is to find ways to help large numbers of teachers develop the relevant skills and understandings. This is made more complex by the fact that different nations have different forms and traditions of professional development. I will discuss ways in which TRU can be used to build professional learning communities and go to scale, even in different cultural contexts.

Biography



Alan Schoenfeld is a Professor of Education and Mathematics at the University of California at Berkeley. He is a Fellow of the American Association for the Advancement of Science and of the American Educational Research Association (AERA), and a Laureate of the education honor society Kappa Delta Pi; he has served as President of AERA and vice President of the U. S. National Academy of Education. He holds the International Commission on Mathematics Instruction's Klein Medal, the highest international distinction in mathematics education; AERA's Distinguished Contributions to Research in Education award, AERA's highest honor; and the Mathematical Association of America's Mary P. Dolciani award, given to a pure or applied mathematician for distinguished contributions to the mathematical education of K-16 students.
Schoenfeld has written, edited, or co-edited more than two hundred pieces on thinking and learning, including twenty-two books. His most recent book, How we Think, provides detailed models of human decision making in complex situations such as teaching. His current R&D projects involve understanding and supporting teaching that produces students who are powerful thinkers.

Keynote 2: Teachers professional development: Lessons learnt from a large-scale German PD programme

Olaf Köller
Professor at the Leibniz Institute for Science Education, Kiel, Germany
Tuesday, 8 November 2016, 9:00-9:45, Aula

Findings from international large-scale assessment like TIMSS initiated many reforms in the German school system. One of the most prominent reforms was the so-called SINUS-project (Initiative to improve the quality of teaching in math and science) which started at the end of the nineteen-nineties in secondary schools and was then (starting in 2004) continued in primary schools. Based on scientific knowledge from educational research, SINUS strived to enhance teaching quality by initiating teacher collaboration in schools. Particularly the SINUS program in primary school (comprising approx. 900 schools) was intensively evaluated using a multi-method approach with teacher and student questionnaires, classroom videos, interviews, document analyses, and achievement tests. Qualitative content analyses of documents delivered by schools provide information of implementation quality which differed substantially among schools. With respect to achievement, 80 SINUS schools participated in the national assessment study in 2011. The data allows a comparison of SINUS students at the end of grade 4 and their classmates from a nationally representative sample. Using propensity score matching, effects of SINUS on students' math and science competencies were analyzed. Findings suggest that after controlling for many student and school characteristics, SINUS students outperformed their classmates at regular schools. The difference, however, was quite small (d = 0.20), indicating that school reforms take very long time to have (small) effects on student outcomes.

Biography

Olaf Köller is currently director of the Department of Educational Research at the Leibniz Institute for Science and Mathematics Education (IPN), IPN's scientific managing director, and full professor of educational research at the University of Kiel, Germany. Till September 2009, he was founding director of the German Institute for Educational Progress at Humboldt University, Berlin (IQB). After graduation in psychology in 1991 he started his scientific career at IPN. In 1996 he changed to the Max Planck Institute for Human Development, where he finished his dissertation (Ph.D.) in 1997. In 2002 he accepted the offer of a full professorship at the University of Erlangen-Nuremberg. In 2004 he changed to Humboldt University, Berlin. As a full professor of educational research and the founding director of IQB, Olaf Köller was responsible for the national assessment of educational progress in Germany. Aside from his activities in academic assessment, his major research interests are reciprocal effects of motivation and achievement, the development of academic interests and their effects on achievement, educational and occupational choices. Olaf Köller has published more than 200 national and international journal articles, book chapters and monographs.

Final Keynote: Problem Solving, Scaling up and Systemic Change

Michiel Doorman
Associate Professor at Utrecht University, Utrecht, the Netherlands
Tuesday, 8 November 2016, 16:30-17:15, Aula

To equip our students to act as informed citizens in a rapidly changing world we need more attention for problem solving skills in mathematics education. In school, students are rarely required to tackle non-routine problems of the type that are common in the workplace. In most classrooms the focus remains on individual technical fluency rather than on developing collaborative problem solving approaches.
The question is how to innovate education in order to meet these new needs? Local, national and even European projects try to tackle this challenge. However, it is still unclear how the process of the implementation of such a reform may take place, and which factors are decisive in its success or failure during scaling up.
This talk will discuss and exemplify some of the tools and processes we need to create in order to support teachers and to foster scaling up innovation. The challenge is one of design and of communicating best practices on all levels involved in scaling up. We will discuss the design of example materials that support reformed pedagogies, as well as the travel, and the adaptation, of the ideas behind these materials along curriculum documents, textbooks and high stake assessments.

Biography

Dr. Michiel Doorman works as a researcher and teacher trainer at FIsme. His interests are context-based mathematics education and coherency between mathematics and science learning. He has been involved in various national projects on designing educational materials and connecting science and mathematics, with a special focus on context-based tasks and IBST. In the past, he has led the materials work package in the Comenius Project Compass (developing interdisciplinary teaching units), and is currently coordinating the materials work package in the FP7 project Primas (teaching materials and professional development units for IBST). He is chief editor of the national magazine on research in science and mathematics education (TDBeta). Doorman is involved in the international network for Mathematics and its Connections to the Arts and Sciences (MACAS).

4. Research – Practice interactive sessions

In each of the three tracks, the first day will start with a moderated long session that combines the perspectives from research and practice and actively engages the audience in small group work and discussion. The research-practice interactive sessions will each relate to a topic of major current concern in scaling-up teacher professional development and will, since they are placed at the beginning of the conference, open up inspiring exchange between participants of the conference.

Researchers and practitioners will frame and introduce each session topic and then engage in a short moderated panel discussion. During the discussion, the audience will also have the opportunity to clarify issues or raise questions of concern. This first part of the session will be followed by a work phase in smaller groups during which participant opinions, concerns and experiences on the topic and input presentations will be discussed. In the final part of the research-practice interactive sessions, a plenary discussion will provide the opportunity to learn from the diversity of perspectives represented in the audience. A moderator will encourage participants to present key points and conclusions made in the group work phase and engage all participants in a forward-looking discussion. The aim of the final discussion is to agree and sum-up core concerns, current problems, and ways of moving forward.

Researchers and practitioners will frame and introduce each session topic and then engage in a short moderated panel discussion. During the discussion, the audience will also have the opportunity to clarify issues or raise questions of concern. This first part of the session will be followed by a work phase in smaller groups during which participant opinions, concerns and experiences on the topic and input presentations will be discussed. In the final part of the research-practice interactive sessions, a plenary discussion will provide the opportunity to learn from the diversity of perspectives represented in the audience. A moderator will encourage participants to present key points and conclusions made in the group work phase and engage all participants in a forward-looking discussion. The aim of the final discussion is to agree and sum-up core concerns, current problems, and ways of moving forward.

Research – Practice sessions: Personal Dimension

Professional learning communities and the multiplier concept

Moderator: Birgit Pepin
University of Technology Eindhoven, the Netherlands
Monday, 7 November 2016, 15:00-16:30, KA 101

Input: Geoff Wake (University of Nottingham), Ragnhild Lyngved Staberg (Norwegian University of Science and Technology), Eirik Lyngvær (multiplier, Flatåsen skole Trondheim, Norway), Lucy Hughes (multiplier, Toot Hill School Bingham, UK).

One of the major conclusions of the first Educating the educators conference was that one of the ways to move forward in scaling-up STEM teacher professional development is to better (conceptually and in practice) combine the best aspects of PD that have proven effectiveness. Two particularly effective methods are the pyramid model of training multipliers or facilitators, who then work with teachers in PD courses, and the professional learning community model that results in groups of teachers researching their professional practice. Although we often seem to rely on one of the two concepts, uniting the benefits of each may lead to a larger scaling-up effect.

The session will present two different models of PD: From the UK, an example of developed professional learning communities working across schools; and from Norway, an example that has

developed a hybrid model of training teachers as multipliers who then work with communities of teachers at their own school or neighbouring schools. In the two countries, as part of the project mascil, innovative approaches in maths and science education (inquiry-based learning) have been implemented using internationally developed materials. Researchers from the UK and Norway will present the different PD concepts and backgrounds, as well as implementation principles. Practitioners (teachers, multipliers) from each country will share reflections on their experiences in their roles as facilitators/multipliers and/or teachers in PD courses or professional learning communities. These presentations will stimulate a group workshop discussion followed by plenary discussion. These will focus on the advantages and disadvantages of different conceptualisations of, and approaches to, PD that can be scaled-up with the aim of identifying what is potentially most effective.

Questions for the group and plenary discussion:

- Which PD concept is mainly used in your country? Why?
- What appear to be the advantages of different PD concepts?
- What can we learn from practical experience of implementation of different PD models in order to provide effective PD support?

Research – Practice sessions: Material Dimension

Usability of internationally developed materials

Moderator: Marta Romero Ariza
University of Jaén, Spain
Monday, 7 November 2016, 15:00-16:30, KA 102

Input: Michiel Doorman on the design of PD Materials;
Country presentations combining researcher and practitioner perspective:

- Malta: Josette Farrugia (University of Malta) and James Calleja (Head of Department for Mathematics. St Clare College, Pembroke)
- The Netherlands Michiel Doorman (Utrecht University) and Dédé de Haan (NHL Hogeschool Leeuwarden, the Netherlands).

In recent years, many EU projects have been funded in which materials for classroom practice and teacher professional development (PD) courses for inquiry-based science and mathematics teaching have been produced. These materials are usually developed by international consortia of researchers and practitioners. This ensures that materials are of high-quality and represent cutting edge research and practices. At the same time, internationally developed materials need to be usable in local contexts which are coined by different systems, structures and cultures.

In this session we will explore these issues by presenting an example of internationally developed PD materials. It will give insight into the developmental process that aims to ensure adaptability and usability in several contexts. After this presentation participants will have the opportunity to work on the module themselves and explore the usability in their contexts. Participants will then have the chance to experience how these materials have been used and adapted in local PD courses of two countries: The Netherlands and Malta.

With these activities we aim to better understand how to design such materials for an international community (involving a research–practice spiral model) and to better understand how pre-designed PD materials and experiences with them can become powerful tools for PD in different national contexts. Furthermore, we will discuss the challenges of using materials developed in other countries and how these challenges can be overcome. We will also discuss what issues of inquiry-based learning

(IBL) can be addressed with such materials and how to stimulate a creative use of them to foster IBL in science classrooms.

Questions for group discussion after experiencing a module for PD:

- What are your views about the module?
- What are your views about the structure of the module (analysis – implementation – reflection) for addressing IBL with teachers in your country?
- From your experience what adaptation would be necessary in order for the module to be used in your country?
- Which features of this module make it internationally usable? (not only in your country)

Questions for plenary discussion:

- How can PD materials support PD facilitators across Europe in providing high-quality PD about IBL?
- What criteria or features of materials need to be fulfilled to be of use for others?
- To what extent are/should materials be: Country specific? Context specific? Subject specific?
- What are the challenges of using materials developed in other countries and how can these challenges be overcome?

Research – Practice sessions: Structural Dimension

Successful project designs to achieve scaling-up

Moderator: Konrad Krainer
University of Klagenfurt, Austria
Monday, 7 November 2016, 15:00-16:30, KG5 103

Input: Diana Wernisch (University of Education Freiburg, introduction), F. Javier Garcia (researcher/team leader local implementation, mascil project ES), Mar Jimenez (policy, Spanish Ministry of Education), Christoph Selter (introduction, TU Dortmund university), Silke Sondermann (Primary School Essen)

In this session we will explore examples of sustainable project architectures and their core features: the project mascil is implemented in 18 countries and the German Centre for Mathematics Teacher Education (DZLM) is a nationwide centre in Germany (where each federal state has responsibility for determining its education system).

Mascil aims to improve STEM education and main measures are developing classroom and PD materials based on the IBL approach with a world-of-work context and delivering related PD courses. The project architecture contains elements that aim to ensure that scaling-up effects are sustainable after project lifetime. Important principles that will be presented from research, practice and policy perspectives are the instigation of National Advisory Boards (NABs) that anchor international innovation in local settings. These boards represent key stakeholders, such as education authorities, teacher associations, parents, etc., that need to work together in local settings to reach scaled-up PD. This interactive session will also show how NABs are linked internationally so as to foster knowledge exchange. It will also address such principles as a participatory and collaborative style of working that allows external project groups to actively engage with the project and develop ownership, and, for example, the management of innovation, by actively taking up current trends and needs and connecting project work as much as possible to existing trends, structures or developments.

A moderated session will first introduce important principles of the mascil project (K. Maaß) and then allow the audience to see in detail how the principles are implemented in one country (example country: Spain). The case presentation will come from both a research and a practical perspective (F.J. García, local team leader in implementation), and aim to identify the interplay between these two dimensions. The policy perspective (M. Jimenez) will complement the case presentation.

Subsequently, the DZLM (German Center for Mathematics Teacher Education, **www.dzlm.de**) will present its approach of a central institution that provides teacher training in mathematics in a federally organized country (Germany).

Structures for funding: The DZLM was initiated and is funded by the Deutsche Telekom Stiftung (**www.telekom-stiftung.de**), a corporate foundation centred on improving STEM-education. On the recommendation of a panel of experts for 'Mathematics across the Educational Chain', the foundation created the DZLM in 2011 as a nationwide centre aiming at general quality standards for teacher training.

Structures for research and development: The DZLM develops long-lasting, research-based, continuing PD programmes especially for multipliers by combining the expertise of researchers at eight universities throughout Germany. The presentation will show how they work together across eight universities in different departments – some of them specialised on topics at specific school levels, others on concepts for research (also at PhD level), online-resources or networking. The departments cooperate with a network of developers and researchers from practice and other universities.

Structures for dissemination: To disseminate the courses at a large scale and to ensure their practicability for the target group, the DZLM cooperates closely with the education authorities in the different federal states, strengthened with the help of specific local coordinators and federal delegates from education policy. As an example for the dissemination of a material-based PD-program in several states, the DZLM-project PIKAS for primary schools will present how they offer the federal states different modular cooperation forms – both from the research and practice perspectives (Ch. Selter, **www.pikas.dzlm.de**). The case will be complemented by the view from the policy perspective.

Questions for panel discussion:

- Which structures have proven to be efficient, which have not?
- What challenges do you face despite these structures for cooperation, despite long-term professional development courses and combination off- and on-job phases?

Questions for group discussion:

- Which structures do you use in your countries? Which have proven to be efficient, which have not?
- Why are they more or less effective?
- Which challenges do you face in your country when implementing such scaling-up initiatives?
- Could structures be transferred from one country to another? What is context-specific and what is general?
- What makes a structure? Which are key elements of a workable structure?
- Which theories can be used and have proven to be effective when tackling the structural dimension for scaling-up professional development?

5. Discussion Groups

The discussion groups will discuss on the actual issues in the personal and structural dimension: After 5-10 min inspiring input (presenting challenges or differences between approaches as well as questions to discuss), small groups will discuss for 25 min along well-defined questions in order to exchange perspectives, also between policy makers, researchers and practitioners in the field of educating the educators. Reporting back the small group results allows a larger discussion (25 min) to widen the perspectives.

Discussion Group – Personal Dimension

Background & problems in education facilitators / multiplier

Katja Maaß & Susanne Prediger
Professor at University of Education, Freiburg, Germany & Professor at TU Dortmund University, Germany
Tuesday, 8 November 2016, 13:00-14:00, KA 101

Facilitators (synonymously multiplies, lead teachers) are crucial for the personal dimension of scaling up, as they conduct professional development courses or support schools in their development processes. However, educating the facilitators is a field which has not yet attracted much attention. A typical challenge in qualifying facilitators is the ways they deal with different kinds of knowledge: Is a classroom example (e.g. a task, a students' product) the key content of the PD itself, or is it only the concretization for a more general principle? Other challenges of qualifying facilitators arise and shall be discussed in the discussion group, e.g. What are the needs as regards their preparation for running PD courses? How difficult is it for them to change their role from a teacher to a PD facilitator? The aim is to exchange experiences as well as theoretical perspectives.

Schedule:

- 10 min input by the discussion group organizers on typical challenges in qualifying facilitators
- 25 min small group discussion on different questions related to the input involving different perspectives (researchers, practitioners, policy makers)
- 15 min presentation of small group results, 10 min whole group discussion

Discussion Group – Material Dimension

Scientix Workshop

Àgueda Gras-Velázquez
Scientix Project Manager
Tuesday, 8 November 2016, 13:00-13:45, KA 102

During the Scientix workshop the Scientix platform, opportunities and its database of materials will be presented. Participants will learn about the services and opportunities offered by Scientix (workshops, conferences, translation on demand) and get an overview of the Scientix database that contains a large number of STEM materials (classroom materials, PD materials, reports and guides) that were developed in the course of international projects. We particularly invite teachers, teacher educators, teacher associations, PD Centres and European projects in the area of STEM from across Europe to this

session since they are important actors in ensuring that teachers in local settings get to know internationally developed materials.

Discussion Group – Structural Dimension

Systemic project designs for scaling-up and their evaluation

Bettina Rösken-Winter & Konrad Krainer
Professor at Humboldt University Berlin, Germany & Professor at University of Klagenfurt, Austria
Tuesday, 8 November 2016, 13:00-14:00, KA 106

It is a long way from high-quality CPD to scaling high-quality CPD. Research on the maintenance of CPD has substantially contributed to defining high-quality CPD in terms of quality criteria. However, little is known about the processes of dissemination, particularly with regard to the nature and the quality of change processes that are to be enhanced. The research base is thin, and research on scaling is often restricted to investigating scaling interventions simply in terms of quantitative numbers, e.g., increasing the number of teachers or schools that profit from CPD. Aim of the discussion group is exploring mechanisms of scaling up by paying attention to systemic project approaches that focus on the relevant processes and contribute evaluation data.

Schedule:

- 10 min input by the discussion group organizers on scaling CPD (frameworks, projects, research findings)
- 25 min small group discussion on different questions related to the input involving different perspectives (researchers, practitioners, policy makers)
- 15 min presentation of small group results, 10 min whole group discussion

6. Paper Presentations

Besser, M. (University of Education Freiburg), Leiss, D. (Leuphana University of Lueneburg) — Research-based presentation on structural dimension

Designing Teacher Professional Development to Foster Mathematics Teachers' Pedagogical Content Knowledge and to Improve the Quality of Teaching

Tuesday, 15:45-16:15, Room KA 101

Fostering teachers' pedagogical content knowledge (PCK) and improving the quality of teaching by teacher professional development (TPD) successfully is crucial when thinking about teaching and learning at school. However, empirically based knowledge about how to make TPD happen is rare. Therefore, the research project Co2CA1 investigates empirically the effect of TPD being designed in line with some "core features" being stresses by actual reviews of TPD (content focus, active learning, coherence, duration, collective participation) on mathematics teachers' PCK and on the quality of teaching. Quantitative analyses point out that such a kind of TPD can successfully foster teachers' PCK. But the quality of teaching has not been improved successfully. Within the presentation, the concrete idea of designing TPD based on core features highlighted by reviews of TPD is pointed out in detail and implications for scaling-up TPD based on empirical results of the research project are discussed.

1. Teachers' Pedagogical Content Knowledge as Crucial Element of Teachers' Competence
Understanding successful teaching and learning at school by identifying teacher-related characteristics influencing the quality of teaching and explaining students' progress is of special interest within empirical educational research. For a long time, research has mainly focused on investigating teachers' personality or teachers' behaviour in the classroom to explain teaching and learning at school. Within the last years, many empirical studies additionally investigated the influence of teachers' competence on successful teaching. Results of these studies especially stress the effect of teachers' pedagogical content knowledge (Shulman, 1986) as selected part of teachers' competence on the quality of teaching and on students' progress (see besides others: Hill, Rowan, & Ball, 2005; Kunter et al., 2013; Tatto et al., 2012). However, only little is known about how to foster inservice teachers' PCK successfully: "PCK – the area of knowledge relating specifically to the main activity of teachers, namely, communicating subject matter to students – makes the greatest contribution to explaining student progress. This knowledge cannot be picked up incidentally, but as our finding on different teacher-training programs show, it can be acquired in structured learning environments. One of the next great challenges for teacher research will be to determine how this knowledge can best be conveyed to both preservice and inservice teachers" (Baumert et al., 2010, p. 168).

2. Actual Knowledge about Making Teacher Professional Development Happen
At the end of the 20th century Wilson & Berne (1999) emphasize that "what the field 'knows' about teacher learning is rather puzzling" (p. 173). Therefore, recent reviews of TPD have worked on structuring knowledge about the effectiveness of TPD (see e. g. Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009; Grossman & McDonald, 2008; Putnam & Borko, 2000). Referring to the work of Garet et al. (2001) and Desimone (2009) especially some "core features" of TPD "are critical to increasing teacher knowledge and skills and improving their practice, and which hold promise for increasing student achievement" (Desimone, 2009, p. 183). These core features are: (1) content focus, that is focusing on subject matter knowledge and linking this knowledge to student learning; (2) active learning, that is plenty of activities beyond listening passively to lectures; (3) coherence, that is making teacher learning consistent with teachers' knowledge and beliefs; (4) duration, that is TPD lasting for at least 20 hours spread over a semester; (5) collective participation, that is making interaction and

discourse among several teachers happen. Making TPD happen successfully means implementing these core features into TPD deliberately.

3. The Research Project Co2CA: Designing Teacher Professional Development to Foster Mathematics Teachers' Pedagogical Content Knowledge and to Improve the Quality of Teaching

Referring to empirical results on the crucial effect of teachers' PCK on the quality of teaching and referring to actual knowledge about making TPD happen the research project Co2CA investigates empirically the influence of TPD on the development of mathematics teachers' PCK and the quality of teaching mathematics. Concretely, e. g. the following research question is addressed: Does TPD being designed in line with the five core features highlighted by Garet et al. (2001) and Desimone (2009) support mathematics teachers in building up PCK and in improving the quality of teaching. The core features have been implemented as follows: Dealing with learning material, mathematical tasks (out of text books), videotaped math lessons, and students' working on mathematical problems, immediately caused teachers to focus on subject matter 1 Co2CA: Conditions and Consequences of Classroom Assessment. Supported by the German Research Foundation. Principle Researchers: E. Klieme, K. Rakoczy, D. Leiss, W. Blum. knowledge and to link this knowledge to student learning (content focus). Active collaboration has been called for by designing TPD as workshops and not as lectures, that is, teachers had to develop, present and discuss concrete material of their own (and of course guided by the supervisors). Furthermore, lessons for teaching mathematics within one's own class had to be planned, conducted, and reflected upon. Doing so in small groups of teachers teaching similar grades at school not only engaged them in multifaceted activities (active learning), but also required their participation in TPD as teams (collective participation). By extending TPD over a period of more than ten weeks for implementing central ideas of TPD into the own teaching, participating teachers had to work on these ideas over a long period of time. Offering additionally the possibility of communication by using an online-tool for chatting, discussing materials, and reflecting on both one's own lessons and those of colleagues, the teachers were given the opportunity to take part in TPD continuously (duration). Finally, by claiming teachers to reflect about their own teaching of mathematics as a starting point for nearly every work-session, the TPD aimed for consistency with teachers' knowledge and beliefs (coherence). Overall 67 mathematics teachers participated in TPD as part of the research project. The teachers assigned themselves to one out of two experimental groups (EG 1, N = 30, and EG 2, N = 37; content of TPD differed between these two groups). Using special tests on teachers' PCK and on students' perceived quality of teaching at the beginning and at the end of TPD within both experimental groups, the effect of TPD on teachers' PCK and on the quality of teaching can be analysed. Quantitative analyses of variance point out: teachers out of EG 1 outperform their counterparts out of EG 2 within a test on PCK referring explicitly to the content of EG 1 – and vice versa (Besser, Leiss, & Blum, 2015; Besser, Leiss, & Klieme, 2015). Based on these results it can be stated: Designing TPD with special regard to the core features highlighted by Garet et al. (2001) and Desimone (2009) supports teachers in building up PCK. But: The perceived quality of teaching did not increase, neither in EG 1 nor in EG 2.

4. Implications for Scaling-Up Teacher Professional Development

Although having fostered teachers' PCK successfully, TPD having been designed in line with central reviews of TPD did not improve the students' perceived quality of teaching. These results are not in line with actual empirical research stressing the influence of teachers' PCK on successful teaching. Understanding and explaining these results may cause some trouble – but maybe it is the work of Cobb & Jackson (2011) offering some starting points for further research and for thinking about ways of scaling-up TPD based on a design as pointed out here: "To date, research on instructional improvements in mathematics education has focused primarily on supporting groups of teachers' learning. However, the challenge of instructional improvement at scale involves supporting schools' and broader educational jurisdictions' development of the capacity to scaffold teachers' (and others') ongoing learning" (Cobb & Jackson, 2011, p. 7). Taking this idea seriously, it is not teacher professional

development but educational professional development not only fostering teachers' PCK but also improving the quality of teaching simultaneously.

Biehler, R. (University Paderborn), Friedrich, H. (University Paderborn), Nieszporek, R. (University Paderborn) — Research-based presentation on structural dimension

Scaling up professional development courses for upper secondary mathematics teachers through systematic collaboration with mentor teachers

Monday, 17:45-18:00, Room KA 102

1. Context of the project

As part of the German Centre for Mathematics Teachers Education (DZLM) we have developed a four day course "stochastics compact" spread over about four months for supporting a sustainable professional development with impacts into actual classroom teaching. The course was offered three times since 2013 and reached more than 270 teachers (see Oesterhaus & Biehler, 2014 for a description of version 1 and 2 of the course). In each round, the course was improved on the basis of the feed-back provided by the teachers and by systematic evaluations. Currently, in spring 2016, we are piloting the 4th version of the course, which was extended to 5 days and which is now further developed together with the regional school administration from one of the 5 administrative regions in North Rhine-Westfalia, namely Arnsberg.

Stochastics is the German name for probability and statistics. The teachers are from in the federal state of North Rhine-Westfalia (NRW), where, from 2014 onwards, a new state syllabus made teaching stochastics obligatory which is also included in the final central examination (Abitur). The syllabus are based on the new national standards (KMK, 2012), where stochastics has also a prominent obligatory place. A further new feature is the obligatory use of graphic calculators (GC), which can and have to be used in the final examinations, too. The national standards emphasize competence oriented teaching of mathematics, which is in line with the principles of innovative teaching that are in the focus of the ETE conference.

2. Collaboration structure

The design of the first three versions of course was based on results from stochastics education and based on design principles of the DZLM (Barzel & Selter, 2015). It took the new syllabus and the national standards into account, but provided an elaboration and interpretation of the standards from our own research perspective. The role of the school administration was that they formally supported the third version in the sense that the PD course was advertised as recommended by the ministry of education in NRW. The 5 regional administration only had a minor role and just organized the process of applications of teachers from their region.

In early 2015, a new level collaboration with the regional school administration in Arnsberg started. The regional administration is responsible for offering official courses for the teaches of their region according to the NRW state standards for teachers' professional development and their current needs. Five mentor teachers, who are experienced mathematics teachers and mathematics teacher educators, entered the team as well as the two leading administrative persons responsible for professional development and for mathematics teaching in the region of Arnsberg. From the DZLM at the university of Paderborn, the three authors form the team from late 2015 respectively early 2016.

The scaling up model is as follows. First of all a new 5 day course is collaboratively developed on the basis of the previous DZLM course. From the DZLM perspective it is a kind of 4th version of its stochastics compact course, but it can be considered as a generally new course, with new elements, foci and goals. The goal is that finally the 5 mentor teachers are enabled to teach these 5 day courses themselves. The region has about 130 schools with grades 10-12 and Abitur and the goal is to reach all

these schools. After representative teachers of each school have taken the course, the Arnsberg team will offer their support in school and classroom development in stochastics teaching.
In order to achieve this goal the following structure has been developed

1. Development phase
2. Piloting phase
3. Collaborative phase
4. Regular phase
5. School development phase

In the “development phase” the systematic collaboration between the DZLM team and the 5 mentor teachers occurs. This can not be considered a process of educating the educators but it is truly interactive and both parties deeply learn from each other. It is also clear that it is difficult to “hand over” previously developed material to educators and assume that this material is “multiplied” in their teacher education courses. On the other hand, having concrete material as the product of the collaboration is an important feature. The material consists of PowerPoint presentations, handouts for the teachers and files to be used with the graphic calculator in the classroom. We develop a shared view on these materials, but aim at developing “moderator guidelines” after the piloting phase. In the piloting phase, 3 persons from the team are responsible for each of the 5 days, the other team members take notes followed by a collective reflection. The collaborative phase uses an updated version of the pilot course and is taught by one member of the DZLM team and one member of the Arnsberg team. In the regular phase, two members of the Arnsberg team are responsible. Probably members of the DZLM re-enter in the school development phase.

3. Design principles of professional development course and the classroom material
In the presentation we will describe the content structure of the course based on the discourse in probability and statistics education as well as our model of dimensions of teacher knowledge that we include in our course: background and horizon content knowledge, curricular knowledge, pedagogical content knowledge as well as technological pedagogical content knowledge concerning the use of the graphic calculator as student tool and as tool for teacher demonstrations, based on Wassong and Biehler (2010).
For the participating teachers the design for adult learning follows a three step role changing model: progressing from teacher in the learner’s role, role of reflecting and selecting content, to teachers’ role as classroom designers.

4. Constraints and affordances in the collaboration in the development and teaching team
We built on previous experiences of designing a mentor teacher course for professional development in teaching stochastics (Kuzle & Biehler, 2015; Wassong & Biehler, 2014). The collaboration is a great experience although not tension free. Our role changing model was not undebated in the collaboration with the school administration with regard to the emphasis that has to be put on the different aspects. The position was put forward that teachers should know the content already to a large extent or learn the content themselves, their role in the selection and shaping of content is regarded as limited, as we “have” the curriculum, central examinations and text books, that have taken many decisions for the teachers. An emphasis is to be put on classroom implementation focusing on coping with heterogeneous students requiring differentiation and individual support. From our perspective teaching methods have to be also intertwined with stochastic content, stochastic content knowledge is not “there” in the teachers’ mind because of limited or too abstract stochastics education in their pre-service training.
We will report on how we resolved these problems in developing and piloting the new material.

5. Selected results of evaluations
In this section we will report on selected evaluations of the pilot courses and the previous versions of the course.

Bilek, M. (University of Hradec Kralove), Simonova, I. (University of Hradec Kralove), Machkova, V. (University of Hradec Kralove), Musilek, M. (University of Hradec Kralove), Manenova, M. (University of Hradec Kralove) — Practice-based presentation on structural dimension

Mascil Project Implications for Teachers Professional Development in the Czech Republic

Monday, 17:45-18:00, Room KG5 103

1. Introduction – Current Czech School Reform and Mascil Project Objectives

Currently, a reform of the education system is in progress in the Czech Republic bringing substantial changes into the education system. The changes relate to wider policy perspectives (macro level), school level (meso-level) and classroom level (micro-level), and are evident in the following lines. In relation to wider policy perspectives, new curricular documents for primary and secondary education include, among others, the fields relating to Mascil project (Mathematics and Science in Life) (Maass et al. 2013): "Mathematics and its applications", "Man and Nature" and "Man and world of work". Main objectives of Mascil project – inquiry based learning (IBL), as well as relations to world of work (WoW) are a big challenge for improvement of school practice but the realisation is continuing slowly and with various difficulties. In curricular documents the call for inquiry-based methods has appeared, but only generally mentioned for the time being. Indeed, inquiry based teaching and learning approaches are prioritized in policy making national documents on general level only, without concrete explanation and comments in examples and expected competences. Consequently, the national curriculum prioritizes inquiry based teaching and learning approaches, in general and in specifications in science and mathematics subjects, in the primary, general secondary and vocational education, however, unfortunately, rather on general level, without concrete explanation and comments in examples and expected competences (as in the national curriculum). Regarding professional development, teacher training on IBL has become the main policy priority recommended trend. Although such an orientation is being declared in educational documents on all levels, it is hardly implemented in practice. At the school level, there seem to be only rare relations between general education and industry, mostly in the form of joint projects or funding, both in the field of formal and informal education. Direct relation between the vocational schools and industry does exist. The extent to which schools implement policy priorities in relation to inquiry based teaching and learning approaches is not large, in general and in specifications in science and mathematics education on all educational levels. In relation to the teacher training, overall concept of prospective training includes both the theoretical background and topics connecting school and the world of work, on all levels of the education system.

2. Czech Classroom Reality in Relations to IBL and WoW

On the classroom level, the evidence in science and mathematics curricula of the connection between schooling and the IBL and WoW in terms of content has not been applied to sufficient extent (if any). Assessment of skills/competences in science and mathematics in relation to the IBL and WoW in general education has been developed to a low degree only. Inquiry teaching approaches are rather applied as predominant teaching methods in vocational schools in professional subjects. Regarding the nature of students' assessment in vocational schools, mostly traditional approaches are evident to be applied. In addition, there are several examples of curriculum supporting materials for science and mathematics education that support inquiry based teaching and learning approaches. The existing materials are mostly outcomes of projects focused on innovations. As for the nature of students' assessment in relation to inquiry based teaching and learning in mathematics and science education, there hardly any exist. For the primary school mathematics the latest Czech textbook reflects not only basic calculation processes but also develops competence for inquiring and solving the given problems,

focusing on collecting experience in organization of single phenomena, data processing, and joining ideas of mathematics, geometry and combinatory are included in the learning content. On the lower secondary level various programmes are supported by enthusiasts, sometimes funded by private or state companies and non-governmental institution. These programmes do not cover all population – the state policy neither supports, nor creates obstacles to the implementation of IBL approaches.
Last but not least, in the Czech Republic the national educational context seems to be passive to some extent, and definitely more supportive efforts for the IBL implementation could be included in all documents. Although the implementation of the Mascil project objectives and its professional development courses into the currently-designed educational reform on the policy making level are obvious, the objectives are not widely reflected in school and classroom practice yet (Engeln 2014). To improve this state significantly is one of the Mascil contributions to the Czech curriculum on all levels. Pedagogies and learning materials developed within the Mascil project provided significant support of maths and science education in the Czech Republic (Dorman et al. 2014).

3. Teachers Professional Development in the Czech Republic and Mascil Project

Teachers of three levels of the Czech education system participated in the Mascil based professional development (PD), evaluation and continuous development of teaching materials. The IBL and WoW oriented courses were used also in preservice teacher´s education with participation of the students of the Faculty of Science and Faculty of Education, University of Hradec Kralove. It means main parts of the courses were included to courses of subject didactics (mathematics, chemistry, biology, physics and informatics). The in-service teachers were selected from applicants from the whole country. From the view of type of education, in the group of in-service teachers, 52 were from general-education institutions and 9 were from vocational schools, and all multipliers were from general education institutions. From the view of disciplines, in the group of in-service teachers, 15 participants were teachers of maths and 46 of Science-Technology disciplines, and 2 multipliers were of Maths and 4 of Science-Technology disciplines. Totally, 61 in-service teachers and 6 multipliers were trained.
Teachers and multipliers were selected by personal interest, which was the strongest criterion after qualification for both the teachers and multipliers. From the view of professional qualification, the main criterion was the university degree – M.Sc. or Ph.D., experience in administration, years of teaching practice. Moreover, it should be added that the master degree is obligatory for all Czech teachers, for multipliers also additional 5-year-long practice was required. Teachers participating in PD had minimum experience in IBL implementation and different kinds of experience in WoW, which was not explicitly stated in the Czech recommended curriculum and was applied by own interest and conditions of the school.
The Mascil based PD model, identical for teachers and multipliers, was structured as follows:

1) two face-to-face (F2F) meetings; the first one presenting main goals, structure and tasks, the second held one or two week later, dealing with participants´ final work based on presentation of own created or modified IBL task and experiences of its using in own classroom,
2) selection of IBL task (from own production or from Mascil or other sources modified by own conditions) and its application in own classroom as base for final course work.

The three PD courses oriented to teachers on primary, lower and upper secondary schools were developed and accredited by Ministry of Education as courses of teacher´s continuing education. Following types of activities were included in the PD course content:

1. Principles of inquiry based learning in school subjects mathematics and natural sciences in relations to current curricula.
2. Methods of IBL implementations in everyday classroom (on concerned level).
3. Levels of IBL and examples of their realisation in preparation, realisation and evaluation of teaching activities (on concerned level).

4. Confirmation inquiry as first level of IBL – teaching and learning process application (on concerned level).
5. Structured inquiry as second level of IBL – teaching and learning process application (on concerned level).
6. Guided inquiry as third level of IBL – teaching and learning process application (on concerned level).
7. Open inquiry as highest level of IBL – teaching and learning process application (on concerned level).
8. Using of ICT in mathematics and natural sciences IBL (on concerned level).

From in-service teachers and multipliers, training of 8-hour PD course (two F2F meetings, meetings with distance of 1-4 weeks), the design of IBL task related to the study specialization and analysis of learning situations were required for graduation from the course. PD between F2F meetings was oriented on the self-development and own classroom teaching. For PD and classroom teaching following resources were used: database of IBL task at Mascil Web-portal, Problems of the Month, Mascil Toolkit (Czech translation), Tasks and presentation of "good practice" from Czech curricular reform Webportal (http://rvp.cz), Modified task from pre-service Subject didactics courses, and Modified tasks from Czech textbooks and other teaching materials.

4. Conclusion

The implementation of the Mascil project outcomes in the Czech Republic, particularly in teacher PD, brought supportive arguments for positive evaluation of the implementation of IBL and WoW what we can be summarized as follows: there exists a project results of which are directly applicable in teacher pre-service and in-service maths and science education; the application of IBL and WoW strongly relates to the personality and professional abilities of the teacher, as well as to the school and its climate; at lower secondary schools subjects are more isolated (in our opinion), they are no interrelations, particularly in Science subjects, so that the IBL could be effectively implemented; IBL in the Czech Republic is currently a marginal approach only, but it starts expanding; as for the fragmentation of topics into isolated areas – a general overview has not been provided to sufficient extent; most of Czech teachers still insist on memory based knowledge with learners, which is limited for the IBL application, and elements of IBL and WoW have not been included into the school evaluation criteria.

Reflecting all the above mentioned, we are aware a large extent of work is still in front of (all of) us. It is high time we started with the process of IBL and WoW implementation into the Maths and Science education on all levels of schools in the Czech Republic, as these approaches provide learners the connection (of our system of education) to the real world, which we expect will enable them to succeed on the labour market in the future.

Cameron, D. (Institute of Physics, London) — Practice-based presentation on structural dimension

The Stimulating Physics Network: changing the landscape of physics teacher professionalism in England

Tuesday, 15:15-15:45, Room KA 106

1. The Stimulating Physics Network: introduction

The Stimulating Physics Network (SPN) is a project providing continuing professional development (CPD) opportunities for physics teachers in England. The project is managed by the Institute of Physics and funded by the UK Department for Education. A team of about 35 'teaching and learning coaches' (TLCs) run regular CPD workshops, events and residential courses for teachers, working to improve the

teachers' subject knowledge and pedagogical expertise in physics. The SPN project has been operational since September 2009 and will continue until at least March 2019. In the last 12 months the SPN worked with over 400 targeted schools and generated over 40,000 teacher-hours of CPD.

2. Physics education in England: the national context

Physics provides young people with access to a range of economically valuable career paths. Along with maths, physics is an important gateway subject to a diverse range of careers and opportunities (Russell Group, 2013). However, there is a significant shortage of specialist physics teachers in English secondary schools (Smithers, 2013; NAO, 2016) and there is also a shortage of high-quality professional development opportunities for physics teachers, which are necessary both to improve teacher quality and minimise teacher wastage (Hobson, et al., 2009).

As a result of these shortages, a high proportion of physics lessons, particularly in the 11-14 age range (when pupils' perceptions of subjects and future choices are being shaped), are taught by teachers without a specialist background in physics (SCORE, 2015). These non-specialist teachers are more likely to lack a deep subject knowledge and pedagogical expertise in physics, to have less confidence and enthusiasm in teaching physics, and also to lack fluency in demonstrating the relevance of physics beyond the classroom. All these characteristics are necessary to ensure that pupils (including and especially girls) are engaged by and identify with physics as a subject which is accessible, aspirational and relevant to their lives and future. As a result, participation in physics at A-level (age 16-18) is disproportionately low; numbers progressing to university courses are relatively small; the graduate pool of specialist physicists available for teacher recruitment is very limited, thus perpetuating the shortage of optimally qualified physics teachers.

3. The proposal

3.1 How the proposal relates to the conference theme

This presentation will outline how the SPN, as a mature and successful project, is now evolving a new (and more financially sustainable) model to operate across the whole English school system, by working increasingly through schools and teachers, to provide equity of access to high-quality CPD for all physics teachers in England.

3.1 How the proposal relates to the chosen topic

This presentation will outline the current project design of the SPN and how it will evolve over the next three years to achieve a system-wide change in the professional practice of physics teachers across England. It therefore relates to topic 3: structural dimension – systemic project designs for scaling-up and their evaluation.

3.1 The questions to be addressed

This presentation will address the first three exemplar questions raised in the structural dimension topic:

- What can a design of an initiative aiming at a widespread implementation of innovative teaching and for scaling up professional development look like?
- Which structures prove to be effective in which cultural context? Which do not?
- What challenges remain to be overcome even if such initiatives gain traction?

The presentation will consider which elements of the English education system support, and which conflict, with the intended project objectives.

3.2 Background: principles and definitions of professional development

Professionalism can be defined as an expression of one's commitment to one's own professional practice. Teacher professionalism relies on teachers committing to, and engaging with, a continuing process of professional development (CPD). CPD should not be considered as just formal learning events or courses, but as a way of thinking about one's practice before, during and after the execution

of that practice (Schön, 1983). Professional development, therefore, is not a ‘thing’ to be done, but a state of being; and thus, an expression of professionalism.

Facilitating this state of practice depends on institutions and structures that enable and give agency to teachers’ professionalism; this has been described as the necessary ‘architecture’ of professional learning (Cunningham, 2012). This facilitation generates a ‘culture’ which permeates the environment and supports individuals’ work-based learning (Eraut, 2004); therefore our initiatives to support ongoing professional development focuses on developing a culture of professional learning in schools. For this culture to become embedded it must be led by the school, and CPD activity must involve the active participation of teachers.

3.3 Outline of presentation

The presentation will describe the current operational design of the SPN project, including: how TLCs identify schools at need of support; how schools join the project and how their physics teachers are supported and developed; how headteachers of selected schools are engaged with the project; and how the multi-layered provision of CPD events at local, regional and national levels creates a coherent network and project identity.

It will outline the content of the professional development activities, which is based on research-informed materials on the most effective approaches to teaching physics, developed in collaboration between university- and school-based practitioners. It will discuss the coaching principles and approaches deployed by TLCs, which are derived from andragogic theory and focused on facilitating teachers’ professional learning and autonomy through establishing relationships based on trust, credibility and security (Knowles, 1998).

After addressing the evaluation and impact of the project to date, the presentation will discuss how the SPN project will effect a lasting system-wide change in not just the teaching of physics, but the culture of physics teacher professionalism in England. On the basis of the principles outlined above, the necessary components of this change are based on two strands: all schools in England, and the Institute of Physics (IOP) as the professional body for physics in England.

The important role of the IOP will be outlined: to convene the physics teacher community; facilitate teacher-led activities; recognise professional practice through membership and chartered status; democratize the development of physics pedagogy and curriculum materials; and provide professional pathways for teachers to create a self-sustaining community comprising novice, experienced, expert and emeritus practitioners.

The role of schools, however, will be shown to be even more critical. Over the next three years the SPN project will establish a national network of 50 ‘lead schools’ for physics, each acting as a hub for a local network of at least ten other schools, which will create the national infrastructure for generating a culture of professional development in all schools in England. CPD activity will be increasingly teacher-led, as secondment agreements with each of the lead schools will release expert physics teachers to spend about 20% of their time supporting and coaching teachers in other schools. The schools will have an important and active role in the management of the project, involved in its monitoring, evaluation and contributing to a developmental dialogue with the IOP.

The presentation will address the anticipated obstacles and resistance to achieving this change in schools’ culture, including the English context of school accountability measures and performance targets, which tends to promote competition and insularity between schools over collaboration and professional trust. Strategies for addressing and overcoming these obstacles will be outlined, and the value of developing a more ‘enlightened professionalism’ amongst schools will be explained.

3.3 Presentation format

The presentation will be delivered orally with support from a prepared presentation, including the key descriptive and analytical points, evaluation and impact data, and some illustrative images of project activities.

Chehlarova, T. (Bulgarian Academy of Sciences), Kenderov, P. (Bulgarian Academy of Sciences), Sendova, E. (Bulgarian Academy of Sciences) — Practice-based presentation on personal dimension

Dynamic support of multipliers' personalization (without forgetting the national specifics)

Monday, 17:45-18:00, Room KG4 301

1. The specifics of the Bulgarian approach to educating the multipliers

The Institute of Mathematics and Informatics at the Bulgarian Academy of Sciences (IMI-BAS) has been involved in organizing various PD courses in Bulgaria, and in developing resources in support of all levels of IBL (as defined in Banchi and Bell, 2008): Level 1 − Confirmation Inquiry, in which students confirm a principle through an activity such that the results are known in advance; Level 2 − Structured inquiry, in which students investigate a question presented by the teacher through a prescribed procedure; Level 3 − Guided inquiry, in which students investigate a question presented by the teacher through a procedure designed/selected by themselves; Level 4 – Open inquiry, in which students investigate a question they have formulated themselves through a procedure designed by themselves. The courses and the resources developed are an essential part of the realization of the Mascil project in Bulgaria.

1.1. The PD courses for multipliers and for teachers involved in inquiry-based education

When talking about PD courses in a Bulgarian Mascil context, we have to consider two types of courses – the first type is for multipliers-to-be. The second type is for teachers who are directly implementing the Mascil ideas in the educational process (Chehlarova et. al. 2015).

The PD courses for multipliers last 128 hours (32 face-to-face part and 96 hours distance learning, including a work on a project and its defense in front of the Mascil IMI-BAS team).These PD courses have been delivered by a team of Mascil members, consisting of 3-5 people. Three such courses were organized jointly with the Ministry of Education and Science (MES). They were held in IMI-BAS with 20 participants each. The topics covered ranged from learning the basics of GeoGebra (as an environment for inquiry-based learning) to practical problems of World of Work (WoW) developed by the Mascil team. The resources used include Mascil Problems of the month as well as dynamic scenarios from the Virtual Mathematical Laboratory, VirMathLab (Kenderov et. al., 2015 a).

The second type courses are led by multipliers supervised by Mascil team members. They also have two stages. The first stage consists of two-day sessions, followed by 6 weeks during which the participants develop and finally present their own projects at a face-to-face session. Participants are experiencing the research approach by considering tasks new to them so that they themselves experience the "aha" effect, the joy of discovery and "project" this approach into their own classes. So far eight such courses have been delivered in seven Bulgarian towns with about 15 participants each.

The resources used in the courses were mainly from the Bulgarian Mascil site – Problems of the month, resources developed by the Bulgarian Mascil team and some of the Mascil partners, adapted to the National curriculum and enriched with dynamic files. The providers of the courses were experienced enough to adapt the communication based on the abilities of the group. For instance, the resources of Mascil and VirMathLab dealing with dynamic files for mathematics explorations were used at three levels – as ready-made files not needing special informatics knowledge to be used, as "transparent" files which could be adapted for other situations, and as models to be recreated from scratch (Kenderov et. al. 2015, b).

The main strategy was "to put the participants in the shoes of their students", i.e. to experience problems of the same nature as their students were expected to face. Other specifics of our PD courses include the use of tangible manipulatives preceding the computer models of mathematics objects, the

re-formulation of traditional problems to fit the Mascil ideas of connecting IBL and the world of work, applying “what-if strategy” for modifying and generalizing the problems, etc.
The world of work was present in the courses in multiple perspectives – from design of a parking to design of art works and liquid containers. Ideas of the participants how to design their lessons in IBL style, and how to relate them with various spheres of WoW were discussed not only during the PD course, but afterwards. The main advantage of the PD courses (as expressed by all the participants) was the feeling that they belong to a community which provides them with an ongoing support. This could be seen in many events following the courses – visits to schools at special events – math fests, celebrating an anniversary of the school, conferences at which teachers were participating together with some students, initiation of short courses led by the teachers in their role of multipliers.
The main problems faced so far deal with the traditions and the conservatism in the Bulgarian math education. The teachers are expected to cover specific curriculum in relatively small number of teaching hours (the smallest in Europe, due to the shortest school year). Another problem is the conservative assessment system, which is still based to a great extent to multiple-choice tests checking the technical skills (manipulation of numbers and symbols). A great number of teachers and experts still think of IBL as too-much-time-consuming, as a complementary load to be introduced and do not necessarily see the synergy it could bring (including with integration of teachers and subjects)… For us, as providers of PD courses, the greatest challenge was the variety of the participants (selected by the Ministry of Education and Science) in terms of background but our strategy with using appropriate resources – manipulative and e-resources alike so as to cope with such a variety turned out to be successful as it could be seen from their feedback (Chehlarova et. al. 2015).

1.2 Other events for the professional development of teachers

A number of other events is being organized by IMI-BAS contributing to the professional development of teachers in mathematics, IT and informatics: National seminar on inquiry based mathematics education, Dynamic mathematics
conference, webinars, STEM related courses with the Institute as co-organizer, workshops in the frames of national (Figure 1) and international forums, novel type of contests such as *Mathematics with a computer and Theme of the month*.

Figure 1. A course for multipliers in the frames of a Conference of the ´Union of Bulgarian Mathematicians´

A very interesting phenomenon is that in many of these events teachers participate with their students as a team.
To support the teachers in their first appearance as multipliers who lead courses of about 20 participants, a member of the IMI-BAS team joins them as a partner ready to offer a hand if needed.
Of course, the individual work with teachers is a crucial component in their professional development − it includes support for the design of a lesson, development of educational materials, organising mathematical fests, work on course projects, feedback on peer reviews, and preparation of a pedagogical experiment.

Another level of partnership with teachers is inviting them as co-authors of scientific articles and didactic resources, as partners in mathematics performances, as authors of collection of good practices.

2. The same but still different – character sketches of six multipliers

Specific examples of multipliers will be presented with emphasis on their work environment and educational strategies:

- Stela Kokinova – a math teacher from an elite language high school in Sofia with very motivated students
- Elisaveta Stefanova – a math teacher in a junior high school in Sofia
- Neli Stoyanova – a math teacher in a mathematics and science high school in Razgrad
- Daniela Kuncheva – a teacher in mathematics who works in a small village with unmotivated high-shool students
- Rumiana Angelova – a math teacher in a vocational high school in Pazardzhik, integrating math with art
- Maria Brauhle – a math teacher working in parallel in a small village with unmotivated students and in a private school in Sofia with highly motivated junior high school students.

3. Students taking the role of mentors

Other important activities of our team related to the Mascil philosophy include the work with students (through their teachers) or directly – face-to-face, in the frames of the High School Institute of Mathematics and Informatics (HSSI), where IBL is implemented at its highest level – doing original research in mathematics, IT and informatics (Sendova, 2014). In the recent years former and current students of HSSI take the role of mentors suggesting topics for scientific research and guiding younger students through the process till the presentation of the results in a written and oral form.

Colakoglu, C.H. (Ministry of National Education, Turkey — Practice-based presentation on personal dimension

Scaling-up PDs in Vocational Education and Training (VET)

Monday, 17:30-17:45, Room KA 101

Turkish Ministry of National Education, department of teacher education and development, is mainly responsible for teachers professional development (PD) programs. PDs have seen a challenging issue in Turkey. PD programs were usually criticised as being too short to make an impact on teachers' classroom practices. Due to short periods of training without any reflection afterwards, no evidence is reported on the effectives of these trainings. Many teachers argue that although the curriculum has recently changed, they haven't had any PD program on the new changes. In this talk, I will present a case study from 25 VET teachers. They participated in a two-day workshop in Istanbul and afterwards they involved in a follow-up workshop in Ankara as facilitators and/or multipliers. The teachers were also contacted to some companies to donate some PD materials and they managed to get enough researches to use in PDs. Such a bottom-up scaling-up PDs seems promising avenue to investigate. The preliminary results show that the participants made a substantial change in their classrooms and created a community of practice within and across schools.

Cyvin, J. (NTNU), Febri, M.IM. (NTNU), Gjøvik, Ø. (NTNU), Sikko, S.A. (NTNU), Staberg, R.L. (NTNU) — Research-based presentation on material dimension

Innovative ICT-based teaching materials in mathematics and science

Monday, 16:50-17:20, Room KG4 301

1. Introduction and relevance for the conference

This presentation will report on two case studies carried out in Norway as a part of the EU-project Fasmed funded under the FP7 scheme. The aim of the project is to examine the use of technology in formative assessment (FA) practices in mathematics and science teaching. Within the project, we have developed innovative ICT-based teaching materials embedding technological formative assessment support. These are both subject matter independent, for instance student response systems (SRS), as well as subject-specific software. The materials were developed in collaboration with the practitioners/teachers in a context of professional development (PD) in which a lesson study model was employed. Teachers tested the innovative approaches embedded in the materials, in continuing cycles of analysis – implementation – reflection. Further, the teachers disseminated the materials to their colleagues and supported them in their implementation. In this presentation, we address Topic 2 (Material dimension) from a target group-specific perspective, i.e. teachers in their everyday classroom practice. The following question will be addressed: "Which factors promote or impede the implementation of innovative materials in practice?" Our reflections will be based on findings from two different case studies in two different primary schools. As teacher educators we have been working with in-service teachers (educators) on designing materials, and therefore the proposal relates to the overall conference theme (Educating the educators), to one of the topics (Materials dimension), and to one of the mentioned target groups (teachers in their everyday classroom practice). We intend to use the oral presentation format.

2. Theoretical background

Formative assessment (FA), according to Black and William (1998) are "those activities undertaken by teachers — and by their students in assessing themselves — that provide information to be used as feedback to modify teaching and learning activities. Such assessment becomes formative assessment when the evidence is actually used to adapt the teaching to meet student needs" (p. 140). There have been several projects and initiatives concerning FA, also in Norway. However, it appears that most of these projects have had a focus in general pedagogy rather than in subject specific areas (Sandvik and Buland 2014). The Fasmed project, however, is focused on science and mathematics teaching and may therefore contribute to new knowledge about FA within a subject specific frame.

Quellmalz (2013) argues that technology can "help teachers plan, implement, and refine classroom for¬mative assessment strategies" (p. 10), and allows teachers to perform assessment that involves cognitive processes- not only fact-based knowledge. According to Aldon and Dempsey (2016), technology can further enable teachers to send and share assessment results, to process and analyse them quickly and to create an interactive, collaborative environment for learning.

In this study, innovative teaching materials embedding ICT-support for cognitive FA-practices were designed and implemented.

According to Drent and Meelissen (2008), use of ICT can be defined as innovative if (1) it facilitates student centred learning and (2) there is a variety in the selection of ICT tools being used (p.191). Several factors may impede or promote innovative use of ICT. In this presentation, we focus mainly on manipulative and endogenous factors, i.e. factors that are possible to change. Manipulative factors on the school level could be school ICT infrastructure, and collegial interaction and reflection. On the teacher level, manipulative factors could be views on ICT in education, and didactical ICT competence.

3. Materials and methods

Two cases were studied. Each case consisted of a series of lessons first developed at one school and subsequently redesigned for a different group of students at another school, using the spiral model (Maaß and Doorman 2013). A lesson was first planned at a Fasmed meeting with didacticians and teachers. One of the teachers subsequently conducted the lesson with the others observing. After the lesson, the group met to reflect upon the session. Based on this reflection, the lesson was redesigned for use at another school. The redesigned lesson was also observed by the same group of teachers. All lessons embedded FA using one or more technological tools.

Multiple data sources were collected to insure in-depth analysis: pre- and post-interview with the involved teachers, lesson plans, student tasks and other written material used during the lessons, observation sheets, audio transcripts of teaching sessions, student interviews, student q-sorting results, student workbooks and photos from the lessons. In this presentation, we focus mainly on the teacher perspective and describe results from teacher interviews and classroom observations.

For the case study in science, the SRS Socrative, was used. The first lesson had three parts; an introductory part about microorganisms, a middle part where students carried out experiments and made graph plots, and a final part where results were presented. Using Socrative, the teacher assessed pupil understanding by asking: "What's the best way to prevent a sneeze travelling? Why do we cough and sneeze? What kind of microorganisms travel in a sneeze? How fast do you think a sneeze can travel?"

The mathematics case involved the use of a graph logging activity. Functions and graphs are not part of the curriculum until lower secondary school in Norway, making this topic open for unbiased experiments. Students worked with technology for visualization of time-distance graphs, making graphs by walking in front of an echo sounder (Pasco system) connected to a computer. The computer gave a live display of graph in a time – position coordinate system. Students worked on a mix of practical tasks, and open-ended questions about interpretation of the graphs from the walks.

4. Factors promoting or impeding innovative use of ICT materials

It is evident from our study that the use of ICT is motivating for students; and as such it is easier for teachers to use ICT as a teaching material than materials without such motivating factors. We see this as a manipulative factor on the teacher level. One teacher said in the post interview

It is motivating I think and that is a big added value really for me, that you get kids that are often not inspired by reading or writing and doing things that way, to get inspired by the use of technology.

The echo sound activity made this lesson stand out from ordinary mathematics lesson. A student said that "It was very different (…) In maths lessons we never move, we sit at our seat; except sometimes we go out to do measurements". Another commented that in the classroom they usually have to compute things, whereas in these lessons "there were word problems and we had to do things". It is apparent that a motivating factor was that the lesson involved physical activity and engagement.

After the 2nd session the teacher said that those groups who had done the echo sound activity first, solved the part with pairing story and graph faster. The teacher found that this, with high probability, was because they had done the practical activity first and had better understanding of the concepts. It was not possible to distinguish any big differences between high and low achieving students, indicating that these kind of activities may raise low achieving students' motivation.

After the sessions with time-distance graphs one of the teachers said he had learned a lot about his students, and in particular how good these tasks had been to reveal misconceptions.

In post-interviews, SRS systems were said to be well liked and easy to implement. It had been used a lot since being introduced in Fasmed lessons. It is also clear that most teachers didn't have any prior knowledge about SRSs, and simply learning about it opened up new possibilities:

I have worked with graphing and interactive resources with the kids before, but I haven't used any of the tools that we've discussed in the seminars. I haven't used any of them before we started this project. Kahoot or Socrative or any of this, (…), so it was all completely new. (Teacher post interview).

Peer-to-peer feedback was encouraged by the teacher e.g. by asking students to comment on each other's results during a presentation with Socrative: "What do you think?" "Do you agree with..?" "Which statements do you agree with the most? Or least?". She further stated the value of technology in connection with FA, e.g. by saying:

I do see the value of using the technology now, especially when you can do a quick thing, go into the report and see, and then come back to that in a follow-up lesson, because it gives you more of a chance to look over and see who is understanding this, and who isn't, in a way you don't get when you're doing a very quick forms of assessment in the classroom on white boards. (Teacher post interview)

A well-known advantage with technology is its ability to provide instant feedback. Feedback was provided live on-screen, both with the SRS and with the graph plotting software. On the other hand, a well-known drawback with technology is unforeseen technical issues. In the case of SRS, the system depends on WiFi being available and functioning. For the graph plotting activity, there were some software issues that called for technical assistance.

5. Conclusion

We found that through this study the teachers have become more conscious of the importance of FA and in implementing them. A great range of approaches for FA has been employed, digital or non-digital. They were all found to be useful in making students' thinking visible to teachers. The digital ones were found to be convenient and effective as means for presenting and recording the results of students' work or answer to questions. There were concerns however, about the dependence on the internet access and stability in using student response system such as Socrative or Kahoot. It seems that technological issues are unavoidable part of using technological tools in the classroom. Despite this, teachers became more confident in using technology. Teachers did also become more conscious of the use of technological tools, especially with regard to students learning outcomes.

Dalby, D. (University of Nottingham) — Research-based presentation on personal dimension

The role of the facilitator in developing collaborative professional learning communities

Monday, 17:45-18:00, Room KA 106

1. Introduction

This paper relates to the conference theme by examining two contrasting cases involving the development of collaborative professional learning groups from another EU funded project and considering findings relevant to the Mascil professional development model. The comparison focuses on the role of the facilitator in developing an effective professional learning community and therefore relates to the personal dimension (Topic 1) of the conference theme, addressing the question of how different approaches and pre-conditions concerning the facilitator in relation to his or her colleagues affect the development of the community.

The session will take the form of an oral presentation and discussion, based on the development of professional learning communities during the EU funded Fasmed project (Improving Progress through Formative Assessment in Mathematics and Science). This study focuses on the use of digital technology within formative assessment processes in mathematics classrooms but also involves groups of teachers in a collaborative professional development journey as they work with a research team.

The development of professional learning communities as a means of effecting sustainable changes in teacher practice has received much attention and seems to offer an effective, practical method of achieving this aim (Wiliam 2007). To build such communities, teachers need to be involved in collaborative activities with a shared vision and a focus on student learning (OECD 2013). Collegial interaction has been identified as an important element of professional learning that can assist

teachers in integrating new ideas into their existing practices (Timperley 2008) and shared activities such as reflection, observation and feedback can contribute to the establishment of effective learning communities (OECD 2013). In view of these claims, the construction of such collaborative teacher communities seems crucial in designing effective models of professional development and the roles of individuals as agents in the development of a learning community are worth some further examination.

2. Methodology and analysis

For the Fasmed project, in each of the participating schools a group of teachers worked collaboratively with researchers to develop a series of lessons using digital technology within formative assessment in different ways. The development of each lesson followed a cyclical model, based on design research methodology, with a repeated pattern of design, trial, feedback and revision to explore the different ways of using iPads in formative assessment. The cyclical design activity also engaged teachers in a professional development cycle as they used their existing knowledge, received input from the research team, trialed lessons in the classroom and received feedback from observers. This way of working has some similarity to the Mascil model in which spirals of analysis, implementation and reflection are used in professional development. Despite some differences in the main project aims, a study of the collaborative professional learning process that took place with these groups of teachers during the Fasmed project suggests some useful considerations for the implementation of the Mascil model. In particular, the significance of the facilitator is highlighted and how their positioning within the group influences the development of a professional learning community.

An analysis of qualitative data, from teacher interviews and observations of group meetings, was carried out and cross-case comparisons were then used to identify points of difference between the two case study groups. The characteristics of domain, community and practice, suggested by Wenger (2009) as critical in constructing effective communities of practice, formed a framework for this analysis and led to an examination of how certain key features were influential in the development of each group as a professional learning community. The findings suggest four particular aspects that have an impact in these cases: the development of shared aims, the division of responsibilities, the communication between members and the professional relationships between the teachers. The first of these aspects is connected to the domain of interest whilst the others relate to the characteristic of community.

In both of these cases there were initial differences in aims between individual members of each community but in the first case the facilitator ensured that these were discussed and negotiated before the lesson development took place. This enabled some shared aims to be established and for each member to make a commitment to a clearly-defined domain of interest. In contrast, in the second case, the teachers approached the project with individual aims but these were not discussed and the diversity remained. This group had more difficulty working together collaboratively due to the lack of a shared vision for what they were trying to achieve.

The *division of responsibility* in the first case involved the facilitator taking the lead when convening meetings, liaising with the research team and sharing information. Despite this concentration into one organisational role, other responsibilities were distributed and all the members were equal contributors of ideas and reflections in meetings. In the second case, the facilitator, who was the expert with technology, quickly assumed the main responsibility for designing the lessons and liaising with the research team. As a result, less collaboration took place, an unequal distribution of responsibilities and the other group members had limited input into the design process.

The development of a collaborative community in the first case was based on pre-existing strong professional relationships but these were supported by regular communication between teachers and shared responsibilities in a culture of trust and mutual respect. This combination of responsibilities, communication and relationships led to the development of a strong and effective community. In the second case there was less evidence of discursive communication between colleagues and the group

had more difficulty making the transition from being a collection of individuals to becoming an effective professional learning community.

3. Conclusions

These cases show how certain key features of these teacher groups and their interactions influenced their development as professional learning communities. The evidence from this project suggests that facilitators have a particular role to play in creating suitable conditions for the growth of these learning communities. The potential to act as an agent of change within a developing community is illustrated here by the contrasting effects of the roles and interventions of these two facilitators. One of these took actions that promoted collegiality and allowed a collaborative learning community to be developed whilst the other used their individual expertise and skills to fulfill the main aims of the project without developing an effective collaborative learning community with their colleagues. The expected impact on changing classroom practice (Timperley 2008, Wiliam 2007, OECD 2013) therefore seems unlikely without the facilitator acting as an initiator of key actions to develop elements of domain and community (Wenger 2009, 2011) that appear fundamental to the establishment of an effective professional learning community.

By examining the evidence from these two specific cases, there are some indications of how the role of the facilitator plays an important part in the development of a professional learning community. These findings indicate some key areas for further consideration that may be beneficial in the implementation and refinement of the Mascil professional development model.

Dannemann, S. (IDN Didaktik der Biologie, Hannover), Gropengießer, H. (IDN Didaktik der Biologie, Hannover) - Researched-based presentation on material dimension

Using video vignettes as cases to foster the abilities of pre-service teacher students to design learning activities

Tuesday, 9:55.10:25, Room KA 101

1. Pre-service teacher students do not consider students' conceptions

The knowledge how to design learning activities is exclusive and fundamental for teacher professionalism. Shulman (1980) emphasizes the consideration of students' conceptions as a crucial factor. However, many science teachers (Abell 2008) and pre-service teacher students (Dannemann et al. 2014) are not reflecting on students' conceptions when it comes to design learning activities. They are focusing on the teaching of scientific facts that are classified as correct.

Video vignettes are used as material to scale-up professional development in various ways. In this research project they serve as cases (Merseth 1991) to foster pre-service teacher students' abilities to diagnose students' conceptions and to consider them to design learning activities in biology education. The presentation focuses on quality criteria to design video vignettes and the effects of a tutorial with pre-service teacher students who work with them (Topic 2, Question 1). Both approaches could be transferred to other subjects.

2. Students' conceptions are crucial for effective learning processes

The theory of experientialism explains how understanding processes take place (Lakoff and Johnson 1997). To understand a specific biological phenomenon conceptions are combined in order to construct a meaningful explanation. In many cases these explanations are not scientific, but everyday explanations that were constructed from everyday experience. Biological explanations are often counterintuitive. To construct scientifically adequate explanations students need to reflect on their everyday experiences and conceptions. If teachers know about their students' conceptions they are

able to design learning activities that foster scientific understanding. Studies show positive effects if individual students' conceptions are explicitly addressed in learning activities (Reinfried et al. 2009).
To structure design processes for learning activities the model of educational reconstruction was developed. It divides the planning process into three parts: 1) diagnose the learning needs, especially students' conceptions, 2) clarify critically the scientific understanding, and 3) design learning activities using the results of the other parts. The three parts are linked to each other and performed iteratively. They describe core skills teachers need to design learning activities in a professional way (Reinfried et al. 2009). Therefore, pre-service teacher students have to acquire them during their education.

3. Video vignettes as cases to foster diagnosis and design abilities

The video vignettes include short sections of an interview with one learner, a middle or a high school student, about a biological phenomenon. These sections are key scenes that were taken from a longer interview. They show typical students' conceptions. Therefore, the video vignettes are cases and offer an opportunity to experience the importance of students' conceptions. Since more than twenty years case studies are used in German teacher education mainly for pedagogical purposes. In this study the video vignettes have a dual purpose for biology education: 1) they show typical students' conceptions for different biological topics and 2) they work as impulses to design learning environments for the pupil in the video. Practical and theoretical abilities of pre-service teacher students are addressed.

3.1. Quality criteria for the design of video vignettes

Video vignettes that are designed in order to promote the diagnosis and design abilities of pre-service teacher students need to comply several conditions. The basal criterion is that the video recording is useful and the learner and the interviewer speak understandably and appear authentically. If the pre-service teacher students have any doubts many of them are not motivated to spend their time on planning processes. To reach authenticity the atmosphere has to be pleasant and the learner is motivated and acts independently.
Most decisive are the content and the analytical potential of the video vignette that have to meet different quality criteria. The video vignette has to enable pre-service teacher students to interpret typical students' conceptions. Therefore, it presents statements, visualisations, or other representations. The chosen key sequences shall allow an interpretation of the learner's explanation, i. e. they have to be meaningful. To facilitate the interpretation, the complexity of the vignettes is reduced compared to school education: they focus on the statements of one student that are examples. Compared to many case studies that concentrate on multiple perspectives on situations (Merseth 1991) the video vignettes focus on the cognitive perspective. Coherence means that the learners' statements shall show their understanding of relations that often spread about different biological levels of organisation. These three aspects ensure that the video vignette is readable for the pre-service teacher students. At least, the students' conceptions have to correspond to typical conceptions due to recent scientific knowledge. These quality criteria give orientation to design cases that combine the evidence of an authentic video situation and the theoretical perspective on students' conceptions.

3.2. Effects on pre-service teachers diagnostic and design abilities

Three video-vignettes were implemented in a tutorial with bachelor and master pre-service teacher students. One tutor works with two or three pre-service teacher students. They were asked to design learning activities for the learner that they saw in the video vignette. The design abilities of the pre-service teacher students were diagnosed and they were fostered according to their individual learning needs. To test if the seminar scales-up the diagnosis and design abilities six tutorials were videotaped and evaluated (N = 14). The planning processes and the products, i.e. the analysed conceptions and the designed activities, are analysed using qualitative content analysis and metaphor analysis (Gropengießer 2005).
The results show that three factors mainly influence the quality of the design process: orientations, theoretical knowledge and the performance of the pre-service teacher students (Fig. 1). They are

related to each other. The orientations comprise the perspective on education and, consequently, on the teacher’s performance or the students’ understanding processes. The preservice teacher students refer to their orientations to justify their performance in the design process. In the beginning many students think and act teacher-centred (left side of fig. 1). To design learning activities they use existing material that is just revised regarding the mode of expression and the presentation. While working with the video vignettes the pre-service teacher students are able to broaden this perspective. They also consider the learner’s perspective as important to design learning activities and they improve their abilities to diagnose students’ conceptions. Furthermore, they start to analyse scientific texts critically because they realise that they sometimes support everyday conceptions. In many cases even the designed learning activities focus on a conceptual reconstruction from the students’ everyday to scientific conceptions.

The model of educational reconstruction seems to be a helpful structure. It enables the pre-service teacher students to bring together the scientific and the students’ perspectives in order to design learning activities. The most promising learning activities to foster this conceptual reconstruction of the pre-service teacher students will be presented. They can give suggestions to design tutorials for other subjects.

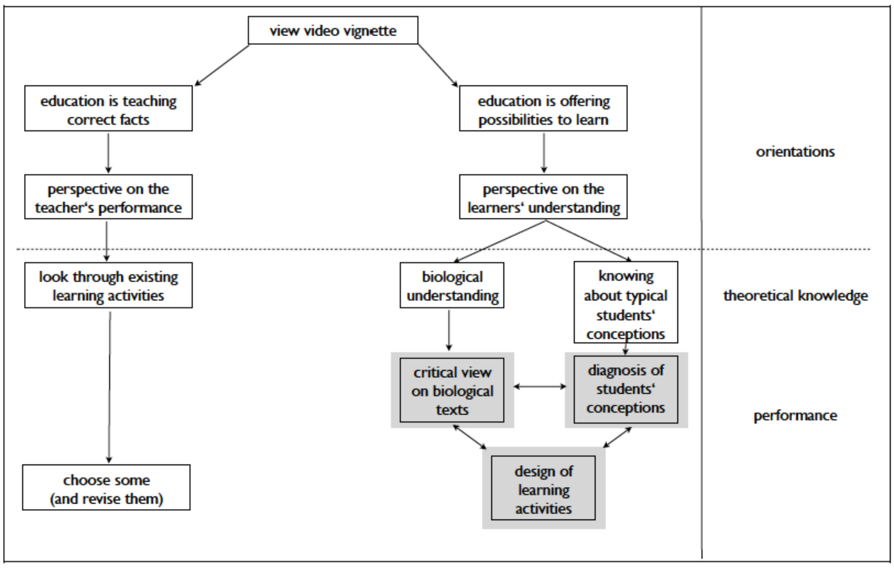


Figure 1. Comparison of the everyday and the elaborated model of design competencies of pre-service teacher students

Up to now more than 30 video vignettes for different biological topics were designed (e.g. evolution, blood circulation, and photosynthesis). A selection may be ordered from the author. They are used in different university courses and for teacher training programs. In the presentation a video vignette is shown to illustrate the quality criteria. Furthermore, the structure and learning activities of the tutorial are discussed.

Doorman, M. (Utrecht University), Wijers, M. (Utrecht University), Jonker, V. (Utrecht University), de Haan, D. (Utrecht University) — Practice-based presentation on material dimension

PROMOTING 21st C SKILLS WITH PROBLEM SOLVING CHALLENGES FOR TEAMS

Tuesday, 11:30-12:00, Room KA 101

1. Introduction

To survive in modern day society, the emphasis of education should be on 'learning what to do with knowledge', rather than to focus on 'what knowledge to learn' - this shift is referred to as the essence of 21st century skills (Silva, 2009). This implies a focus on skills like critical thinking, problem solving, inquiry, creativity, communication. These skills are not only related to the 21st century, however. Problem solving and mathematical thinking have been part of mathematics education in several countries around the world more for than decades (Törner, Schoenfeld & Reiss, 2007).

The growing interest for promoting these 21st century skills in education results in a major challenge for the mathematics and science education community. In the Netherlands we have experience with team competitions for mathematics in lower and upper secondary education that serve the purposes of 'learning what to do with knowledge'. Teams of three or four students work one day on an assignment - an open ended problem situation - in which 21st century skills must be used to solve a real world problem. The result of the assignment is a written report. Since the start about 150 schools and over 5000 students per year participate in these competitions in the Netherlands.

The tasks for these competitions are carefully designed, they create the need for being creative and for collaborating. Furthermore, participating the competition influences the school-mathematics culture, especially in cases where schools participate for many years. In such schools exists a more open understanding of mathematics as a tool for solving problems that occur in workplace contexts or in daily life.

In this presentation we will discuss the characteristics of these tasks, the work of the students, the implementation strategy in the Netherlands and ways to evaluate the students' final reports.

2. Problem solving challenges for mathematics

2.1. The problem solving challenge for teams in lower secondary mathematics education

The Mathematics Day for Lower Secondary schools (http://www.fi.uu.nl/nl/onderbouwwiskundedag/en) is a mathematical competition for teams of three or four students, It often is the first time students in lower secondary education are confronted with an open-ended problem that appeals to a creative use of their mathematical knowledge and to problem solving skills. In teams of 3 or 4 students, they work on such a problem in which they have to systematically organize their work.

Examples of problems are: design a timetable for your school, in which lessons and breaks are scheduled in such a way that the result is most "effective"; design of patchwork (which appeals to creativity), based on an investigation of symmetry and patterns in patchwork; write an advisory report for fish biologists using mark-recapture methods for estimating the number of fish in a pond (the problem was called "Fish and peas", because the students had to systematically design and carry out experiments with marked peas); design a way to efficiently (based on research and calculations) package 10 tennis balls, present a manual for actually producing the package. See figure 1.

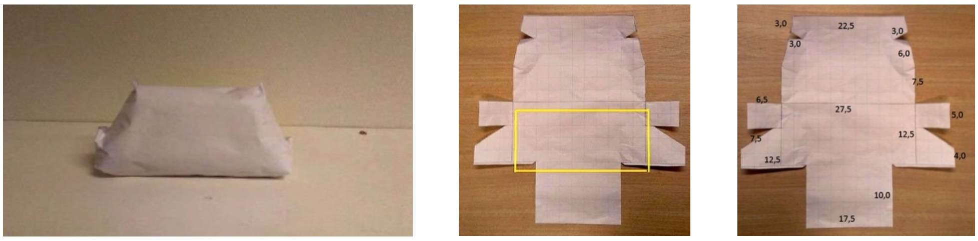


Figure 1. Student solution of the packaging problem

Especially the inquiry part on systematic experiencing and collecting and organizing data appeared to be very hard for the students. They are easily satisfied, sometimes already after one or two experiments that confirm their initial ideas - which makes it relevant for teachers to prepare their students for these type of problems (Wijers, 2015). The assignments regularly start with introductory questions on the context, in the middle part the main focus in on exploration and analysis of models or solutions to experience the scope of the problem. The last part asks for creativity and new models or solutions, the product is mostly a written report.
Each school may send their best report to the organizing committee at the Freudenthal Institute, the jury will determine the winning team. Teachers of participating school are responsible for the organization in the school and the selection of the candidate-reports.

2.2. The problem solving challenge for teams in higher secondary mathematics education

Since 1990 the Mathematics Alympiad (http://www.fi.uu.nl/alympiade/en/) provides tasks to practice 'higher order' skills related to modelling, problem solving and learning to inquire (Doorman e.a., 2007). These tasks are used for team competitions of three or four students (upper-secondary level) in schools. This is the case in the Netherlands as well as in other participating countries (e.g. Denmark, Germany and Iran). Each school may enter the Mathematics Alympiad with one or more teams. One of the teachers of the participating school is responsible for the organization in the school, the selection of the candidate-reports and the assessment of a number of reports of the preliminary round. Teachers organize student-led inquiry, group work and support students while they work on a very open-ended problem.
The contents of the mathematics curricula in the participating countries do not need to be exactly the same. In the Mathematics Alympiad skills like being mathematically creative, being able to collaborate and communicate about mathematics, have to be used and are assessed. The assignment consists, in general, of three parts: an introduction of the context with introductory questions, a more explorative part to experience the scope of the problem and analyse models or solutions of others and finally a part that asks for a creative solution that must be presented as a product, for example an advisory report, a design for a game or for a lay-out for safety cameras in a museum, or a plan for container logistics in a harbour.

3. Task characteristics

The tasks are primarily designed for use in competitions, aimed at assessment and less at ‘learning’. Students work on the assignment in teams for one full day and produce a report. This report is first ‘judged’ by their own teacher; the best ones are then judged by a teacher of a different school or by the jury of members of the committee. This results in a winning team.
As said before the assignments need to be designed in such a way that they elicit problem solving mathematical thinking and inquiry. An important characteristic of the tasks is that they are ‘new’ to students; the problems are non-routine and non-trivial. Schoenfeld (2007) states that these types of problems are needed for problem solving to happen. The absence of a known procedure forces students to come up with ‘new’ strategies, that need to be tested, compared and evaluated.
Besides general characteristics that elicit problem solving, mathematical thinking and inquiry it is important that the assignments are suitable for a competition. An important condition for a competition is that the teacher has a minimal role. The teacher facilitates the organisation and the

process, but provides no content-related guidance. This asks for a well-structured but open assignment. All teams must be able to 'enter the problem' without help from a teacher, and at the same time – in order to determine a winner – the problem has to allow for different approaches and strategies based on decisions by the students. When describing characteristics of rich collaborative tasks, Swan (2005) speaks of tasks being 'accessible and extendable'. The accessibility and extendibility of the tasks, which are situated in real contexts - is realised by a more or less fixed structure:

- The first part is an introduction with some smaller, less open problems to get to understand the context. This ensures that the assignment is accessible for all students;

- The middle part often asks for an analysis of data, a model, or a solution that is presented in the assignment;

- The final part asks for creativity in designing, comparing and evaluating a new approach, system, model, solution or product. In this way extendibility is made possible, this will differentiate between teams.

This structure has proven to be successful in over the years of developing and implementing the team competitions.

4. The potential for PD
In connection with the team competition, teachers are offered the opportunity to join a professional development event. During this one-day PD-event teachers work on the task and experience themselves the task characteristics and aspects of skills related to inquiry, modelling and problem solving within the context of the task. The mathematical aspects of the possible solution strategies are discussed. An important topic of the day also is the preparation of students for this type of problems, and the evaluation of student (team-)work on such open-ended, but carefully structured tasks.

5. Conclusion
The combination of these team competitions together with the PD events appeared to be a successful leaver for scaling up the promotion of 21st century skills in mathematics education. Teachers feel the need to prepare their students for these team competitions and they are provided with the tools to evaluate the promoted skills. Students are offered the opportunity to engage in problem solving, to be creative and to work in teams. Furthermore, they experience the value of using mathematics while solving real world problems in teams.

Dreher, U. (University of Education Freiburg), von Gehlen, M. (University of Education Freiburg), Hochbruck, W. (University of Freiburg), Holzäpfel, L. (University of Education Freiburg) — Practice-based presentation on structural dimension

"Praxiskolleg" Freiburg: Creating a Community of Practice Network for Teacher Education

Tuesday, 15:45-16:15, Room KA 106

The Freiburg Advanced Center of Education (FACE) started officially in December 2015 as a project backed by Federal funding, and designed to establish and/or improve cooperation between the Albert Ludwigs University, the Freiburg University of Education, the state teacher training seminaries, and schools in the region. A central element of this cooperation is the community of practice known as 'Praxiskolleg'. Its prime objective is to build a network between all institutions that share in the training and continuing education of teachers. The aim is to integrate all phases of teacher training and

education. So far, universities, state teacher training seminaries, and the school system, have been operating in the training of teachers in succession, and with reasonably good results. However, their efforts were arranged more or less independently of each other. The new system is aimed at convergence, integration, and more efficiency. It is also designed to encourage teachers already in the school system to upgrade their scholarly as well as didactic skills with the help of special programs offered by the two universities.

Throughout the process of integration, it is important to keep in mind that all participating institutions are dedicated to the same goal, the improvement of the teacher training process. For this reason, it is necessary to understand the process of networking as dehierarchised and generated discursively, and as a process of learning (see Weber 2002, p. 10), in which all parties subscribe to the same underlying principles. The network processes themselves are subject to high quality standards (cf. Minderop 2016, p. 294), which entails that they are being monitored, and accompanied by qualitative interviews and evaluations.

The community of practice / 'Praxiskolleg' will ideally ensure that, through the cooperation of their alliance of schools, universities and state seminaries, especially the practical phases of the teacher training program build on each other, providing a systematic, gradually increasing teaching experience, and a constant exchange on mutual expectations. Special attention will need to be paid to the transitions from one phase to the next; from the orientation phase during the double-major Bachelor course of studies, via the (integrated) practice course during the Master phase, to the 18-month state training program (Referendariat), and eventually to employment as teachers in the school system.

The integration and improvement of the processes and phases of teacher training will also enable the participant parties to reform and redesign the current image of teachers in society. This (admittedly rather formidable) effort will be conceptually coordinated with state education authorities, and school administrations. In order to ensure the effectivity of all measures, an internal system of quality control will be established, based on regular meetings of a task force of experts, and representatives of all participant institutions.

A new level of intensity in the cooperation between schools and universities is generated through the new status of participant schools as 'university partner schools'. Networking cooperation at this level will enable university scholars (e.g. from the Ph.D. collegiate group) to conduct extensive as well as intensive research operations in these schools, to accompany students in their practical phases etc. In exchange, teachers from the 'university partner schools' can access training modules in the theory, methodology, and didactics of their subjects, as well as advanced courses in their respective subjects themselves. In the future, all of these courses will be certifiable; credits are supposed to be used towards diploma and degree courses.

The scaling up idea is especially realized by a special feature: Schools whose main focus of cooperation lies on the internship that students' aiming for the teaching profession have to attend, a new qualification program. Each school sends one teacher to these professional development courses. Their learning aims are improvements in organisational skills, supervision, feedback and reflexion. The "teaching consultants" generated in these professional development courses then act as multipliers in their schools, and convey the respective standards to their colleagues. Their role extension from supervisor for student teachers to multipliers is comparable with that of a school-based teacher educator (cf. van Velzen et al. 2009, p. 61). Furthermore a teaching consultant arranges the cooperation between all teachers who supervise students in the school. On some schools teacher consultants install structured meetings, other ones use mainly informal arrangements to coordinate this cooperation.

Our paper will review incipient as well as firmly established experiences with the networking cooperations outlined above, both in terms of how research is facilitated and as regarding the promotion of continuing education modules within the framework of the 'Praxiskolleg'.

The presentation will focus on the structural dimension: Our project aims at the implementation of innovative, research-based approaches in education (in several subjects) within a regional network.

Regional strategies, contextual factors, effective exchange formats, structures for supporting the cooperation between different stakeholders and upscaling aspects will be discussed.

García, F.J. (University of Jaén), Romero-Ariza, M. (University of Jaén), Quesada-Armenteros, A. (University of Jaén), Abril-Gallego, A.M. (University of Jaén) — Research-based presentation on material dimension

Understanding differences between face-to-face and e-learning professional development, from the dual perspective of designers and facilitators

Tuesday, 15:15-15:45, Room KA 101

1. Introduction

The novelty of Mascil in contrast with other European projects is the design of an e-learning professional development programme. There were several reasons for the project to explore this way of professional development. One the one hand, many teachers are demanding more flexible professional development programmes that could fit better in their work schedules (TALIS, 2013). On the other hand, scaling-up is a main challenge that projects like Mascil are facing, and e-learning delivery has been identified as a possible successful strategy to involve a higher number of teachers, considering that the time and space limitations can be overcome more easily.

Mascil project has developed innovative materials to support the professional development of teachers in professional learning communities, although they can be used in a more traditional way as well. The design is rooted in Lave and Wenger's theory, which points out that "knowing about teaching is not acquired in courses about teaching, but in ongoing participation in the teaching community in which such courses might be a part" (Adler, 1996, p. 4).

2. Analysing Mascil's toolkits from a dual perspective

A set of materials to support the professional learning of face-to-face communities (the so-called Mascil PD toolkit) has been created within the Mascil project. Later on, these materials have been re-designed to be used in supporting e-learning professional development communities, giving rise to the so-called Mascil e-PD toolkit.

It is the aim of our presentation to carry out a theoretical analysis of the design of the Mascil PD toolkit, and of its redesign to be used with e-learning communities. The analysis will be mediated by the Anthropological Theory of the Didactics (Chevallard and Sensevy, 2014).

First of all, the Herbartian scheme proposed by Chevallard (2012) will be used to get a deeper understanding of the way in which the toolkits have been designed to support professional learning communities. This analysis seems to be especially relevant because it allows us to uncover intended dynamics within the professional learning groups, that would be useful to both analyse other professional development materials, or to create new ones.

Second, we will focus on group facilitators of professional learning communities, as it is described within the Mascil toolkits. The notion of didactic praxeologies (Chevallard, 1999) will help us to describe and analyse their role when they are supporting and guiding these communities. Particularly, we will focus on commonalities and differences when facilitators' work is about supporting a face-to-face community or an on-line one.

Finally, we will draw some conclusions from our own experience as designers and facilitators of e-learning professional development communities. These will be connected to the previous analysis, and might be useful for others when designing e-learning professional development programs, or facilitating e-learning professional development communities.

Throughout the paper, we aiming at shedding some light into the following questions:

- What are the quality criteria for the design of materials for PD? What are the features of materials for PD that are suitable for promoting IBL and/or more closely connect science and mathematics learning to the world of work?
- Which features do excellent e-learning materials have? How can existing PD materials be modified and adapted for use in an e-learning environment?

Geiger, V. (Australian Catholic University), Mulligan, J. (Macquarie University) — Research-based presentation on material dimension

Creating STEM Online Materials for Pre-Service Teachers Through Interdisciplinary Collaboration Between Mathematics Educators, Mathematicians and Scientists

Monday, 16:50-17:20, Room KA 101

1. Introduction
The purpose of this presentation is to describe processes utilised in developing an online learning program for preservice teachers as part of a significant teacher education project in Australia, Opening Real Science (ORS) – Authentic Mathematics and Science Education for Australia. ORS is part of the national program Enhancing the Training of Mathematics and Science Teachers (ETMST) (2013-2016), initiated in response to growing concern about declining enrolments in mathematics, science and engineering in Australian schools and tertiary institutions. The ORS project draws on the expertise of mathematics and science educators, mathematicians and scientists in a collaboration that aims to enhance the content and pedagogical knowledge of pre- and in-service teachers by structuring the learning of mathematics and science as they are practised – as a dynamic inquiry into the nature of real world phenomena. To this end, ORS has developed 25 online learning modules across mathematics and science. Within these modules mathematical and scientific knowledge is situated within authentic contexts drawn from the experiences of practicing mathematicians and scientists. Consistent with the principle that teaching and learning should mirror authentic practice in these disciplines, enquiry-based pedagogical approaches were considered essential. Students access these modules via a Moodle site that is enabled with a range of online pedagogical tools. Thus, this presentation will address Topic 2 – Material dimension of educating teachers and facilitators: The role of classroom and PD materials and tasks and attend to questions 2, 3, 4, 5 and 6 of the dimension descriptions. This will be an oral presentation within which participants will have online access to selected modules within the ORS project.

2. Background
Falling participation in mathematics, science and technology in Australia has created doubts about Australia's long-term capacity to innovate and compete in an increasingly STEM driven global economy (e.g., Australian Academy of Science, 2016). The root cause of falling participation rates has been linked to students' perceptions of mathematics and science as characterised by didactic instruction and that practical classes are "largely about recipes or watching teachers following recipes" (Office of the Chief Scientist, 2012, p. 9). Accordingly, five key areas were identified as necessary to strengthen mathematics and science teaching in the report Mathematics, Engineering and Science in the National Interest (Office of the Chief Scientist, 2012): (1) Inspirational teaching; (2) Inspired school leadership; (3) Teaching techniques; (4) Gender issues; and (5) Scientific literacy. The principle foci for ORS has been on attention to (1), (3) and (5) of these identified key areas.

3. Conceptual underpinnings
Module development has been underpinned by the Biological Sciences Curriculum Study (BSCS) 5Es Instructional model (Bybee, 2009). This model has been used to structure and sequence all modules

across the project. The 5Es enquirybased approach to science education consists of five phases: engagement, exploration, explanation, elaboration and evaluation. Each phase has a role in developing students' understanding of scientific and technological knowledge, attributes and skills (Bybee, 2009). A summary description of these phases is set out in Table 1.

Table 1. Summary description of the 5Es instructional model (Bybee, 2009, p.8)

Engagement	The teacher or a curriculum task assesses the learners' prior knowledge and helps them become engaged in a new concept through the use of short activities that promote curiosity and elicit prior knowledge. The activity should make connections between past and present learning experiences, expose prior conceptions, and organize students' thinking toward the learning outcomes of current activities.
Exploration	Exploration experiences provide students with a common base of activities within which current concepts (i.e., misconceptions), processes, and skills are identified and conceptual change is facilitated. Learners may complete lab activities that help them use prior knowledge to generate new ideas, explore questions and possibilities, and design and conduct a preliminary investigation.
Explanation	The explanation phase focuses students' attention on a particular aspect of their engagement and exploration experiences and provides opportunities to demonstrate their conceptual understanding, process skills, or behaviors. This phase also provides opportunities for teachers to directly introduce a concept, process, or skill. Learners explain their understanding of the concept. An explanation from the teacher or the curriculum may guide them toward a deeper understanding, which is a critical part of this phase.
Elaboration	Teachers challenge and extend students' conceptual understanding and skills. Through new experiences, the students develop deeper and broader understanding, more information, and adequate skills. Students apply their understanding of the concept by conducting additional activities.
Evaluation	The evaluation phase encourages students to assess their understanding and abilities and provides opportunities for teachers to evaluate student progress toward achieving the educational objectives.

4. An exemplar module

In this section, the processes engaged to develop a module on mathematical modelling, Modelling the present: Predicting the future, is presented to illustrate a typical approach to material development. The module team consisted of eight academics with backgrounds in mathematics, science, and mathematics and science education volunteered expertise in biological evolution, financial mathematics, astrophysics and environmental science as well as experience in the teaching and learning of mathematical modelling and instructional design. The process of module development was collaborative and emergent consisting of four phases: selection of content, identifying structure, and planning for subsequent phases; initial case study development; draft case study review; and finalisation of the module by linking of case studies. Case studies were identified through discussion of contexts that had the potential to promote students understanding of mathematical modelling and settled on the following topics: evolution and transmission of disease-causing agents (epidemiology); effect of market forces on the stock exchange in relation to investment and risk (financial mathematics); nature of eclipsing binary stars (astrophysics); and impact of pollution in waterways (environmental chemistry). This decision led to a subsequent discussion of how to organise the case studies within the module in a manner consistent with the 5Es model and within the constraint of 36-

40 hours of study over 4-5 weeks allocated for a module. The structure the team agreed on was: an introduction; a case study mandatory for all students; a second case study chosen from three options; and a final reflection tied to a capstone assessment. An overview of the module phases and their alignment with the 5Es model appear in Table 2. The module provided a high level of initial scaffolding that was slowly removed with the expectation that students would adopt increasing levels of independence as they progressed.

Table 2. Module phases and alignment with the 5 Es model

Description	5Es Model
Introduction: Description of the process of modelling and its importance. Overview of the unit, learning outcomes and assessment. Examples of how modelling is used to explain phenomena and make predictions (videos).	Engagement
Case study 1 Epidemiology-Humanity's greatest killers: Introduction to the nature of infectious diseases and how modelling can be used to predict transmission rates. Examination of specific epidemics, such as Ebola, to explore the mathematical modelling associated with understanding the spread of disease, based on biological mechanisms Assessment that required students to investigate mortality rates in relation to changes to influential factors in infectious disease spread based via the use of a prepared spreadsheet.	Engagement Exploration Explanation
Case study 2 (choice of Trading-Understanding investment and risk, Environmental chemistry-Impacts of pollutants in Catchments, Astrophysics-Modelling the big, the strange, and the too far to see): While the contexts varied, each case study provided: a description and background to real world scenario and specified an open ended problem within the chosen context; introduced a digital tool (e.g., a prepared spreadsheet) for investigating and responding to the problem; activities designed to promote students' understanding of the scenario, the problem and familiarity with the digital tool; assessment in which students were required to make predictions about aspects of the scenario/problem.	Engagement Exploration Explanation Elaboration
Reflection and capstone assessment item: Students must develop teaching resources for secondary mathematics students in which: mathematical modelling is introduced via a real world scenario; assumptions which underpin the chosen model are described; the model is used to make a prediction about a problem associated with the scenario; the usefulness and validity of the model are evaluated.	Engagement Exploration Explanation Elaboration Evaluation

5. Final Comment

The dimensions of the 5Es model underpin each module within the ORS providing for consistency and coherence across the program. At the same time, the processes associated with module development allow for ground breaking interdisciplinary collaborations among mathematics and science educators with practicing mathematicians and scientists – an intentional linking of perspectives and expertise within the project. Trials of these modules are currently underway with evaluation reports on the effectiveness of modules, in relation to student learning, forthcoming.

Hahn, T. (University Kassel), Eichler, A. (University Kassel) — Research-based presentation on structural dimension

Changing beliefs and motivation based on reflection on student outcomes

Tuesday, 15:45-16:15, Room KA 102

1. Relation to the Conference theme

Our study refers to research on effective characteristics of professional development programs. We focus especially on the professional development of teachers. Thus, we refer on educating in-service teachers which fits one part of the conference theme. International research shows that there are features of professional development programs which make them effective referring to teachers' learning. For example, professional development for teachers seems to be sustainable, when it is contend-focused, enables teachers to make extended experiences, is a part of daily work, etc. (Kedzior & Fifield, 2004; Lipowsky 2014). Especially, if the teachers focus on students' learning and if they notice improvement on students' outcomes, they seem to change their teaching practice (Guskey, 2002; Timperley, 2008). However, there is little research that is focused on one of the aspects of a potentially significant impact of professional development on teachers' knowledge and beliefs. Further, there is a lack of experimental or quasi-experimental studies that focus on the effectiveness professional development as a specific way of educating educators (cf. Yoon et al., 2007). For this reason, a main aim of our study is to investigate, how one feature of a teacher development course, i.e. the teachers' reflection of students' learning, could impact on teachers' knowledge and beliefs. Although our research project does not focus directly to the aspect of scaling up, we understand this project as a contribution to this aspect since scaling up needs a solid fundament of empirically proved characteristics of effective professional development.

2. Perspective

The study takes place in Germany. It investigates the effects of a professional development program in a federal state of Germany (Saxony-Anhalt). The course is supported by the German Centre for Mathematics Teacher Education (DZLM) and aims to prepare teachers' for teaching a new curriculum in lower secondary schools (grade 9 and 10). Our study has a national or rather a regional focus if the content of the program is regarded. However, our study has an international focus if the research on aspects of an effective teacher development is regarded since we conduct the professional development courses in a quasi-experimental design to investigate the impact of teachers' reflection on students' learning outcomes on these teachers' knowledge and beliefs.

3. Relation to topic 3: Structural dimension

This oral presentation refers to the third topic "structural dimension – "Systemic project designs for scaling up and their evaluation".

<u>Aim of the research</u>: Based on existing research in this field, we investigate, which are the effects of teachers' reflections on students' learning outcomes. Thus, in our research we refer to the structural dimension of effective professional development programs. As effects of potentially effective professional development programs, we measure the teachers' pedagogical content knowledge (PCK, Shulman, 1986), beliefs and motivation referring to PCK. Although reflecting students' outcomes in professional development programs seems to be a factor of effective teacher development (e.g. Franke et al., 1998), it is still not clear if reflection is a crucial factor of effective professional development compared to further characteristics that are addressed in a specific professional development program (Lipowsky, 2014).

<u>Focus of the presentation and related theoretical framework:</u> In this oral presentation we focus on one potential impact of an efficient professional development program, i.e. a change in teachers' beliefs. Teachers' beliefs are understood as an important part of teachers' professional lives since these beliefs have an impact on teachers' perception and interpretation of the teaching and learning of

mathematics (Eichler & Erens, 2015; Fives & Buehl, 2012). Teachers' beliefs could refer to the epistemology of mathematics (Muis, 2004), to preferences in respect to different mathematical subdomains (Eichler & Erens, 2014) or to an overarching teaching orientation that is understood to be independent from a mathematical subdomain (e.g. Staub & Stern, 2002). Two different learning orientations were discussed, i.e. the transmission view and the constructivist view (Fives et al., 2015). Transmission oriented beliefs focus on the direct transfer of knowledge from teacher to learners. In this teaching orientation, a teacher sends information directly to learners. The students are passive recipients. Instructional practice points out repetition of information and exact instruction that show step by step how to solve mathematical problems. For this reason, teachers talk most and demonstrate how mathematics works (Gates, 2006). Instead of this, a constructivist teaching orientation mirrors constructivist learning theories. Therefore, it highlights the active role of learners as constructors of their own knowledge. Based on their existing beliefs and knowledge structures they integrate new information in their mental networks (Decker, Kunter, and Voss, 2015; Staub & Stern, 2002). Voss, Kleikmann, Kunter and Hachfeld (2013) showed that these two dimensions are not the endpoints of a continuum. Instead of this, they are two distinct, negative correlated dimensions. A professional development course potentially aims to change teachers' knowledge and beliefs. However, teachers' beliefs are characterized to be robust and relative stable. Nevertheless, Liljedahl et al. (2012) argue that there is not a unique definition of beliefs stability. They point out that it is possible to change beliefs by interventions (like professional development), but it requires time. For this reason, beliefs in this study are understood to be changeable. A potential approach to change teachers' beliefs seems to be an explicit reflection on practice (Wilson and Cooney, 2002).
<u>Research questions:</u> Our main question for this proposal is, how the impact of teachers' refection on students' learning outcomes is on these teachers' mathematics related beliefs.
<u>Method:</u> We investigate two treatment groups in the federal state "Sachsen-Anhalt". One group took part in a professional development course with focus on reflection on students' learning outcomes. Instead of this, the other course did not use this feature, but reflect on the use of tasks without a specific focus on students' learning outcomes. A third group of teachers did not take part in a professional development course (control group). The teachers of each group completed questionnaires referring to beliefs towards mathematical teaching and learning two times: in the first meeting of the professional development course (pre-test) and at the last meeting (post-test). The control group completed the questionnaire in a similar time span. The instruments for measuring beliefs referring to a learning orientation are a short version of the questionnaire from Staub and Stern (2002). The instrument for measuring epistemological beliefs towards mathematics teaching and learning was adapted from TEDS-M (Voss, Kleickmann, Kunter & Hachfeld, 2013).
<u>Results:</u> Since the post-test will be in June 2016, we will present the results of the pre- and post-test. Furthermore, we show the development of teachers' beliefs in both groups to answer, whether reflection on student outcomes is a characteristic of professional development that makes it effective for teachers referring to belief change.

4. Questions will be addressed

It is important that teachers see learning through the eyes of their students (Hattie, 2009). For this reason, it seems to be necessary to integrate students' learning outcomes into professional development courses. Therefore, our study deals with effects of teachers' reflection on student outcomes. In our oral presentation we address the following questions:

1. What can a design of an initiative aiming for scaling up professional development look like and which features of professional development programs prove to be effective?
2. How can we investigate empirically the impact of different project designs?

As described in the above sections we want to investigate features that make professional development effective for teachers. The results of this study can be used to implement effective PD on a large scale in Germany and other countries.

Hornung, G. (University of Kaiserslautern), Engelhardt, A. (University of Kaiserslautern), Thyssen, C. (University of Kaiserslautern), Lutz, P. (University of Kaiserslautern), Kiekbusch, L. (University of Kaiserslautern) — Practice-based presentation on material dimension

“real-LiFe”: Using interactive feedback tools for teacher education in science

Tuesday, 10.50-11:20, Room KG4 301

1. “real-LiFe” a project and its relation to the overall conference theme

Expert teachers show proficiency at creating a classroom environment that is more conducive to learning by increasing the probability for more relevant, useful feedback (Hattie, 2003). This is not just a principle of importance for teachers at school; it is also relevant in teaching students who want to become teachers at universities. One point in educating educators is to improve their instructional quality, which is considered a major modifiable factor influencing students’ achievement (Hattie, 2009). Improving the quality of instruction requires the identification of the weaknesses and strengths of teachers’ performance concerning their teaching. Furthermore this identification should not be based on self-judgment, since for example results from video studies show differences between teachers’ self-judgment of own speaking time and their real speaking time (Helmke et al. 2008). Educating the educators in science education encompasses a broad range of topics and formats including professional development in field specific domains like practical lab skills. However, concepts and experiences approved in non-scientific education can be very useful in this area and vice versa.

“real-LiFe” is a concept with the aim to interactively identify strengths and weaknesses of students while training or analyzing classroom situations. The framework and concept of “real-LiFe” includes time resolved and summative feedback with voting-tools and digital questionnaires usable in a large variety of educating situations. The tools provide real-time feedback and results. This direct feedback allows a time saving analysis of the situations and the integration in multi-perspective cycles of analysis – implementation – reflection as in the spiral model. Our focus is to combine potentials of face-to-face situations and corresponding live feedback in an e-tool to provide less abstract and formative opportunities to learn.

2. Our specific learning community and educational settings

It is obvious that the traditional format of experimental exercise lectures arranged for science teachers - a simple presentation in front of the peers group - cannot really provide teaching training. However this is by far the most common structure applied at universities. Nevertheless, even the generation of authentic teaching situations is no guaranty for good lectures or practical courses since the success is also determined by the corresponding feedback for the trainees. The feedback stimulates the self-reflection of the practicing, self-assessment is sharpened and supports professionalization. In this context the "real-LiFe" project is integrated into teaching future educators at the University of Kaiserslautern in face-to-face lectures for students in the field of didactics of chemistry and/or biology. In the courses, there are a huge number of possible applications for tools that generate individual feedback. Such tools can be used by lecturers, teachers, students and pupils as a support for the reflection of their teaching units and their self-judgment. I. e. both, lecturers and students, can get a direct feedback indicating key points of performed seminars or learning settings in such lectures. The feedback from lecturers, teachers, fellow students and pupils is used to generate an analysis or graphical representation of the teaching achievement based on pre-defined, individual assessment profiles.

3.1 “real-LiFe” as an e-tool based project in the material dimension of educating teachers

The recording of a wide feedback considering multiple perspectives and the comparative analysis of the collected feedback data enables a student to improve his/her personal teaching performance. At the same time, giving feedback using the mentioned tools is an important training of the observation-

and assessment-competence. To ensure full cooperation of the students the survey has to meet different needs: a) it has to be time saving and b) the generation of the visualisations representing the data must be comfortable and quick. Hence, the project uses digital questionnaires and survey techniques instead of paper and pencil methods. Using data collected over time allows the creation of a personal e-portfolio to monitor individual progress and/or development. It can include for example profiles of the given talks in combination with the observed performances and diagrams that visualize the individual progress. As an electronic medium the e-portfolio has potentials which a paper-based portfolio cannot offer: e.g. entitled people can access the contents and material from everywhere.

3.2. How can we successfully combine face-to-face learning with e-learning in the concept of "real-LiFe"

Since safe and proper experimentation is a central content of studies in science, it is for example necessary to monitor one's progress regarding this topic. One possible application of "real-LiFe" is the evaluation of footage of scientific experiments, intentionally containing deficits regarding different aspects in scientific experimentation (i. e. safety precautions, perceptual laws, experimental skill ...). Beside this e-learning potential another obvious domain is the application to live performances of trainees.

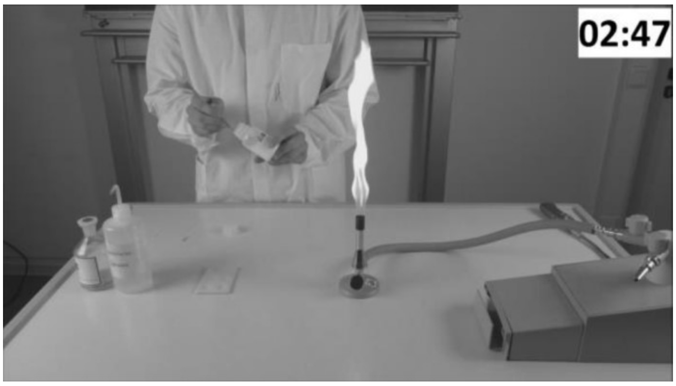


Figure 1. Still frame of experimentation footage or live performance during a classroom situation

Viewers can mark the point of time and the associated aspects of observed mistakes, while watching footage, videos or classroom situations.

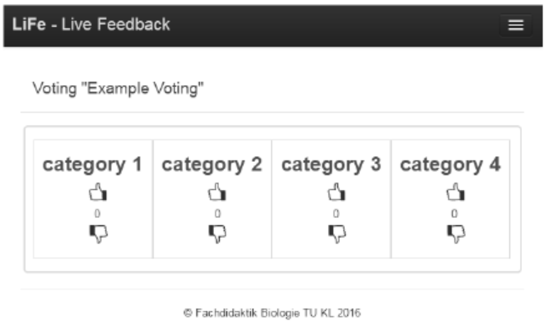


Figure 2. User interface of the voting tool used in "real-LiFe"

Tools included in the "real-LiFe" project can be used by educators to evaluate, if the students receive the mediated contents of experimentation, while students can check for their own shortcomings to improve their expertise in experimentation.

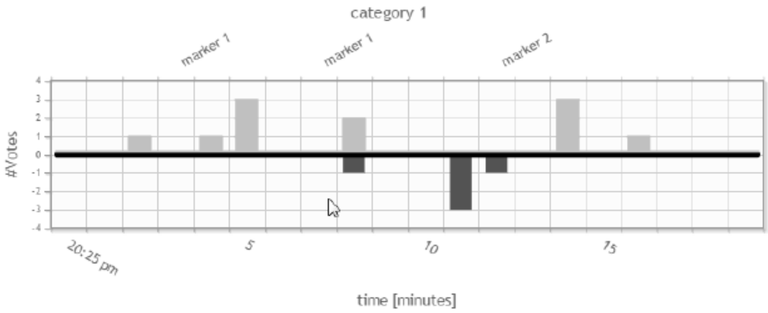


Figure 3. Example of a graphical summary in a tool used in "real-LiFe"

4. Intended structure for a practice-based presentation of "real-LiFe" as educational project
The potential und functionality of tools used in "real-LiFe" will be demonstrated with direct connection to an approximately 15 min talk covering the concepts, tools and aims of "real-LiFe". During this talk, as part of the presentation, selected tools developed for the project can be used by the audience to generate live feedback for the calculation of ratings and graphics describing instructional performance or quality according to selected categories. Based on this practical online testing and the information given in the talk, "real-LiFe" can be discussed as a concept and approach in educating the educators.

Jahnke, A. (Gothenburg University) — Research-based presentation on structural dimension

Analysing the architecture and epistemological foundation of Boost for Mathematics – a PD program conducted by 37,000 mathematics teachers in Sweden

Tuesday, 10:50-11:20, Room KG4 222

1. State-of-the art in Sweden
Since the publication of the Swedish Government Official Report (2004) from the Mathematics committee the 2000s have been marked by national attempts to increase students' results in mathematics by strengthening the quality of mathematics teaching through profession development. However, despite major initiatives the results have not improved (OECD 2015). The initiatives have been based on the pyramid model where multipliers at municipality level disseminating materials or by support to local projects through state funding. But changes in the Education Act have meant an increased focus on the scientific base of school practice, which in turn requires that the design of national initiatives to a greater extent makes use of research findings. During the years 2012–2016, 8 out of 10 mathematics teachers have participated in the Boost for Mathematics (BM) program, which is a (to a higher degree) research based professional development program. The Government has invested 65 million euro and the National Agency has conducted the BM program during four years in cooperation with National Centre for Mathematics Education (NCM) at Gothenburg University.

2. The Architecture of the Boost for Mathematics program
The National Agency and NCM interpreted the commission from the Government and developed a Program Declaration (Swedish National Agency of Education 2012) formulating two goals: to develop the culture of teaching mathematics and the culture of professional development. These goals form the architecture for the different parts of BM and are used by evaluators, in addition to investigating students' results. The goals are based on the difficulties to break the tradition of teaching practice, the socio-mathematical norms and didactic contracts (Cobb and Yackel 1996; Brousseau 1984; Jahnke, 2014), making students work alone on tasks using mostly imitative reasoning (Bergkvist 2014; Lither 2000). The goals also challenge the Swedish teachers' lonely work in planning, conducting and evaluating their own teaching and the tradition of individual based PD. The amount of collaboration

between Swedish teachers in order to improve teaching is below OCEDaverage (Mullis et al. 2011). The goals were meant to put focus on collaboration between teachers in teaching and to develop new knowledge – aiming for strengthening the ability to form community of practices.

2.1. Building parts: teachers, group of teachers, math tutors, principals, PD programs and material

The content of the program focuses on pedagogical content knowledge (PCK) as an important form of teacher knowledge in relation to students' learning (Baumart et al. 2011). BM is based on collegial learning with external support of a math tutor and a web-based material. The program is conducted during one year at the teachers' school during their working day and consists of a cycle; individual reading and watching classrooms films; meeting with colleagues and the tutor to discuss articles/films and prepare a classroom activity; trying out the activity and meeting again to discuss the experienced consequences (Clark and Hollingsworth 2002; Hattie 2008).

This form and content depended on three parts playing the roles of both multipliers and facilitators, i.e. math tutors, principals and the material. BM involved 1700 math tutors, educators of math tutors from different universities and a PD program for math tutors. Special attention was given to the importance of principals as accountable for students' results (Day and Sammons, 2013; Leithwood and Riehl 2005; Stoll et al. 2006; Hattie 2008) and therefore a specially designed PD program for principals was conducted by NCM with 3000 participants. The material was developed by a peer-reviewed process of teacher educators from all universities in Sweden and after being launched, it was revised by collecting data from school visits. The material was structured in "modules" and closely related to different mathematical areas and school years in the national syllabus. For example, "Algebra, school year 1–3" forms a module. Every module discusses at least four predetermined didactic perspectives; socio-mathematical norms, classrooms interactions, assessment and mathematical competencies. In addition to this, other perspectives were included as for example ICT or variation theory.

3. The epistemological foundation

On what theoretical landscape of knowledge is the architecture of BM built and lived? In research on the nature of knowledge Aristotle's categorization of knowledge (based on Nussbaum's interpretation, 1992) is often addressed as episteme (researchbased knowledge), to know 'what', techne (skills), to know 'how' and phronesis (practical knowledge) to know 'when'. Practical knowledge is not to be regarded as applied theoretical knowledge and some aspects are tacit (Schön 1983; Polynai 1963). This has similarities to what Shulman (1986) called strategic knowledge as one part of PCK. Practical knowledge develops by reflection and action on experienced consequences in practice, but to raise the quality of reflection colleagues and theoretical knowledge is needed. Cnversely, to reach conceptual understanding of new theories and concepts, experiences in working life can concretize abstract theories. In this way, practical and theoretical knowledge can support each other. BM is making use of an integrating strategy, mixing formal and in-formal learning and supporting an enabling learning environment, which in research on competence development in a wider range of organisations, including industries, is showed to be the most successful combination in terms of learning outcomes (Ellström and Kock 2011).

4. Analysing the correspondence between the architecture and the epistemological foundation

As a researcher of professional praxis and as a project leader of NCM's work with BM for four years, I will in my proposed paper critically analyse the architecture, the epistemological foundation and the correspondence evolved during four years of upscaling, which resulted in reaching 37,000 teachers. My analysis will involve discussing questions like: Climbing on top of the buildings of BM, do the resulting buildings fit the epistemological landscape? Are the foundations of the buildings stable or unstable? Do some buildings tilt? Or, standing on the top of the resulting constructions, does this give us a new perspective on the chosen and developed epistemological landscape?

Analysing the correspondence will give us a deeper understanding of the reasons behind the construction of BM. For example, the perspective on knowledge implies that you need to have relevant experiences to reflect on and therefore all the PD programs for teachers, tutors and principals run

parallel in time, making it possible to “Learn to Do by Knowing and to Know by Doing” (Dewey, 1889, p. 1).
Analysing the correspondence will also give us a means to reach a deeper understanding of the positive short-term effects and the shortcomings highlighted by the evaluations so far conducted by Ramböll Management Consulting and Umeå University. Above all I will discuss the risks of no sustainable long-term effects despite a research-based and well-funded project (McKinsey & Co 2006). I will also suggest how to empirically study a large professional development program using narrative inquiry (Craig 2007) in order to capture, analyse and represent teachers’, math tutors’ or principals’ knowledge and experience developed during a major PD program.

Juen-Kretschmer, C. (Pädagogische Hochschule Tirol), Alber, E. (Pädagogische Hochschule Tirol) — Research-based presentation on structural dimension

Joint development of sustainable mathematical competences

Monday, 17:30-17:45, Room KG4 301

1. State of the art
Teachers are confronted with new challenges due to innovations in the field of curricula and teaching, which are being launched in Austria at present. The testing of educational standards and Austrian standardized national school-leaving examinations focus on process-based mathematical competences besides content based competences. The curriculum for the New Middle school with features like backward learning design, core ideas, core questions and list of competences promotes the focus on skills. Here the interaction of knowledge, competences and comprehension serve as a basis for more or less successful handling and solving of mathematical tasks and problems. Up to now there has been little focus on competences in teaching mathematics in the German speaking countries (cf. Leuders et al 2005). Therefore teachers need to further develop and professionalize their own performance when teaching mathematics. The strengthening of the teachers ´competences can have a big impact on the improvement of the students´ performance (cf. Binsen 2010). Sustainable further training measures for teacher play an important role in this process and in supporting all these innovations.

2. Basis from current research
In order to develop concepts for further training we have to tackle several questions: what quality criteria does further training in mathematics have to meet, how can the effect of measures of professionalism be assessed and what accounts for the success? The present state of research focuses on results by Helen Timperley, Frank Lipowsky and Stefan Zehetmeier. They have done thorough research of the professional development of teachers. Further training has a positive impact on the teaches´ knowledge and performance and on the students’ learning development, according to the latest findings. The following criteria play an important role in the development of competences.
Short term further training does not have any sustainable impact, according to the latest results of research. It is advisable to span the duration of further education across a longer period of time (at least half a year), by retaining the absolute duration of the course. This enables the teachers to process the acquired knowledge and skills, to put it into practice and to reflect on the changes in their teaching. The time factor alone does not promote any change. But it is the reflection on their own practice and supporting measures in this process of change that assists the teachers. The 3-phase – model can help here: input-trial-reflection. This makes monitoring possible over a longer period of time. The motivation for further training rises particularly if teachers experience that a change in their teaching has an impact on their students´ performance.

The trainers are confronted with a wide range of tasks. On the one hand they should have a scientific expertise in the field of subject discipline and subject didactics of mathematics, to be able to offer further training in research-led teaching. On the other hand they should tie in with the respective situation of the participants, offer flexible action approaches and integrate existing opinions. The connection between the altered teaching methods and the learning of the students must become evident. Teachers who had focused on knowledge should be made aware of the importance of process-oriented teaching of mathematics. The main task of the teacher trainers is to offer new, science- based knowledge and present input that the participants find useful for their teaching practice. This requires data protected feedback to the teachers, to be able to reflect on their students´ learning process.
The professional competences of teachers of mathematics includes, apart from pedagogic knowledge, academic competences and competence in teaching methodology: The Project COACTIV shows the following four facets of competence: "Thorough knowledge of school mathematics, knowledge of the students´ mathematical way of thinking, knowledge of mathematical tasks, methods" (Kunter, Klusmann, Baumert 2009, 155) .
Special competence in teaching methodology, which can hardly be acquired without professional competence, has a big impact on the quality of teaching. Effective further- and in-service teacher training does not focus on abstract theories, but is concerned with clearly outlined mathematical topics, which are actually taught and focus on teaching units. This exemplary approach makes it easier to address the issue of similarities and difference in the students´ learning process of mathematics. It also allows the participants to reflect on didactical fields of learning. By including teachers in the interaction of students, the analysis of students 'papers and the results of assessment of the state of knowledge the diagnostic knowledge of teachers increases. The effect can be enhanced, if school-based or cross-institutional teams (organized by themselves) work on the development of teaching mathematics.
Didactical principles play an important role when choosing the content and designing lesson plans and teaching mathematics. These principles result from normative considerations and "best practice" in class. When developing competences we follow the survey of didactical principles by Krauthausen and Scherer (Krauthausen 2007, 133). Fundamental ideas, aiming at understanding mathematics as a coherent whole, enable teachers to be selective when choosing the teaching contents, make apparent the process-orientation of mathematics at schools and can be used at various levels. Professional mathematics classes use misconceptions in the students´ knowledge as a starting point for further learning. Teachers organize their classes from a genetically point of view. Here the students 'insights are based on (re)construction. The focus is on inquiry-based
learning and problem-solving teaching. Here the choice and the development of learning tasks are very important. Teacher training and also further training should focus in fundamental ideas, to support teachers in structuring the knowledge. Together with the spiral principle, where topics are being dealt with on a certain level in each form, one can refer to these ideas by applying new ideas like considering presentation method's that are appropriate for the students 'age (enactive – iconic – symbolic (cf. Bruner 1973)).

3. The project

3.1. Description

Taking into account the current state or research two tracks for further training were designed: PRESENTATION
MUGW- joint further development of mathematics (intensive supervision of pilot schools) - POSTER
NAKOM-sustainable competence development in teaching mathematics (competence for entire further teacher training M)

Both tracks switch between units of input, application and reflexion. Scientists, didactics experts and school teachers work together on concrete, clearly outlined mathematical topics. In the input phase the teachers´ knowledge in didactics is expanded in a section of the core topic (e.g.: modulus, internal differentiation in teaching mathematics using the example of fractions). In the trial phase development tasks are being fulfilled and concepts of the input phase enhanced, options for action in one's own teaching practice reflected and the individual need for further training defined. This makes an exchange possible of the impact on teaching and students in the reflexion phase. These courses are designed to include teachers of all types of schools (nursery school – primary school –lower and upper secondary school), to make them familiar with the spiral principle.

3.2. Project design and research questions

Core research question: To what extent does a sustainable offer of further training support the content- and process-oriented mathematical competences of teachers and students?

Specific research question:

- Does positive evaluation of the new track for further training in mathematics result in a sustainable change of the teachers 'knowledge and teaching?
- Does a participation in further training result in a chance of the teaching practice (process- and comprehension- oriented)?
- Do the concepts of the new tracks for further training in mathematics expand the teachers´ knowledge of diagnostic and didactics in teachers?
- Is there a correlation between the content of further training courses and change in teaching practice?
- To what extent do further training courses have an impact on the students 'learning progress (but this will more like be dealt with in a follow-up project)

3.3 Objectives of the project:

The correlation between a sustainable track of further education and the change in teaching practice will be illustrated with a concrete didactical subject area and processed for teaching practice of mathematics.

3.4 Project stages:

- Pilot studies (concept development, offers for further training): 2015
- Pilot studies (design of the evaluation) 2015, 2016
- Pilot studies (Implementation of the results of the evaluation in concept design of further education) 2016/17
- Selection of the didactical topics that will be explored 2016
- Study on the efficiency on the basis of a selected subject area 2016 – 2018

Karsenty, R. (Weizmann Institute of Science, Israel) - Researched-based presentation on personal dimension

Preparing facilitators to conduct video-based professional development for mathematics teachers: Needs, experiences and challenges

Tuesday, 10:50-11:20, Room KA 102

1. Background

A critical component of a sustainable and scalable professional development (PD) model is the ability to prepare PD facilitators who can adapt the model to various contexts while maintaining integrity to its original goals and agenda (Borko et al. 2014). The non-trivial move from a lead teacher in mathematics to a successful facilitator of PD is extensively studied in recent years (e.g., Borko et al. 2015; Even 2008; Kuzle and Biehler 2015). In this presentation I will report on a preparation course for facilitators, carried out as part of the upscale of a project focused on video-based PD for secondary mathematics teachers. Through the description of the course design, implementation and evaluation study I aim to touch upon fundamental questions concerning the training of mathematics PD facilitators: What are the needs of lead teachers entering a preparation course, and to what degree can we cater for these needs? What are their experiences during and after the course? What kinds of challenges underlie the design and maintenance of such a course, and the support system following it?

2. Preparing PD facilitators in mathematics education: What does the literature tell us?

Even (2005, p. 344) asserts that "being a good teacher does not necessarily imply the ability to help others develop their teaching", and advocates that designing courses for PD leaders should focus on knowledge, practice, and their interrelations. More recently, Borko et al. (2014) have labeled the knowledge needed for PD leaders as "Mathematical Knowledge for Professional Development" (MKPD), a term which encompasses (a) specialized content knowledge (e.g., deep understanding of the mathematics that stands at the core of the PD and how to make it accessible to all PD participants); (b) pedagogical content knowledge (e.g., how to engage teachers in productive analysis of instructional practices); and (c) learning community knowledge (e.g., how to establish group norms and foster active participation). It follows that before designing a course for PD facilitators, as part of the upscale process of a certain project, the designers should have clear definitions of the content knowledge needed for conducting PD within this project, the types of pedagogies and analyses that are seen as productive, and the desired community norms. These definitions are likely to be already discussed during the pilot phase of the project, yet the need to prepare facilitators who will maintain the project's original agenda, within a pyramid model, may well result in re-articulating and sharpening them. As a second step, it seems worthwhile to consider at what stage each of these forms of knowledge can begin to be instigated. Kuzle and Biehler (2015), based on the work of Maaß and Doorman (2013), have suggested that a longitudinal model of training mentor teachers should include three phases: Learning-off-job, which consists of gaining fundamental knowledge, Learning-by-job which consists of using the knowledge acquired in the first phase for planning and implementing a PD, with a close support and counselling by experts, and finally Learning-on-job, which consists of further growth enhanced by experience, reflection and peer support (alternatively, Zaslavsky and Leikin (2004) integrate the second and third phases into one complex model of growth-through-practice). One of the challenges that may be encountered by designers of a course for facilitators, concerns the adjustments of knowledge acquisition levels to the readiness of participants, in all three domains of MKPD. Following Even (2005), it seems reasonable to assume that the interrelation between knowledge and practice plays a significant role in the development of facilitators, thus certain progress will only be achieved after the Learning-off-job phase; this awareness makes decisions on knowledge acquisition targets for the initial stage, i.e., the course, quite complex.

3. Scaling up the VIDEO-LM Project: From lead teachers to PD facilitators

VIDEO-LM (Viewing, Investigating and Discussing Environments of Learning Mathematics), is a project running in the Weizmann Institute of Science since 2012. Its central aims are to enhance the reflective skills of secondary mathematics teachers and to enrich their mathematical knowledge for teaching. In this project, videotaped lessons serve as objects for teachers' peer-discussions, directed by a framework of analysis developed for this purpose. The framework comprises six lenses for observing a lesson: mathematical and meta-mathematical ideas; goals; tasks; dilemmas and decision making; interactions with students; and beliefs (see Karsenty, Arcavi and Nurick 2015). Since the 2012-3 academic year, when the first VIDEO-LM course took place, the demand for courses is rapidly increasing (so far, 36 courses of 30 hours each were conducted in various locations across Israel, including the Arab, Druze and Ultra-Orthodox sectors). This situation necessitates the preparation of suitable facilitators; therefore we have designed and implemented a system for recruiting, training and supporting lead teachers to become the "new generation" of VIDEO-LM facilitators. In the 2014-5 academic year we have conducted the first facilitator course. During the 2015-6 academic year we are supporting the group of the course graduates who went into actual practice, while simultaneously conducting a course for a second cohort. This process is the subject of an on-going study which aims to explore the perspectives of participants at different stages of the process.

4. The facilitator course: Design, implementation and evaluative research

The first stage of the preparation process (cohort #1) was a 30-hour course, with 28 participants. Twenty-three participants were secondary school teachers (average teaching experience: 22 years; 74% of them held also other positions such as heads of mathematics departments in their schools or mathematics counsellors appointed by the Ministry of Education). The other five were mathematics educators interested in integrating VIDOE-LM workshops within their activities. Participants were selected from among graduates of previous VIDEO-LM courses, and were individually invited to attend the facilitator course. This stage consisted of 7 monthly meetings, each lasting 4-5 hours.

The main design principles for this Learning-off-job stage were (I) Relevance: course activities are directly linked to realistic issues that VIDEO-LM facilitators deal with, according to our own experience as leaders of VIDEO-LM courses; (II) Feasibility of learning goals: At this initial stage, participants need to learn from the experiences of others. Therefore it is our responsibility to supply them with vivid cases to examine and assist them with developing a set of tools to analyse these cases, yet at the same time recognize that we are merely "sowing the seeds" for understandings that will fully ripen only at a later stage; (III) Commitment to the VIDEO-LM agenda and norms: in analysing cases, explicit and recurring references are made to the six-lens framework and to desired norms such as maintaining non-judgmental discussions and the strive to "step into the shoes" of the filmed teacher in an attempt to articulate his/her goals, beliefs and dilemmas; (IV) Modeling: Our conduct as leaders of the facilitator course is aligned with what we expect participants to do as course leaders in the future, e.g., maintain a supportive atmosphere, use diversified and engaging activities, etc.

The program of the course consisted of several central topics, such as the roles of VIDEO-LM facilitators; the challenges they may encounter; how to select videotaped lessons for discussions with various audiences; typical dilemmas and possible ways to resolve them; and more. Sessions were built around a range of activities, for instance discussions in small groups, analyses of video episodes filmed in previous VIDEO-LM courses, short simulations, and "Live Labs" of facilitation conducted during the course. In examining facilitation cases, we directed participants to use what we termed "Meta-Lenses": analyze the facilitator's goals, tasks, interactions with teachers, dilemmas, beliefs and maintenance of VIDEO-LM agenda.

The data collection within the evaluative study of the course consisted of video documentation of all sessions, questionnaires filled by all participants at the end of the course, and semi-structured interviews with 5 participants.

At the second stage of the preparation process, participants were requested to plan and enact a pilot VIDEO-LM session with a group of teachers they know, and report back to us. The VIDEO-LM team

offered counselling for the planning of sessions. At the third stage of the process, 21 of the 28 graduates were assigned to facilitate courses in their region, either alone or in teams of two, with a continuous support given throughout the courses. These latter stages are still under exploration and will not be reported in the current presentation.

5. Preliminary findings

Participants' experiences: From the perspective of future facilitators, the main needs that were addressed during the course, as revealed in the analysis of data, were: (1) Deepening the understanding of the VIDEO-LM agenda, i.e., the six-lens framework and the desired norms of discussion. (2) Gaining practical tools for facilitation (e.g., how to plan a session; what models of watching and discussing videos exist; how to create curiosity and maintain teachers' interest and involvement; what kind of tasks can lead to a mathematically rich and productive discussion). (3) Creating a community of peer-facilitators, in which issues, ideas and concerns can be shared. Interestingly, participants also reported that the course influenced the way they think about their own teaching, and enhanced their reflection about, for instance, how they interact with students, how they think about the goals of a lesson, etc.

Readiness for taking on the role of a facilitator: 22 of the participants (79%) noted at the end of the course that they feel confident enough to plan and lead a pilot VIDEO-LM session. However, regarding being ready to lead a full 30-hours course, only 37% participants wrote that they feel highly prepared, 56% felt moderately prepared, and 7% noted that they are not yet ready to take on this role. Most of those who felt only moderately prepared expressed the need for more opportunities to practice the tools and skills presented in the course, in situations of "demo facilitation" within the peer community of the course participants. However, they assumed that their confidence will increase over time and through actual practice in "real" courses. In the presentation I will describe and exemplify these findings and the further challenges they pose.

Lamberg, T. (University of Nevada) — Practice-based presentation on structural dimension

Nevada Mathematics Project: A Scale up Professional Development Project in U.S.A

Monday, 16:50-17:20, Room KG5 103

Professional development that makes an impact involves communities of teachers working together, and integrates the development of content knowledge and is sustained over time, (Joubert & Sutherland, 2009). Conducting professional development in one local setting is challenging enough. However, conducting professional development of scale adds complexity if more than one school system and multiple facilitators are involved. This paper describes Nevada Mathematics Project, a professional development scale up project in Nevada, USA. This paper addresses the following questions in the Structural Dimension strand: The scaling up of innovative, research based approaches to mathematics education and sustainable structures. It addresses the design features, and structures proven to be effective and challenges to be overcome.

1. Professional Development at Scale

Researchers (Cobb, McClain, Lamberg & Dean) point out the broader context in which teachers teach and develop their practices must be taken into account when designing professional development. Furthermore, professional development must be connected to the practice of teaching for meaningful change to take place. Jackson, Cobb, Wilson, Webster, Dunlab and Appelgate, (2014) point out those central issues of practice must be tied to materials teachers use in their classroom. The Nevada Mathematics Project http://www.nevadamathproject.com has an ambitious goal of attempting to improve mathematics instruction state-wide in the U.S. The goal was to develop teacher leaders who have the potential to serve in their schools and local school districts. This project is in the currently in

the third year of implementation. This funding agency required state wide (regional) collaboration as well as collaboration with mathematicians/scientists, local school districts and institutes of higher education. The funding was to provide teachers with content knowledge and pedagogical content knowledge in mathematics aligned to the Common Core standards in the U.SA. (National Governor's Association, 2010). The project team was made up of math educators, mathematicians from multi-institutions, Regional Training Centers who serve as the role of professional development trainers to the districts and teachers. The third year, we decided to integrate STEM and therefore the team expanded to including a science educator, scientists and even an industry partner(RHK Technology).

2. Designing Professional Development of Scale

The design of the project needed to addresses the following challenges: 1) The geographic regions spanned large distances which created challenges in communication and physical accessibility. This challenge was addressed by strategically offering professional development in four geographic regions. This gave many teachers across the state access to attend one of the locations.

Figure 1. Map of Nevada Mathematics Project PD Locations

2). The institutional context shapes how teachers are able to implement ideas and even make sense of the professional development within the context of their teaching settings (Cobb et al., 2003). Therefore, we needed to conceptualize how to take the institutional context into account when designing the professional development. Therefore, we tied the geographic locations to the Regional Professional development training centers that supported the schools. The Regional Training Centers have facilitators that works directly with local school districts to support teachers improve their instruction. Therefore these facilitators had an intimate knowledge of the schools, principals and the institutional context of the districts. These facilitators were instrumental in providing input and feedback to the higher education team on the local context and shaping the professional development design for each localized context. Furthermore, these facilitators were embedded their work in the school settings and were in communication and familiar with teachers and schools. We also involved district mathematics coordinators as well who provided input and shaped the design professional development to local needs. 3) One of our goals of the project was to develop a systematic long term plan to support improvement of instruction in Nevada. Therefore, it is critical that the teacher leaders that we develop not only improved their instruction, but also had potential to support others. Therefore, we needed to think about how to ensure that teachers in the project were a useful resource to the school districts. Therefore, leadership potential was a recruitment criterion for the project teachers. In addition, we communicated with superintendents, and district math coordinators about how the project can fit into their district wide goals for improving math instruction. We received support from every superintendent of each school district. It was critical that the districts provided input and were instrumental in the recruitment and selection of teachers. 4.) The project needed to think about large scale state-wide improvement while considering the local context. Therefore, researchers point out that the tools that teachers use should be embedded as part of the professional development. (Cobb & Jackson, 2003). Therefore, we used a design research approach (Lamberg &

Middleton, 2009) to our work to design and deliver the professional development. Using local job embedded tools was a design feature of the professional development. The challenges that were faced were that multiple tools were used across the state that was quite different in design features. The professional development needed to adapt with the local context. Even though, there was a larger plan, the actual delivery of the professional development was adapted to the needs of the local professional development context. 5) A large team made up of math educators, mathematicians, scientists, a business partner, district coordinators, regional training centers who were located in different regions of the state of Nevada as well as across multi-institutions across the country. This in itself is a challenge when individuals form a team from multi communities of practice. A two day planning meeting was held to develop a shared vision, co-create goals for each year's professional development, articulate and clarify each person's role and contribution to the project. The project was designed that a central team of higher education faculty and business partner travelled to each site. Each local regional team made up of district math coordinators and the Regional Training facilitators joined at each site. One of the distinguishing features of this project is that the entire team stayed in the same room observing, taking field notes providing input into the sessions while each other was presenting. As a result the team became a professional learning community by co-creating knowledge and learning as well (Stoll, Bolam, McMahon, Wallance & Thomas.2006). A joint enterprise developed as a shared set of beliefs and working together evolved. At the end of the first year, the team became familiar with each members strengths and weaknesses and were able to fluidly work with each other as a team, support each other and style focus to the mission. The team also travelled together for 4 weeks and had an opportunity to refine our thinking. The challenges were is making sure each team members' expertise was valued and coordinated to develop a focused coherent professional development. The joint meeting was a critical part of communicating and coordinating the initial design of the professional development.

3. Impact

The Project made an impact in the following ways, by the third year a state-wide system of communication and collaboration was established. The structure worked. The teacher content knowledge increased as measured in pre and post-tests. Lamberg Whole Class Discussion framework was administered to measure changes in teachers' pedagogical practice. There were shifts in teachers' instructional practice. The first two years focused on teachers deepening their knowledge and changing practice. The districts began to invite these teachers to participate in district level teams and serving in district roles. The communication as a state improved. No longer were people working in isolation competing with each other for resources, instead it began a path for collaboration. There is much more work needed to be done to make a larger state-wide impact. However, this project set in motion a framework for capacity building for future improvement of instruction.

Lamberg, T. (University of Nevada) — Practice-based presentation on material dimension

A Framework for Shifting Teachers' Instructional Approaches to Inquiry Based Approaches

Monday, 17:30-17:45, Room KG5 103

Effective teaching incorporates productive whole class discussions that support learning (Lamberg, 2012). These types of sense making conversations do not naturally happen. A teacher needs to thoughtfully cultivate a classroom environment and design lessons where such discussions take place. Facilitating effective whole class discussions to support mathematical learning is a complex process. Even though researchers point out that discussion and argumentation is an important part of

mathematical learning many teachers still struggle to effectively implement discussion in the classroom (Stein, Smith, Hughes, 2008). This is because facilitating effective discussion involves a coordination of many interrelated teaching skills such as lesson planning, focusing on student reasoning and questioning techniques (Lamberg, 2012). Therefore, professional development aimed at supporting teachers to implement effective whole class discussion must take into account the process of planning and teaching involved (Lamberg, 2012). This process involves thinking about the design of the physical space, cultivating a classroom environment that includes the physical and social environments, lesson planning and teacher questioning to facilitate connections.

Shifting teaching practice to a more inquiry discourse based approach for discussion is not easy. Especially, if traditional instruction is taking place. Traditional teaching approaches involves teaching students procedures to solve problems, memorize facts, regurgitate information without focusing on the deeper understanding of the math content knowledge is still prevalent in many classrooms in the U. S. (Cohen, McLaughlin, & Talbert, 1993; Darling-Hammond & McLaughlin, 1995; Porter & Brophy, 1988). A critical part of supporting teachers to shift their instruction towards more inquiry based approaches involves helping teachers make their teaching visible. This means helping teachers see what they are doing, and how it is impacting student learning. This process supports teachers to develop professional noticing skills so that they become mindful of what they are doing and impact on student learning in order to refine their teaching (Sherin, Jacobs, Philipp, 2011; Kazemi & Franke, 2004).

The Framework outlined in the Whole Class Mathematics Discussion: Improving In-depth Mathematical Thinking and Learning highlights outlines the critical parts of the process of teaching that needs to work together. These components of the framework must work together for optimal discussions and learning to take place. If only one part of this framework is addressed and other parts not attended to, then it is hard to implement effective discussions. The first two parts of the framework involves developing a learning environment and cultivating routines. The third part involves thinking of lesson planning as a three part process that eventually leads to the discussion. The first level of Three levels of Sense Making) involves students making their thinking explicit to communicate their ideas to the group. The group's responsibility is to make sure they are listening and reflecting on the ideas presented. The second level of sense making involves analysing each other's solutions and examining the structure in mathematics. It is recommended that modelling strategies and more sophisticated strategies be carefully sequence so that students can follow each other's thinking. The third phase involves examining rules and patterns and making generalizations to reach the level of abstraction. It is not necessary the three levels take place within one discussion. It can be continued across multiple lessons (Lamberg, 2012).

Setting Up the Physial Space
Cultivating Classroom Routines • Routines for preparing for discussion • Routines for communicating • Routines for Listening and Reflecting
Three Levels of Planning: First level –Long Term and Short Term Goals • Concept Map • Unit plan (Sequencing) Second Level- Planning the Lesson • Lesson planning- 5 E Third Level • Adapting Instruction based on at the moment sense making
The Discussion – Three Levels of Sense Making

1. Making Thinking Explicit
2. Analyzing Each other's solutions
3. Developing New insights

Teachers who used this framework in conjunction with content based professional development experienced growth in student achievement scores in the U.S. A. A copy of this framework is available at https://mathdiscussions.wordpress.com/whole-class-discussion-framework-checklist/ The framework in the blog when used in conjunction with the tools in the book is a useful tool for making teaching visible. A teacher commented:

> While looking at the whole class discussion rubric, I discovered my weakness in asking guiding questions of students based on their responses. I feel that I can identify what misconception students have or what holes in their learning are causing these misconceptions or mistakes. However, when I get strapped for time. I tend to get frazzled and find it difficult to quickly think on the spot. While looking at the "Whole Class Discussion" Rubric, I was verified that my classroom management and the setup of my classroom are areas of strength that a strong foundation for Common Core discussion. On the other hand, my weaknesses lie in routines for listening and holding students accountable for discussion.

The following represents one teacher's analysis of her teaching based on the whole class discussion framework.

Reflect on a recent discussion you had with students. What kind of questions did you ask?

> Recently, my class investigated the properties of polygons. After creating shapes from triangles, we had a discussion about how to sort the shapes we had made. The students began sorting them based on their number of sides, and their number of angles, as well as by regular and irregular polygons. To prompt their thinking, I asked questions such as: Where would you place this shape and why? If I group the shapes this way, where would I put this next shape? If we keep sorting the shapes in this way, what might the shapes in the next category look like? Why did ___ place her shape in this group? What other ways could you sort the shapes?

What kinds of sense-making took place in that discussion?

> I began the discussion by silently sorting the shapes the students made. I asked the students what they noticed about how I was sorting the shapes. They noticed that I was organizing them by the number of sides. I asked how else we could sort them, and students came up with by number of angles, and then by irregular versus regular polygons. This shows the first phase, making thinking explicit. I then asked students how the sorts (number of sides, number of angles) were different or the same. This pushed them to the second phase of sense-making, analyzing solutions. This discussion did not reach the third phase, developing new insights, which is appropriate considering the discussion was introductory to third grade concepts of geometry.

What were some challenges in helping students make mathematical connections?

> The students had not mastered the vocabulary and struggled to explain their thinking for this reason. Additionally, the discussion content did not lend itself to a wide variety of student solutions, and therefore students had fewer opportunities to analyze solutions.

What are some strengths and weaknesses in your techniques for facilitating a discussion?

> My strengths include scaffolding and guiding the discussion. I note student thinking during the exploration activity, and consider how to pull those various ideas out during the discussion. I scaffold discussions to go from more obvious/less sophisticated ideas to the more sophisticated ideas in this way. I am also strong in holding all students accountable for each other's ideas by having them summarize each other or build off of each other. I am still working on wait time and think time before having students share.

What are some areas you would like to improve?

> I am working to improve my wait time and built in think time. I would also like to push myself and my students to get to the third phase, developing new mathematical insights. In our discussions, we often

analyze each other's solutions and thinking, but we don't frequently end by making generalizations. I would like to plan for this more often and more purposefully.

The activities in this book are carefully designed to maximize the PD time of teachers. The ideas presented are research based. Therefore, it gets to the point quickly so that the ideas can be easily implemented. Teachers and PD facilitators don't have to spend an extensive amount of time reading and trying to figure out how to use this book. Rather, the thinking is done, so that it can be used as a tool. The book references approximately 65 journal articles and books and synthesizes the key ideas in a form that is easy to implement. This book is kept concise intentionally. The goal of this book was to provide a resource/tool for teachers that gets to the point quickly, provides tools and resources to implement ideas and strategies and to monitor its' effectiveness. Adaptive: Teachers can use it in a book study, grade level teams, individually to refine the ideas. They can focus on sections of the book that meet their immediate needs. Therefore, the book can be adapted to the needs of the individual teacher/school etc. Not all tools provided needs to be used, rather the teacher/PD coach can choose from a variety of tools such as rubric and worksheets. Tool for PD Facilitators: Chapter 6 provides the PD facilitators/coaches with suggestions on how to use and adapt this book to meet their needs of teachers. The purpose of this book is to highlight the PROCESS of teaching. Therefore, lesson planning, and what it means to focus on conceptual understanding is addressed in this book.

Maaß, K. (University of Education Freiburg) — Research-based presentation on personal dimension

Scaling up within the cascade model: What are PD facilitators' needs?

Monday, 16:50-17:20, Room KA 102

1. Introduction

This paper presents the results of an exploratory study in Germany, in which facilitators have been educated, who in turn carried out professional development courses for inquiry-based learning in mathematics. It will address the topic from a researchers' perspective and relates specifically to the personal dimension: Which roles, contents and activities have to be considered in the PD for facilitators (in professional learning communities and in the multiplier concept)? It addresses the following questions:

- What are the features of successful concepts for educating multipliers?
- What are the needs and experiences of the different target groups (here facilitators)?

The paper will be presented as an oral-presentation.

2. Theoretical background

Most experts regard teachers as a key group that is needed to bring about change in a sustainable way (Krainer, 2015). However the issue of how to scale up professional development (PD) in order to reach as many teachers as possible remains a challenge (Krainer, 2015). One model discussed for scaling up is the cascade model (Maaß and Artigue, 2013). Here, facilitators are educated, who in turn train other teachers. This model requires intensive efforts in educating facilitators, but unfortunately, not much is known about what qualifies someone to be a facilitator and there is little support for their ongoing learning (Ball and Even 2009; Robert 2009; Krainer 2012).

Facilitators' PD can be seen as being nested in three domains (Luft & Hewson, 2014): (1) In the School Domain the focus is on students' learning of content distributed by the teacher; (2) In the Professional Development Domain the teacher becomes a learner supported by a PD facilitator; (3) In the Leadership Development Domain the PD facilitator acts as a learner learning to lead. Therefore, becoming a facilitator is a personal challenge, because the teachers need to build up a new identity and bridge between different identities (Krainer, 2015). The question of how to overcome this

challenge and how to educate facilitators so as to enable them to run PD as intended by initiators of change is vital to scaling up.

3. Exploratory research study

The paper presents a concept for the education of multipliers which was designed within the European project Primas (2010-13). The aim of Primas was the implementation of inquiry-based learning (IBL) (Dorier & Maaß, 2013) into day-to-day mathematics and science teaching on a large scale. In order to reach more than 100 teachers in each of the 12 participating countries, we chose the cascade model and developed the concept of the multiplier education within the framework of design research (Maaß & Doorman, 2013). It is based in theory, adapted to the needs of the different countries and was improved through iterative cycles of evaluation and optimization. Here, we will present the concept designed and adapted to the German needs of educating facilitators for PD courses in mathematics. Based on a qualitative analysis (Grounded theory, Strauß & Corbin, 1998) of nine retrospective interviews focusing on the needs of facilitators, we suggest how the design of the facilitator concept can be optimized.

4. The concept of multiplier education applied

The multiplier education was long term and carried out over nine days within two years, one year before the facilitators started running their courses and one year in parallel. It aimed at facilitators learning on two levels in an integrated way: (1) as teachers as regards IBL and (2) as facilitators as regards running courses on this topic.

In (1), we implemented commonly discussed quality criteria (such as relevance for practice, participant orientation, initiating cooperation (Barzel & Selter, 2015, Roesken-Winter et al. 2015, Maaß & Doorman 2013, Lipowsky & Rzejak 2012, Timperley et al. 2007)).

The concept in (2) was based in practice (e.g. for the course, materials were used which facilitators could then use afterwards in their own courses, (Koellner et al. 2011, Jackson et al. 2015). Further, we used a variety of methods (Roesken et al. 2015), supported cooperation between facilitators by setting up pairs who would run courses together (Roesken et al. 2015, Jackson et al. 2015) and included PD management (Roesken et al. 2015) by simulating PD courses and reflecting on a meta-level how facilitators could react in certain situations.

5. Results & Conclusion

The data evaluation reveals that facilitators actually feel fear when taking up their role as a facilitator for various reasons: e.g., they do not feel confident with IBL themselves; have a high esteem of their colleagues and feel insecure about their own competences; have very high expectations as regards the impact of their course; and they consider it to be difficult to legitimize their standing in front of other teachers. In particular, they clearly differ between motivating colleagues (who have a high workload) and pupils (who have to pay attention because it is in the curriculum). Also, there is a clear connection between their role of a teacher and their role of a facilitator: Data hints to the fact that their view as participants in the PD course influences their view as facilitators (when running a PD course). The role they actually found was quite different: Some carried out show-and-tell sessions, others used more communicative forms of PD courses and felt like primus inter pares. These different roles might influence to what extent they considered themselves as having a legitimization of running the course. Consequently, we argue that the domain of learning to be become a facilitator needs to be given much more attention. Although we did follow quality criteria for facilitators as discussed in literature, and although facilitators appreciated measures taken (like working in pairs, their education going on in parallel to their courses and simulation of courses), facilitators should be offered more possibilities for identification if we want to take the criterion of participant orientation seriously.

Fears of the future facilitators, ways of finding the new identity and possibilities for filling this role should be discussed explicitly. As regards relevance to practice, not only practice of the teacher but also practice as a facilitator should be taking into account, e.g. by analyzing cases and/or video-sequences from PD courses and teachers' written documents, and by planning and discussing PD

activities (Jackson et al. 2015). We also agree with Jackson et al. (2015) who suggest that facilitators should learn how to communicate with teachers and reflect on the objectives of PD activities.
Learning to become a facilitator is indeed a challenge as it is nested in three different domains. In order to structure facilitators' learning and to emphasize the learning as a facilitator, we suggest clearly separating learning as a teacher from learning as a facilitator, e.g. by offering clearly separated workshops in the course.

Mousoulides, N. (University of Nicosia), Evagorou, M. (University of Nicosia) - Research-based presentation on personal dimension)

Title 'An Interdisciplinary Approach to Mathematics Teaching and Learning - Educating the Teacher Educators dimension'

Monday, 17:30-17:45, Room KA 106

1. Introduction and Theoretical Framework

A focus on advancing STEM (science, technology, engineering, and mathematics) in schools is escalating across many countries, with its powerful role across multiple sectors being formally recognised (The Royal Society Science Policy Centre 2014). Further, other policy documents, like the one developed by the STEM Taskforce Report (2014) underline the importance of providing students opportunities for "real-world, problem-based learning" that integrates the disciplines "through cohesive and active teaching and learning approaches" (p. 9). Mathematically literate students not only know how to analyse, reason, and communicate ideas effectively; they can also mathematically pose, model, formulate, solve, and interpret questions and solutions in science, technology, and engineering (p.9).
One of the key elements of this new role of mathematics in interdisciplinary approaches (e.g., mathematics and science) and in STEM deals with statistics and data handling. More recognition needs to be given to the core role of mathematics in dealing with uncertainty, and in analysing and reasoning with data to make informed decisions and engage in constructive debate about local and global issues (The Royal Society Science Policy Centre, 2014). One approach to emphasizing mathematics within STEM and to provide a coherent interdisciplinary approach to mathematic is modelling with data.
The paper addresses a professional learning community development approach, namely a multitiered research design, and a teaching experiment, involving a models and modeling approach to learning. Our presentation will describe how the Models and Modeling Perspective (MMP) principles and theory (Lesh & Doerr, 2003) can be used to understand the nature and development of teacher educators' (inspectors in this study) knowledge, conceptions and experiences for connected mathematics and science. In our approach we focus on mathematics content and pedagogy, and the nature of teachers' developing knowledge in working with complex, technology based modeling problems for elementary school students (Niess, 2005).
The professional learning community developed in this study followed the guidelines provided in the work by Lave and Wenger (1991), was organized around a multitiered professional development approach. Specifically, we adopted a three tiered research paradigm (see Figure 1) that addresses the developments of teacher educators (inspectors and researchers), teachers, parents, and students, in an attempt to provide a learning and development environment for classroom practitioners, teacher educators, and researchers to work together in generating meaningful change within modeling learning contexts (Lesh & Kelly, 2000). The learning community built on four distinct characteristics, namely: (a) diversity of expertise and experiences among its members (and especially among the teacher educators), (b) a shared vision of continually advancing the collective (and individual) knowledge and skills (with an emphasis on the successful integration of science and mathematics

teaching and learning), (c) an emphasis on the development of participants' metacognitive abilities, reflective thinking, and the notion of learning how to learn, and (d) mechanisms for sharing what is learned.

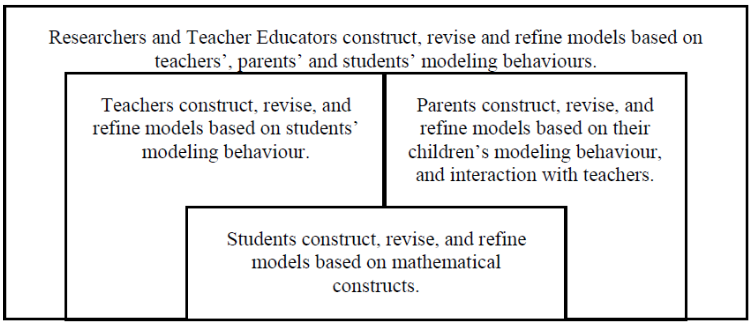


Figure 2. The structure of the professional learning community developed

2. The Study

The purpose of the paper was to examine mathematics teacher educators' conceptions and experiences related to connected mathematics and science. Four mathematics inspectors (providers of in-service teacher training) participated in the study. Three of the participants were male and one female, all aged between 50-60 years. All four participants hold a master's degree in mathematics education and didactics, while one of them also hold a Ph.D. in mathematics and technology education. In a series of workshops designed for teachers, within the activities of the mascil project, we also invited some of the teachers' inspectors to participate. The purpose of this approach was to provide an environment in which both teacher educators and teachers could participate in a collaborative design approach to develop a number of model-eliciting activities, to examine different ways to implement these activities, and to explore the assessment aspect of such an approach (both for student assessment and teacher assessment purposes). There was a common understanding that using data handling inquiry- Researchers and Teacher Educators construct, revise and refine models based on teachers', parents' and students' modeling behaviours. Parents construct, revise, and refine models based on their children's modeling behaviour, and interaction with teachers. Teachers construct, revise, and refine models based on students' modeling behaviour. Students construct, revise, and refine models based on mathematical constructs. based student model-eliciting interdisciplinary problems could facilitate a better understanding of their own thinking regarding the skills and concepts of the mathematics curriculum and their students' mathematical thinking.

One of the data handling activities developed by teacher educators, teachers and researchers in this study was the 'Car Accidents and Road Safety' activity. The activity began with a video clip, discussing the problem of car accidents and the measures taken by the police to minimize the problem. The students then considered the general question, "Is it true that young adults are drunk when involved in car accidents during the weekend?" Students quickly realised that the question needed to be refined in order to answer it statistically and meaningfully. Over the course of the two month study, students had come to appreciate that statistical questions require carefully planned investigations and any conclusions drawn from the analysis of the data have a certain degree of uncertainty. To further facilitate student investigations, teachers, teacher educators and researchers also designed a math applet, based on actual data retrieved from 1000 police records on car accidents in Cyprus (see figure 2).

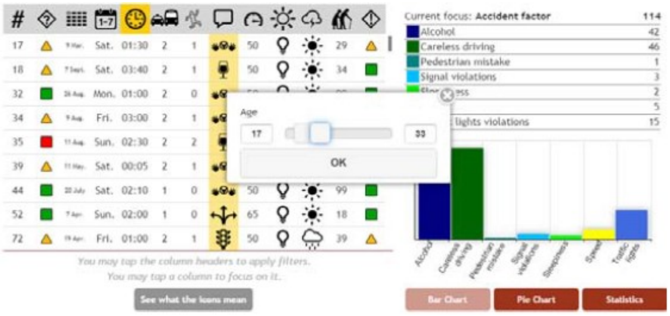


Figure 2. Screenshot of the ´Car Accidents and Road Safety´ applet

The preliminary findings of the study on teacher educators' conceptions and experiences related to connected mathematics and science that emerged during the study revealed that teacher educators conveyed strong convictions about the importance of connecting mathematics and science instruction. They also reported that it is important and possible to integrate mathematics and science, through rich data activities, because they can further promote the understanding of one another. Participants also encouraged their teacher partners to further work on integrating mathematics and science, since that shows students how applicable mathematics is in the natural world, and how mathematics can be used to make sense of the real world problems. Teacher educators (also being inspectors that evaluate teachers) referred explicitly on the evaluation aspect of the activities. They underlined the difficulty for teachers to evaluate students' work during the modeling activities, and identified that they also had to improve their skills in teacher assessment, when working with interdisciplinary modeling activities.

3. Concluding remarks

The idea of learning communities for teacher educators and teachers will grow as we try to address the needs of being able to reason mathematically with data in complex real world problems and situations. Such learning communities are also important as we try to communicate and work with people from diverse backgrounds and views, and share what one learns with others. More research on teacher educators' developments as they construct knowledge and skills for teaching and evaluating interdisciplinary data modeling learning is needed in order to illustrate ways that professional learning communities can meet the needs of teacher educators and teachers.

Pendrill, A-M. (Lund University), Kozma, C. (Stockholm University), Theve, A. (Gröna Lund, Stockholm) — Practice-based presentation on material dimension

Amusement park physics – teacher roles for student learning, through CPD, research-based materials and networking

Tuesday, 9:55-10:25, Room KG4 301

1. Carousels and roller coasters in physics teaching.

A school visit to an amusement park represents a considerable logistical challenge but also offers many educational op - portunities (e.g. Bakken, 2016, Heinz et al. 2009, Pendrill et al., 2013, Pezzi, 2013). Force and acceleration are often con - sidered abstract concepts, but can also be very concrete when experienced throughout the body. Carousels and roller coasters offer many exciting examples, from middle school to university. Students may experience the weightlessness of free-fall in a drop tower – or over a roller coaster hill. They can study collisions in bumber car rides. Students may model the motion when rotations are combined, as the classical teacup ride, and they can investigate forces in rotating systems and energy transform - ations in pendulums and roller coasters. Miniature versions of classical experiments may be performed in the accelerated and rotating systems in the park (Bagge

and Pendrill, 2002). Many of the rides can be used for a large number of assignments of different degrees of difficulty and openness (e.g. Pendrill, 2016), allowing for many opportunities of Inquiry Based Learning. Textbook thought experiments may become real in the rides and the learning takes place in an environment generally per - ceived as positive. Mathematics and modelling can be combined with the experience of the body, as well as with measure - ments, photos and videos. Many of the examples can also be used in physics teaching in the classroom even without a visit. To support the educational use of amusement park examples in physics teaching we have developed teacher material to sup - port classroom based work, as well as tips and worksheets for first-time visitors, suggested group activities, and more elabor - ate exercises and material for experienced amusement park teachers.

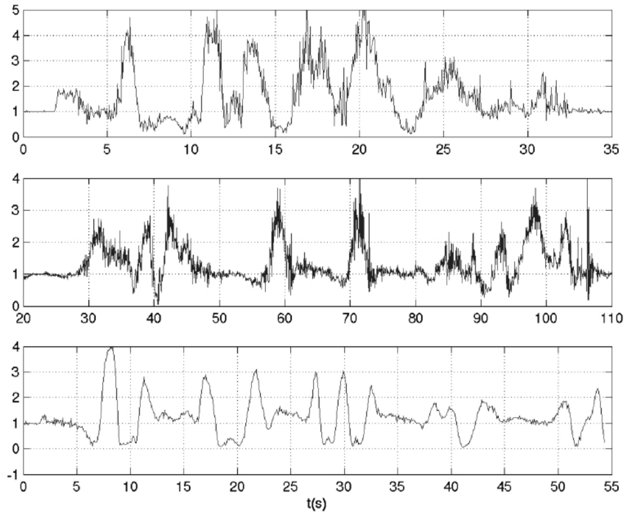


Figure 1. Examples of accelerometer graphs to be matched with roller coasters at Liseberg.

2. Scaffolding the teacher role with www material

Ready-made well-tested worksheets, with answers, comments and background material offer some security to first-time visitors. In addition to a quiz (see e.g. Pendrill, 2005) and a graph-matching activity (Figure 1), we also provide a number of group worksheet for different age groups, adapted to the park. During large-scale physics or "Edutainment" days, we also provide opportunities for discussions on site, both for teach - ers and students. As additional support for teachers, we offer workshops to facilitate their preparation and follow-up in class, which are known to be essential ingredients for the learning outcomes in connection with field trips. Teacher get to try out the worksheets and experiments, and browse additional www-resources, including data, photos and videos from the rides, as well as sample student teacher dialogues and articles where particular rides are analysed in more detail (see tivoli.fysik.org/eng - lish/articles).

Examples of detailed analyses includes studies of roller coaster loop shapes (Pendrill 2005a, 2013), applying smart - phones to the investigations of rotating pendulum rides (Pendrill and Rohlén, 2011), magnetic brakes (Pendrill et al, 2012) and different worksheet questions for wave swingers (Pendrill, 2016). Other more detailed investigations are found on teach - er www pages provided for various rides.

Educators in different parks collaborate in the development and share materials. The development of the project over many years is described by Pendrill et al. (2013), and also illustrated in the flow chart in Figure 1. All our material is avail - able at the project www site tivoli.fysik.org, together with links to other sites.

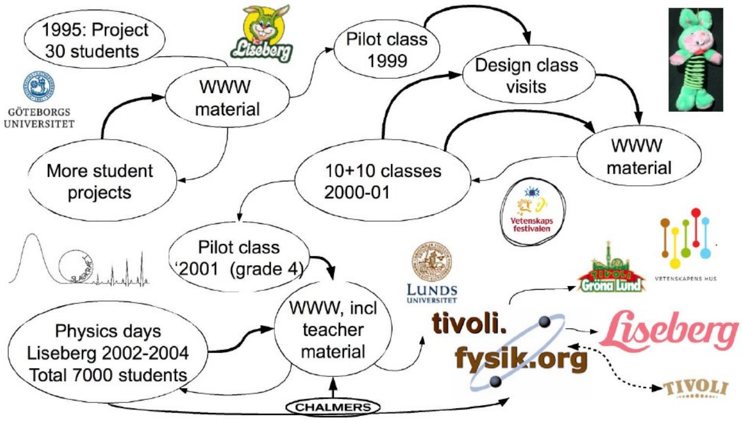


Figure 2. Flow-chart describing the development over two decades

3. Scaling up – with networking and virtual learning communities complementing www material

To support large numbers of teachers in the use of amusement park examples in their physics teaching, we complement the www material with Facebook groups, where teacher can interact and exchange experiences – and, of course, ask questions. We have also been able to scale up assessment and evaluations, by google forms made available to students through their teachers, as complement to observations and discussions in the park. From this assessment, we have concluded that face to face interactions during the park visit do play a role for student learning. To make possible more teacher-student interactions we have invited teachers to spend an hour at one of the rides, during a physics event in the park, discussing with students who have assignments for that ride. Articles and examples of relevant dialogues are sent to teachers well in advance, to enable preparation. As organizers we ensure a mix of teachers from different schools, and of experienced teachers with amusement park novices. In this way, we also enable intercollegiate exchanges and learning, as discussed in more detail during our presentation.

Rösike, K. (TU Dortmund University), Prediger, S. (TU Dortmund University) — Research-based presentation on structural dimension

Specifying what teachers need to learn: The case of noticing and fostering students' mathematical potentials

Tuesday, 11:30-12:00, Room KG4 301

1. Specifying PD contents as an important task for scaling-up professional development

Material-based professionalization for contexts of scaling up require both, materials for realizing innovations in classrooms (curricula for classrooms, e.g. tasks or teaching units), as well as materials for professional development courses (curricula for PD courses, with inputs, videos, activities, readings, etc.). It is the ambition of the DZLM (German National Center for Mathematics Teacher Education) to design materials for PD courses which are suitable for scaling up, and to guide these designs by a strong research base.

In the last years, the need for research-based designs for PD courses has fueled a growing body of empirical investigations into pedagogical features for PD programs focusing on their effectiveness. In that way, important pedagogical principles can be specified for the design of PD programs (for an overview see Goldsmith, Doerr, and Lewis 2014; Tirosh and Wood 2008). However, these studies rarely consider the 'what-question', that is, asking what content is most crucial for which PD programs and especially from which perspectives it should be addressed, i.e. "restructured" for the purposes of the

PD (criticized in Prediger et. al 2015). Specifying what teachers should learn in which perspective about a certain content (e.g. a mathematical topic or noticing students' difficulties) usually refers to the current state of research on classroom practices or teachers' professional knowledge for this content. This reference can be substantiated by also taking into account typical teachers' perspectives, which can be reconstructed when qualitatively investigating content-specific professionalization processes.
In our contribution, we combine both: developing materials for PD programs and empirically specifying what teachers should learn. Combining these two aims of design and research is well established in the research methodology of Design Research (Bakker and van Eerde 2015), which has been elaborated with a focus on learning processes (Gravemejier and Cobb 2006). We adapt this research methodology to Design Research for teachers with a focus on content-specific professionalization processes (Prediger, Schnell, and Rösike 2016). It comprises four intertwined working areas which are addressed in several cycles: (1) specifying and structuring PD goals and contents in hypothetical intended professionalization trajectories, (2) developing the specific PD design, (3) conducting and analyzing design experiments in PD settings, and (4) developing contributions to local theories on professionalization processes.
Design Research allows to specify empirically what exactly teachers need to learn for a certain PD content as it reconstructs teachers' professionalization pathways and typical obstacles. The talk will present this approach for the specific PD content "noticing and fostering students' mathematical potentials" (ibid.) which is treated in our DoMath project.

2. The Case of DoMath – Design-Research with a content-focus on teachers' diagnostic perspectives
The DoMath PD program is developed and investigated in an ongoing PD design research project in the described approach from 2014 to 2018. The DoMath PD program addresses secondary school mathematics teachers who intend to develop their competences to notice and to foster students' mathematical potential. For this, we adopt a wide, dynamic and participatory conceptualization of mathematical potentials (following Leikin 2009), addressing specifically those (often underprivileged) students not yet identified as talented. The classroom instructional design therefore builds upon whole class enrichment settings with rich, self-differentiating open-ended problems (ibid.). Teachers become sensitized to notice students' potentials in the rich situations and to adaptively foster the noticed potentials by facilitating supportive interaction.
For the design research project DoMath, three iterative cycles of design experiment series are conducted between 2014 and 2017. Between the PD sessions of one design experiment cycle, mini cycles of investigating processes allow immediate refinement of the program. During the mini-cycles of the first two cycles, the relatively vague intended trajectory matured into a more detailed specification of a model for noticing students' potentials. This refinement of the underlying content-specific theory will allow pursuing the long-term aim to develop a PD course for scaling up with facilitators within the DZLM (Prediger, Schnell and Rösike 2016).

3. Specification of PD content by extending the model of diagnostic perspectives
To engage in fostering students´ mathematical potentials, the first step within the PD program of DoMath was to initiate a shift within the teachers´ perception of potential, from a product to a process perspective, focusing on the richness of processes even if the outcomes stay incomplete. This distinction of teachers' diagnostic judgements in process and product perspectives is well established in the literature (e.g. Empson and Jacobs 2008), and analyzing videos in the PD sessions is well known to be a design element which successfully initiates that shift (e.g. Sherin and van Es 2009). The presentation intends to depict how that shift was performed and what obstacles were to be overcome. Throughout several design experiment cycles, teachers' diagnostic process perspectives on students´ mathematical potential were cultivated and promoted, (a) by focusing situational potentials and seeds of that, (b) by the help of focus questions and (c) by emphasizing the aspects constituting the dynamic view on mathematical potential (Leikin 2009).

However, when analyzing the teachers' diagnostic judgments, it became apparent that the process perspective cannot be described unidimensional, but had to be refined. Three different perspectives have been identified which need to be coordinated for adequate noticing (Prediger, Schnell and Rösike 2016). In the presentation, concrete data from research will motivate the extension of the PD content. The presented extended landscape of perspectives is a major outcome which offers the research-base for material development. In the presentation, the consequences of these findings as well for the theoretical grounds of the PD course will be discussed in concrete and in general.
Beyond the concrete project, the presentation can fuel the discussion on relevant research questions which contribute to developing research-based PD materials for scaling up.

Sensari, Z.S. (Izmir Özel Türk College), Yurumezoglu, K. (Dokuz Eylül University) — Research-based presentation on personal dimension

Effectiveness of an In-service Training Program Regarding Inquiry-based Teaching for Physics Teachers

Tuesday, 9:55-10:25, Room 102

The purpose of the research was, in accord with the revised Physics Teaching Program, to facilitate the adaptation of physics teachers to the curriculum by exploring the effectiveness of an in-service program of education on inquiry-based teaching.
The study was conducted in cooperation with the Provincial Directorate of National Education in the city of İzmir. Within the framework of a 20-hour in-service program of education (ISPE), a group of 9th grade physics teachers (N=26) from İzmir who volunteered to participate in the study were offered a training program on inquiry-based teaching. The in-service education was prepared in conformity with the 9th-grade syllabus and involved the interactive participation of the volunteer teachers in activities designed for inquiry-based teaching. The activities in the PD program used to from Pri-Sci-Net Project which has received funding from the European Union Seventh Framework Program (FP7) (PRI-SCI-NET, 2012) The research was of quasi-experimental design using a pretest-posttest scheme. Firstly, prior to and following the implementation, the teachers participating in the in-service education were each given activity worksheets and the Inquiry-based Learning-Teaching Framework Evaluation Form and the Views on the Nature of Science Questionnaire (Lederman, Abd-El-Khalick, Bell ve Schwartz, 2002) (for teachers) were administered. Additionally, in an effort to evaluate the effects of the in-service training and how teaching strategies changed, an analysis was made of the teachers' diaries (which contained their remarks, recorded on the evening of the same day of teaching, about the activities they performed with their students in the classroom).
In the second stage of the study, the changes implemented in the classroom by the teachers who attended the ISPE were investigated with the performances of their own students. At this point, the effect of the in-service education on the students was assessed using three different data collection instruments. The first of these was the "Views on the Nature of Science Questionnaire (for students)" to assess the effects of inquiry-based teaching on the views of students regarding science and the nature of science. The second tool was the "Science Process Skills Test" (Okey, Burns ve Wise, 1982) that was used to ascertain the association between inquiry-based teaching and science process skills. These were administered as a pretest and a posttest. Lastly, the students' diaries, which they were asked to keep after each activity, were studied in order to understand the extent of their participation in the inquiry process. It was thus made possible to explore whether or not the instruction had made an impact and caused any changes in the way students participated in their own learning process.
The quantitative data gathered from the research were analysed with the SPSS 16.0 package program, using frequency, percentages and the paired-samples t-test. Quantitative data were assessed using

descriptive analysis. The results of the study determined that the ISPE had been successful in that there had been positive changes in the teachers' views regarding the nature of science and in their ideas about inquiry-based science education. Before the in-service training program only %43.44 of teachers believe in inquiry for an effective teaching and learning process, but after the PD program the percentage of teachers increased (% 65.22). On the other hand, despite the success of the program of education, it can be seen that the strategy of inquiry-based teaching and the process of knowledge transfer to students remains largely challenging for teachers. Although teachers appear eager in the beginning, they are resistant to carrying their training experiences into the classroom (Demir & Abell, 2010). At the conclusion of the study, it was seen that no significant difference could be found in students' scientific process skills or in their views regarding the nature of science.
This research is important that in terms of effecting teachers positively in their teaching process and also changed some teachers who are participated in research. As they became more confident with inquiry, they were able to share our teaching and learning experience with their students (Kleine et al, 2002).

Sorensen, P. (University of Nottingham) — Research-based presentation on structural dimension

Developing inquiry-based approaches in science linked to the world of work: a case study of using materials from the Mascil project to support a school-based professional learning community

Monday,17:30-17:45, Room KG4 222

1. Introduction
The Mascil project is one of many European-funded projects, past and present, associated with the development of inquiry-based approaches in STEM subjects. Mascil has drawn on past projects, together with research on professional development (PD) models, in developing materials designed to support the (PD) of both beginning and practising teachers. The materials include a Toolkit with three dimensions: one concerned with explaining ways of working with the Toolkit; a second focused on inquiry; a third concerned with the world of work. Key design principles are that it is flexible and supports the process of developing professional learning communities, with facilitators from within. This paper will present a case study of the use of the PD materials to support developments in the use of inquiry approaches linked to the world of work in a lead school in an academy group in England.

2. Mascil project rationale
Mascil aims to develop the use of inquiry based approaches in science and maths linked to the world of work. The focus on inquiry reflects an emphasis seen across the EU, following the publication of the Rocard report in 2007 (Rocard et al, 2007). In science this called for a shift towards more exploratory, inductive science pedagogies and connections to the broader scientific community. Such moves are linked to concerns about the recruitment of future scientists and worries that science curricula were not helping to develop pupils' aspirations for continuing with science (e.g. Sjøberg & Schreiner, 2010). More recent research (e.g. Aspires Project, 2013) has added to these worries. As England has a long history of innovative, inquiry-orientated, curriculum development in science education, it might be thought that it was likely to be well-positioned in regard to inquiry. However, this is not the case, despite the fact that successive versions of the Science National Curriculum have put emphasis on scientific inquiry and developing students' views of what scientists do. Thus in England, as elsewhere, the need for PD in the area of scientific inquiry, for both beginning and experienced teachers, is clear.

3. The PD model

The approach is one that recognises that PD needs to attend to issues at personal and systems levels. Thus any materials need to be developed in a manner that is flexible and reactive to the individual contexts. At a personal level, a number of individual teacher factors have been taken into account. These include: teachers' pedagogical content knowledge; teachers' beliefs about their subject and its teaching; teachers' capacity to develop self-regulative approaches linked to reflection on practice; teachers' motivation and feelings of professional agency. These have led to an approach that starts from the perspective of exploring teachers' knowledge and beliefs and promotes engagement with the evidence for why they might want/need to change their practices.

While acknowledging the importance of these personal issues, the Mascil project has adopted a systemic approach aimed at working at different layers in the system. This includes giving attention to: policy makers; PD providers; industrialists; schools and their managers; working groups and individuals. In seeking to develop the practice of individuals within broader systems, emphasis is given the development of professional learning communities within a Participatory Intervention Model.

4. Case study

This paper examines how engagement with the Mascil materials and processes has played out in a lead school in an academy group in England. The approach was designed to include the following components:

- Mascil developers meeting with a small group of experienced and beginning teachers within a school context to introduce the Mascil project and Toolkit, with an emphasis on 'Ways of working';
- This small group of teachers working with the toolkit to develop and trial approaches within the school;
- An experienced teacher acting as the facilitator within the school, making use of the Toolkit to support developments in aspects of practice;
- The experienced teacher then working with colleagues to develop approaches across a group of schools.

In this way the aim was to establish a learning community, initially within a school and then scale up across a group of schools.

The case study approach was used as it enabled an in-depth analysis of a particular instance in use to be carried out and also reflected the need to gather evidence of the use of materials in the rather devolved funding and responsibility for PD in England. Research questions have been concerned with the way the approach has supported individuals, encouraged the development of professional learning communities and helped to overcome the kind of obstacles to development prevalent in the literature. Data has been gathered through: field notes; use of questionnaires on views and beliefs; interviews with teachers involved; observation of lessons, involving the use of video; focus groups of pupils following lessons.

5. Results and Discussion

It has been long recognised that developments in practice relating to scientific inquiry are hard to achieve and teachers have often struggled to position inquiry-based approaches within authentic contexts. Hence PD in this area would appear to be particularly problematic. The case study has identified a lot of potential to support developments in practice but difficulties in developing embedded and sustained professional learning communities due to particular systemic factors. These will be discussed in more detail in the full paper. Macro- and meso- level system factors have been identified as important obstacles to development in this English context, even when the beliefs and attitudes of teachers are supportive.

6. Implications

There is evidence from the case study of the potential for this PD approach to support the development of individuals within a community of practice. However, in this English context more attention is

needed at systems levels if significant developments in the use of inquiry based approaches in authentic contexts are to be achieved. There is also a need for inquiry to be a component of professional learning communities more widely.

Sproesser, U. (University of Education Heidelberg), Vogel, M. (University of Education Heidelberg), Dörfler, T. (University of Education Heidelberg), Eichler, A. (University of Kassel) — Research-based presentation on structural dimension

Developing and evaluating teachers' professional development referring to learning difficulties in reasoning with functions

Tuesday, 9:55-10:25, Room KG4 222

1. Theoretical background

Despite the relevance of reasoning with functions within and beyond mathematics education, there is vast empirical evidence that many learners have difficulties in this domain (e.g. Nitsch 2015, Vogel 2006). Unfortunately, their teachers often are not aware of these difficulties (e.g. Hadjidemetriou & Williams 2002). Moreover, Nitsch (2015) concludes from differences between school classes referring to learning difficulties with functions that some teachers are more successful than others in responding to these difficulties. Although the mentioned findings suggest that teachers' professional development (TPD) focusing on such typical learning difficulties may enhance teachers' pedagogical content knowledge (PCK) and students' learning in this field, there is no empirical evidence about these interdependencies, yet.

According to empirical studies (e.g. Lipowsky 2013), several characteristics of TPD have shown to be particularly effective. TPD for instance should intensively focus on one specific domain instead of dealing with a variety of different domains. Moreover, TPD should be of long-term nature to enable phases of input, practice and reflexion. Giving feedback supports learning in different contexts (e.g. Shute 2008) and also appears to have positive effects in TPD. These characteristics can for instance be implemented in teacher coaching, a specific form of TPD. Teacher coaching enables e.g. to give feedback concerning a concrete classroom situation or to encourage reflecting about it (West & Staub 2003). In adaptive teacher coaching, the coach particularly refers back to the teachers' statements and activities (Leutner 2004).

The project described here develops an adaptive teacher coaching in order to promote teachers' PCK concerning learning difficulties related to (mainly linear) functions and hence to support also students' achievement in reasoning with functions. Within the domain of functions, we focus on linear functions and on understanding functional relationships between two variables. The emphasis on this subdomain of functions renders the TPD particularly content-specific and takes into account that viable concepts concerning this fundamental subdomain are crucial for understanding higher-order functional classes.

As various existing TPD do not meet the necessary quality standards to clarify which of their characteristics would be responsible for a certain effect (e.g. Yoon et al. 2007), the main goal of this project is to evaluate if the focus on giving feedback to students showing concrete learning difficulties is a particular effective characteristic of the teacher coaching. Hence, we investigate the effects of 2 coaching variations in an empirical study focusing on the following research questions:

- To what extent can teachers' PCK related to functions be fostered through two variations of teacher coaching?
- Which effect do the coaching treatments have on students' domain-specific competence?

2. Methods

In order to gain empirical evidence about the effectiveness of the coaching, approximately 60 teachers of secondary education are assigned to a control group or to one of two treatment groups. In both treatments, teachers are instructed on PCK about learning difficulties related to reasoning with functions and ways to overcome them, whereas only the teachers in treatment one are particularly trained in giving supportive feedback to students exhibiting concrete learning difficulties.

At two respectively three points in time, teachers and students complete specific questionnaires concerning primarily teachers' PCK referring to functions and students content-related competence. Gathering students' and teachers' data enables analysing coaching effects at the student and the teacher level as well as the interplay between these levels.

In order to clarify the contents of the coaching, prior to this main study a pilot study was carried out in the academic year 2015/16. The purpose of the first part of this pilot study was to investigate if the learning difficulties derived from the literature were also common among students within our learning contexts and whether their teachers were aware of them. Therefore, students of four classes were requested to complete a written competency test referring to reasoning with functions. In addition, the corresponding teachers were shown some of these tasks and they were asked which typical student mistakes they would expect and how they would respond to them within their classes. Large parts of the students' test were adapted from the instrument of Nitsch (2015). To gather further covariates, existing measures were used (e.g. Cognitive Abilities Test by Heller & Perleth 2000) and several items were developed within the project (e.g. domain-specific motivational aspects).

As in mathematics education there is no consensus how to adequately respond to the gathered learning difficulties or how to prevent them through meaningful instruction, in the second part of the pilot study teacher trainers and professors were interviewed about these issues. The purpose of these interviews was to collect methods and material for the coaching.

3. Current status of the project

The pilot study revealed that the examined learning difficulties were also common among students within our learning contexts and that the interviewed teachers were not aware of all of them. Furthermore, the interviews with teacher trainers

and university professors were helpful to gather "best-practice"-methods how to respond to these learning difficulties. Hence, the pilot study proved suitable to develop the coaching treatments. The coaching was already carried out in the academic year 2015/16 and will also be provided in the year 2016/17. In order to recruit future participants, we already offered short modules of the coaching to prospective teachers starting to teach in the academic year 2016/17. Furthermore, we arranged with institutions administering TDP courses that our coaching will be included in their programmes.

Through the pilot study, tasks of the students' competency test and teachers' PCK-items could be tested and – where necessary – be improved. The final test instrument for students includes the revised competency test referring to reasoning with functions. As indicated in Section 2, it furthermore gathers covariates such as students' cognitive abilities (Cognitive Abilities Test by Heller & Perleth 2000) or their mathematics- and content-specific self-concept and interest ((adaptions of) Pekrun et al. 2002).

The PCK-items used in the teacher interviews were revised and included into a teachers' questionnaire. In particular, teachers are asked a) which learning difficulties they would expect concerning several student tasks, b) which misconceptions were assumed to cause concrete student mistakes and c) how they would react to these mistakes in their classroom. The teachers' questionnaire furthermore collects data about their professional background (e.g. university degree, teaching experience, …) as well as about their motivation and beliefs concerning for instance mathematics education (e.g. Staub & Stern 2002) or teachers' professional development (e.g. Klein-Heßling & Röder 2007).

4. Format and contents of the planned presentation

As outlined above, the purpose of this project is to develop, carry out and evaluate two variations of teacher coaching that aim at fostering both teachers' PCK and students' learning. Hence, we address the topic "mathematics teacher professional development" from a research-based perspective comparing two professional development treatments and a control group.

In the planned power point-presentation, we will briefly introduce the theoretical background and the design of the research project as described in Section 1 and 2. Moreover, we will illustrate beyond relevant developmental steps the final (methodological) structure and the contents of the teacher coaching. We will also present several elements of the test instruments to clarify how we plan to evaluate the intended increase in teachers' content-related PCK and students' competency. Concerning the exemplarily raised questions that should be addressed by the proposals / presentations, we would like to make a contribution to the following issues:

- What can a design of an initiative aiming at a widespread implementation of innovative teaching and for scaling up professional development look like?
- Which structures prove to be effective (in which cultural context)? Which do not?
- How can we investigate empirically the impact of different project designs?

Staberg, R.L. (NTNU), Sikko, S.A. (NTNU), Dahl, H. (NTNU), Febri, M.I.M. (NTNU) — Research-based presentation on personal dimension

Impact of Multiplier Concept on Teachers' Professional Knowledge

Monday, 17:45-18:00, Room KG4 222

1. Relevance for the conference

Norway takes part in the mascil project and in the Research-practice interactive session for Topic 1 (Personal dimension) in this conference, we will contribute with our experiences with using the pyramid model (cascade model) for scaling up professional development (PD). One of our multipliers will take part in the conference, and discuss successful aspects of the model and pitfalls to be avoided. Thus, during the morning session on the first day we will focus on the multipliers' role and experiences. Our multipliers were supporting other teachers in PD courses, but also developed a learning community with their teacher colleagues. This proposal focus on another perspective of the pyramid model: the teachers' professional development within each multiplier's professional learning community. We address Topic 1 and particularly the following question: "What are the needs and experiences of the different target groups: Educators of teacher educators, teacher educators themselves, facilitators of learning communities and teachers in their everyday classroom practice?" More specifically, we address the question from the perspective of teachers in their everyday classroom practice in Norway. Our proposal addresses thus both the target group-specific and country-specific perspectives. We want to focus on in-service teachers' needs and experiences in the context of using the multiplier concept. We also look closely at how the teachers have developed in terms of their beliefs, self-efficacy and motivation in implementing the mascil ideas. Thus, our proposal relates to the overall conference theme, to one of the topics, and to one of the mentioned target groups. We intend to use the oral presentation format.

2. Theoretical background

The mascil project has three aims: (1) promote a widespread dissemination and implementation of inquiry-based learning (IBL) in primary and secondary schools across Europe, (2) connect IBL in school with the contexts found in the world of work (WoW), making science more meaningful for young European students and motivating their interest in careers in science, (3) develop Professional Learning Communities that bring together teachers across schools to work together over time in collaboration

to explore - in their classrooms - the implementation of inquiry learning approaches that connect to the world of work. IBL generally refers to student-centered ways of teaching in which students raise questions, explore situations, and develop their own ways towards solutions (Maaß and Artigue 2013). On European level, most educational policy documents clearly support and require an introduction of IBL to school subjects (Hazelkorn et al. 2015, Rocard et al. 2007). The status of IBL in Europe depends significantly on the country and the subject (Engeln et al. 2013) but apparently, IBL is not implemented as widespread as expected (Maaß and Artigue 2013). Thus, many projects focus on further implementation, among them is the EU-project mascil in which Norway participates.

In Norway, the latest policy reform in the 10-year compulsory school and in upper secondary education (Kunnskapsdepartementet 2013) embeds a new main subject area in the science curricula: the budding researcher, which caters the process dimension of the Nature of Science and clearly features inquiry-based learning (IBL). Norwegian whitepapers indeed strongly recommend and support the inquiry approach (NOU 2015: 8). However, the classroom study PISA+ reports few enactments of the budding researcher in Norwegian schools (Ødegaard and Arnesen 2010).

Within mascil, a professional development (PD) program was designed, following the “cascade model” for a widespread implementation of IBL and WoW, and the “spiral model” for improving teachers’ pedagogical competence (Maaß and Doorman 2013). Through the “cascade model” a set of multipliers in every country were trained, who in turn lead PD-courses (workshops) themselves. The “spiral model” was based on cycles of analysis-implementation-reflection.

As part of mascil’s internal evaluation, all participating countries performed at least one case study. The guiding research question was: In relation to the implementation of IBL and WoW, what impact has our overall PD concept on participants and what are the reasons for this? This proposal draws from parts of two Norwegian case studies. We present experiences from teachers. In particular, we look closely at how the teachers have developed in terms of their beliefs, self-efficacy and motivation in implementing the mascil ideas.

3. Materials and methods

Ordinary in-service science and math teachers took part in a PD program run by us, to subsequently act as multipliers. Our PD course was organised as six half-day sessions for multipliers over 9 month period, including two lesson studies; followed by multipliers conducting workshops with teacher colleagues over a 10 month period. The data collection was done following the case-study design (c.f. Yin, 1984 in Cohen et al. (2011)). Our case unit is composed of one PD-course with two multipliers and three teachers from the same school. Two case studies are conducted; one in school P and one in school S, see Table 1 for details.

Multiple data sources were collected to insure in-depth analysis (Cohen et al. 2011): pre- and post-interviews with multipliers and teachers, classroom and workshop observations. In this presentation, we will focus on in-service teachers’ professional development within their community of practice, and describe results from interviews and classroom observations.

Table 1. Overview of our two cases

Case	Multipliers	Teachers
School P primary (grade 1-7)	Andreas (16 years in primary, 1st to 4th grade, teaching math) Berit (16 years in primary, 1st to 7th grade, teaching math and science)	Anna, Bodil, Cate
School S primary and secondary (grade 1-10)	Arne (35 years in lower secondary school, passionate about math) Bjarne (6 years in lower secondary school, passionate about science)	Adrian, Bernt Caroline

4. Results and discussion

We follow closely three case teachers from two schools (Table 1). It is too early to draw any final conclusions regarding the overall outcome of the implementation of mascil in the Norwegian context, as post-interviews and classroom observations are still to be done (as of April 2016). The final and comprehensive results however, will be ready and presented at the conference. Although the data collection is ongoing, we can already see from the preliminary investigation that the multipliers’ work have resulted in fruitful development of teacher professional knowledge in their community of

practice (Febri et al. 2016) and some remarks might be worth our attention at this point of the case study.
The aspects of IBL seem to be well received by the teachers, and in line with their own beliefs on how mathematics and science is best learned. Some of the teachers already have some experiences, though limited, with implementing IBL, and all of them would like to do it more often. The main impediments however, seems to be time to find adequate tasks, prepare, conduct and evaluate IBL-activities, besides lack of confidence and a fear of losing control over the students and/or their learning outcomes. These difficulties are consistent with what primary teachers perceived as obstacles to conduct inquiry science teaching (Harlen 2011). Teachers needed thus time and practice to familiarize themselves with new ways of planning and conducting lessons. Hence, it is crucial to develop teacher-PDs that include classroom management that promotes IBL-practices. This finding resonates with our previous studies on IBL-implementation at lower primary science (Febri and Staberg 2015).
The WoW approaches seems to be harder to convey. The teachers do not seem to consider the link between WoW and school subjects to be crucial for student learning. Especially at primary school, students' young age is an argument for not using WoW-related tasks largely. Similar arguments have been found among pre-service teachers and their mentors (Febri and Staberg 2015). The examples of IBL- and WoW-related tasks the teachers are exposed to during PD-sessions, seems to be highly influential in terms of increasing their enthusiasm and their beliefs in IBL-/WoW-approaches.
So far, most teachers seemed to benefit from the PD-courses run by multipliers. Their PD was considered useful since it gave opportunities for discussions and reflections with teacher colleagues, exchanging ideas of tasks and supporting each other. Some wished for this learning within the community of practice to be more widespread at school and more applicable to the day-to-day teaching. This finding points to the teachers' need for and the importance of communities of learning in order to keep the motivation and enhance self-efficacy.

Stampfer, F. (University of Innsbruck), Kapelari, S. (University of Vienna) — Research-based presentation on material dimension

An analysis of teachers questioning as "mediating artefacts" in a professional development course within the mascil project

Monday, 17:45-18:00, Room KA 101

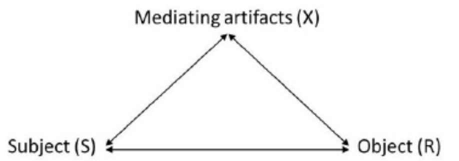
1. Introduction
In an effective teacher training, the importance of interactions between teacher and students must be addressed as a key feature in inquiry-based learning. In the level of guided inquiry, which is the most effective type, cf. Bruder and Prescott (2013), the role of the teacher and the strategic use of questions are the crucial points in the development of the task, i.e. the phase when students work autonomously in small groups (Menezes et al., 2013).
Within the project mascil, we designed a special task to provide a fast and effective tool involving pre-service and in-service mathematics teachers in a mascil learning environment. mascil – mathematics and science for life – is an EU-project which aims promoting inquiry-based learning (IBL) and the connection to the world of work (WoW) in primary and secondary schools. Hardly anything do we know about the role the teachers plays when communicating with learners during particu - lar teaching phases. Thus, we looked closely at how a teacher trainer in a professional development course communicates with teachers during the phase development of the task. Our focus lied on short learning episodes when the teacher trainer reaches the table of a small group and interacts with students. We investigated these artefacts and asked whether they could be explained and analysed within the theory of socio-cultural learning and activity theory.

1.1. Socio-cultural perspective of learning
A fundamental assumption of sociocultural approaches to learning is that actions, rather than the human being or the environment considered in isolation, provide the entry point into the analysis. “When action is given analytic priority, human beings are viewed as coming into contact with, and creating their surrounding as well as themselves through the action in which they engage” (Wertsch, 1998, p. 8).
Habermas argues that many types of categories of action can be distinguished which are based on the relationship between the actor or learner and the environment. He takes Popper´s three world theory to categorize three type of environment in which activity takes place

- facilitated by physical objects or physical states
- facilitated by states of consciousness, mental states, behavioural disposition of act
- facilitated by “objective contents of thought” (e.g. scientific or poetic thoughts, works of art)

Although language is often assumed as being the most important mediating action applied, these two other environments should not be neglected. Actions taking place between the actor and the world of physical objects may be summarised as producing or working with any kind of physical representations of understanding (Wertsch, 1998) such as hand-on tools, lesson plans, portfolios, posters etc.
(Wertsch, 1998, p. 12) particularly stresses the point that: “the most central claim I wish to pursue is that human action employs 'mediational mean' such as tools and language and that this means shape the action in essential ways. According to this view it is possible as well as useful to make analytic distinction between action and meditational means but the relation - ship between action and meditational means is so fundamental that it is more appropriate when referring to the agent involved to speak of 'individual(s)-acting-with-meditational-means' than to speak simply of 'individual(s)'. Thus, the answer to the question of who is carrying out the action will invariably identify the individuals in the concrete situation and the mediational means employed”.
This is in contrast with approaches that treat the individual as a passive recipient of information from the environment or approaches that focus on the individual and treat the environment as secondary, serving merely as a device to trigger certain developmental processes. The actor is assumed to reach a desired state by choosing means that have promise of being suc - cessful in the given situation and applying them in a suitable manner. This is based on a decision among alternative courses of action, with a view to the realisation of an end, guided by maxims and based on an interpretation of the situation (Wertsch, 1998).

1.2. Activity learning
Activity theory is a “philosophy and cross-disciplinary framework for studying different forms of human activity [… hence it is] a philosophical framework for studying different forms of human praxis as developmental process. Both individual and social levels are interlinked at the same time” (Kunit, as cited in Jonassen, 2000). “Activity theorists argue that conscious learning and activity (performance) are completely interactive and interdependent. Activity cannot occur without conscious (the mind as a whole) and consciousness cannot occur outside of the context of activity” (Jonassen, 2000, pp. 97–98).
Initiated by Vygotsky and his Russian colleagues the principles of “Activity Theory” evolved from Vygotsky's triangular model visualising the relationship between the stimulus (S) and the response (R) which is transcended by a complex mediating act (X) (cf. Vygotsky and Cole, 1978).



Common reformulation of Vygotsky´s mediated act (Engeström, 2001)

Thus Vygotsky was first to insert “mediating acts” which are called “cultural artefacts” into human action. “The individual could no longer be understood without his or her cultural means; and the society could no longer be understood without the agency of individuals who use and produce artefacts…. Objects became cultural entities and the object-orientedness of action became the key to understanding human psyche” (Engeström, 2001, p. 143).

According to Mortimer and Scott (2003), we consider the dialogue between educator and teachers during professional development activities as crucial for learning. In our research, we assume that developing a better understanding of how questions are formulated when they are asked and to whom or what they are directed will help us to become more sensible in scaffolding guided inquiry. Thus, our research question is: How do teacher trainers communicate with their students during the task development phase, while students work in small groups?

2. The task: Chocolate bar machine scheduling

In the introduction of the task, the work place of a machine scheduler at a chocolate bar manufacturer is presented. For a customer order, five products have to be processed on two machines: on machine 1 the melted chocolate is poured into bars and on machine 2 the chocolate bars are packed. The processing time for each product on each machine is given. The job of a machine scheduler is to determine the order of the products such that the total processing time – the interval between the time when the first product starts on machine 1 and the time when the last product leaves machine 2 – is the shortest. The final result is the order of the products in form of a machine schedule. The machine schedulers have to develop their own strategies to tackle the problem. The abstract of the task is:

> Five products a, b, c, d, e has to be processed on two machines M1 and M2. The processing time for each product on each machine is given. It is important that each product is first processed on machine M1 and then on machine M2. As an example, we consider the production of a chocolate bar: on machine M1 the melted chocolate is deposited into bars and on machine M2 the chocolate bars are packed.
>
> For which order of the products the total processing time – the interval between the time when the first product starts on machine M1 and the time when the last products leaves machine M2 – is the shortest? Describe your ideas and strategies!

	a	b	c	d	e
M_1	3	4	8	10	7
M_2	2	6	5	7	12

3. Study design and methodology

The study was done in an IBL professional development course for pre-service mathematics teachers. Sixteen students worked in 6 groups of two or three for about 45 minutes on the task Chocolate bar machine scheduling. Each group and also the trainer were audio taped and the data are transcribed. Based on the analysis framework of Mortimer and Scott (2003), we will analyse the dialogue sequences where the trainer interacts directly with his students at their table and sequences where the trainer gives additional information to all students. We are currently analysing data and will present first results during our presentation.

Tirosh, D. (Tel Aviv University), Tsamir, P. (Tel Aviv University), Levenson, E. (Tel Aviv University), Barkai, R. (Tel Aviv University) — Research-based presentation on material dimension

Using cases as materials in professional development

Monday, 16:50-17:20, Room KG4 222

1. The use of cases in professional development

This presentation focuses on the use of cases in professional development (PD) as a way of bridging the gap between theory and practice for mathematics teachers who come from diverse backgrounds. In Israel, although there is one national mandatory mathematics curriculum, different languages are spoken in different areas and cultures vary greatly. Offering meaningful professional development for such a diverse group can be challenging, especially if teachers are requested to bring events from their own classrooms for discussion and analyses during PD. In this presentation we raise the possibility of

having the teacher educator bring cases of classroom situations to the PD course and use those cases as materials to analyse, discuss, and demonstrate theory.

Shulman (1986) suggested that although the case method was historically used in teaching law and medicine, it could also be used for teaching future teachers. He used the term "case knowledge" to describe "knowledge of specific, well documented, and richly described events" (p. 11). He added that the use of the case method in teacher education can illuminate both the practical and theoretical sides of teaching. In other words, it can help bridge the gap between field work and course work. Markovits and Smith (2008) describe two kinds of cases used in mathematics teacher education – exemplars and problem situations. Exemplars consist of lengthy descriptions of an entire instructional episode that highlight the crucial role of teachers' actions and their interactions with students during classroom instruction. Exemplars illustrate authentic practice and not necessarily best practice. As opposed to exemplars, problem situations are usually relatively short and may convey real events that took place in a classroom or a hypothetical situation based on research related to students' ways of thinking. They describe classroom events involving mathematics, which raise a problem or dilemma inviting readers to analyse the situation and to suggest ways of responding to the problem.

In this presentation, we focus on a PD course aimed at enhancing teachers' appreciation of providing both examples and non-examples in teaching and learning mathematics. The material which is the focus of this presentation is a case based on a classroom event, and used as an exemplar. The case material consisted of a classroom transcript, along with guiding questions to be answered by each participant. This was followed by a group discussion with the teacher educator. The presentation will address the following questions: What were the criteria for designing this case material? What are some of the affordances of the case design, specifically, what are the affordances of bringing an outside case for use in a PD course, and what are some of the constraints? How can this material be used in the future by the teachers in their practice?

2. Setting and method

Thirteen practicing teachers took part in the course described in this presentation. The diversity was such that some teachers were native Hebrew speakers and some had Hebrew as their second language. Some taught lower secondary school and some taught upper secondary school. As stated above, the focus of the course was on the use of examples, non-examples, and explanations in mathematics education. Participants read and discussed research papers related to example spaces, pivotal examples (Zazkis and Chernoff, 2008), and intuitive and non-intuitive examples and non-examples, emphasizing the importance of using non-examples and taking into consideration that non-examples are often not used in the classroom (Tsamir, Tirosh, and Levenson, 2008). The cases presented in those papers were studied and analysed.

Midway during the course, the teacher educator handed out a transcript of a geometry lesson which took place in a tenth grade classroom. The criteria for choosing that transcript were as follows: First, the transcript was a word-for-word transcript of an actual mathematics class which took place within a few weeks of the PD lesson. This was important to ensure authenticity and relatedness. Second, the teacher of the classroom was known to be an expert teacher. Third, the mathematical topic discussed in the case was similarity and proportionality in geometric figures. It was thought that this material would not only be relevant to the upper secondary school teachers, but also to the lower secondary school teachers who taught proportional reasoning, albeit not in relation to similar triangles. Fourth, the context of the lesson was thought to be relatively culture-free in that it included simple calculations and geometric sketches, and did not include realistic problems or the writing of formal proofs.

The transcript was handed out with instructions to read it from beginning to end, without interruption, in order to understand the context and get a feel for the classroom. After reading through the transcript, the teachers were asked to reread the transcript and fill out a worksheet with the following questions: What did you learn about the use of examples during mathematics instruction from the examples given in the case presented? What would you do the same as the teacher did with regard to examples? What would you do differently from the teacher with regard to examples? The first question

above was designed to focus the reader of the transcript on the use of examples during the classroom interaction presented in the transcript and how those might have affected the students. The last two questions were designed to elicit reflection regarding the participants' own teaching and their own use of examples in their classrooms. After the teachers wrote their answers and handed them in, a discussion followed. A week later, during the next session, a second questionnaire was handed out which asked the following questions: On a scale of 1-4 (1-not at all; 4-very much), to what extent did last week's activity (analysing the case of similarity and proportional reasoning) contribute to your understanding of the use of examples in mathematics
classrooms? In your opinion, did the fact that the case was taken from an actual classroom event contribute to you in any way or would it have been just as effective (or ineffective) if the case had not been an actual classroom event?

3. Some results and implications

In the previous section, we outlined the criteria for choosing the case and the design of the material. In this section, we describe some of the results of the two questionnaires and then use those results to evaluate the affordances and constraints of the case materials.

From the first questionnaire, we gathered information regarding what aspects of examples and non-examples the teachers noticed in the transcript. Several teachers pointed out in a positive light that the teacher in the transcript began with numerical examples and only later presented examples with parameters; one teacher pointed out that the numerical example used simple numbers so that the students could intuitively recognize the proportion without having to work out the proportion algorithmically. Two teachers wrote that the teacher in the transcript did not present any non-examples, that is, there were no examples of triangles that were not similar and therefore their sides were not in proportion. This is something they said they would do differently in their own classes. This point was also brought up during the discussion which followed the questionnaire. One of the teachers commented, "if you don't show students when a theorem does not work, you cannot be sure if they understand the conditions of when the theorem does work." Finally, one teacher recognized how the example of similar triangles used by the teacher in the transcript led to the specific case of a triangle mid-segment. That recognition led the teacher in the PD course to also comment about the difference between examples which demonstrate a generality and those that demonstrate a specific instance.

When reviewing the second questionnaire we found that teachers felt that the case activity contributed (on a scale from 1 to 4, the average was 2.615) to their understanding of the use of examples in the classroom. One teacher explained her low score as follows: "we only analysed one lesson and one specific topic." Another teacher who gave a low score wrote, "There were hardly any examples in the transcript to analyse." Yet, that teacher also wrote, "It made me think more about the examples and non-examples in my own class." On the other hand, another teacher wrote that the activity was very effective because it made her think about her own class. She wrote, "It made me think that I have to give more non-examples in my class. In general, I only give examples. It also made me realize how important are the examples and non-examples you give when introducing a new topic."

Out of 13 teachers, 12 wrote that knowing that the case was taken from an actual classroom event, contributed to the activity's effectiveness. One poignant response was from a teacher who wrote, "When I looked at the classroom interactions, I also reflected on my own classroom." Another teacher wrote, "The text was an example of the concepts we learned during the course."

To summarize, the case materials afforded the teachers a chance to analyse a realistic classroom event and focus their attention on the use of examples. A fruitful discussion between all participants was possible. None of the teachers claimed that the case was irrelevant or too distanced from their actual practice. One of the constraints of this particular case was that it was not as rich in examples and non-examples as an exemplary case could be. On the other hand, that teachers noticed the lack of non-examples, demonstrates that they were able to use the theory learned in the course, to analyse an actual classroom event. The language of the transcript was another constraint, at least to some of the

participants. Although none of the teachers wrote this, we were able to see from some of the responses that misunderstandings of the text did occur.

How can this material be used in the future by the teachers in their practice? Although we did not ask the teachers this question, one teacher wrote on the second questionnaire that "the lesson analysis will help me greatly in the future to plan my lessons better." Another teacher wrote, "I pictured myself in place of the teacher and asked myself what I would have done." These types of responses were repeated by many teachers from all backgrounds. In other words, one of the ways that this case material may be used in the future by the participants is by serving as an example of how classroom situations can be analysed.

While teacher educators call for cooperation between participants and the establishment of teacher learning communities (e.g., Jaworski 2008), it can be quite demanding and challenging. In our course, we attempted to engage all participants by having them analyse a case which came not from their own classes. While results indicated that most participants were engaged with the materials, it is unclear how a program with such a diverse population can be scaled up. One way could be at the school level, whereby each participant becomes a potential multiplier and uses the case materials for staff development. In the future, participants could use this case material as an example of how to develop cases from their own classroom situations to discuss at staff meetings. We look forward to discussing these possibilities with participants at the conference.

Triantafillou, C. (ASPETE, Greece), Psycharis, G. (National and Kapodistrian University of Athens), Potari, D. (National and Kapodistrian University of Athens), Zachariades, T. (National and Kapodistrian University of Athens), Spiliotopoulou, V. (ASPETE, Greece) — Research-based presentation on material dimension

Aspects of secondary teachers' attempts to integrate workplace in teaching'

Tuesday, 10:50-11:20, Room KA 101

1. The focus of the study

The present study aims to examine how practicing mathematics teachers integrate workplace tools and practices when designing and implementing problem-solving classroom activities and what are the main factors that facilitate or constrain this integration. The study took place in the context of a European project, mascil (see: www.mascil-project.eu), that aims to integrate workplace in the teaching and learning of mathematics and science through implementation of inquiry-based tasks in classrooms. It draws evidence from the project implementation in Greece and more specifically from the professional development (PD) phase. How teachers can use the workplace as a context for designing and using lesson activities in the classroom remains an open question that has only received partial answers from small scale studies mostly on prospective teachers. Nicol (2002) found that a teacher education program including visits to workplace sites helped prospective teachers to keep the mathematics contextualized when designing activities for their students. Frykholm and Glasson (2005) suggested that teacher education courses involving collaboration between science and mathematics prospective teachers provide a fertile ground for them to develop interdisciplinary units connecting both topics. Moreover, school science and mathematics communication can be empowered by lesson designing on the basis of workplace (Shirley et. al. 2011). Particularly, we examine how practicing science and mathematics teachers are involved in integrating workplace tools and practices in their classroom teaching and what factors facilitate or hinder this integration. In the analysis, we adopted Engeström's (2001) model of interacting activity systems. We considered two activity systems, the activity of workplace and the activity of mathematics teaching in which the teachers have been engaged, in order to study the interaction between the two.

2. The context of the study and methodological issues

In mascil implementation in Greece, thirteen groups of practicing secondary teachers (about 10 in each group) from mathematics, science and technology have been established to work in the spirit of lesson study. In each group, teachers collaborated with the support of a teacher educator for a school year to design and implement inquiry-based tasks related to workplace non-routine situations and reflect on their teaching. Before and after each implementation of the designed lessons PD meetings took place. In this study, we focus on five groups of practicing teachers (22 mathematics teachers, 14 science and 9 technology) working in upper or lower secondary school with long teaching experience (more than ten years). We analyze the work of the mathematics and science teachers, who collaborated together as well as with technology teachers in their groups during the PD courses. The analysis of different cases of teachers indicated different ways of interaction among the elements of the activity systems. In this paper, we present the case study of one mathematics teacher based on video recordings of her classroom implementation, her own portfolio and audio recordings of the discussions in the PD meetings. This case shows a strong integration of workplace into mathematics teaching.

3. Findings

In the analysis of the different cases, we tried to identify what are the aspects of a successful path in teachers' design and implementation during teachers' collaboration in the PD course. We will focus on a good example that will be discussed analytically. It refers to a mathematics teacher, Katerina, with about 10 years of teaching experience. She participated in a mascil group with 13 members (eight mathematics, one technology and four science teachers). Katerina developed a task entitled "Seismologists for one day", where the students had the role of a seismologist responsible to study main features of a specific earthquake (e.g. the epicenter). The initial idea of the task was provided by a group member whose specialization was geology. The PD educator suggested collaboration between mathematics and science teachers as a way to integrate workplace context into classroom teaching. The geology teacher designed and implemented the task in his classroom and shared his materials (e.g., description of the main features of this physical phenomenon and how they are studied by specialists) with the PD group. Katerina was teaching mathematics and geography in grade 7 in her school, so she found as a challenge to develop a task for integrating the context of seismologists into her teaching by combining mathematics and geography. Her familiarization with the context of earthquakes in the PD meetings allowed her to identify that it was possible to design such a task for her students. In classroom implementation, Katerina presented and discussed scientific aspects of the earthquakes from physics and geography and provided students with authentic data from the National Institute of Geodynamics. The data included (a) the velocity of p (VP) and s (VS) waves and the exact time these waves were recorded in specific seismic stations, as well as the mathematical formula $D = \Delta t \, . \, (VP \, . \, VS) / (VP - VS)$ (1) which indicates the distance D in Km of the epicenter from the seismic station; (b) a geographical map indicating all the seismic stations in the country with the corresponding codes (e.g., LKD2 for the seismic station in Lefkada island); and (c) the specific measures recorded in the seismographs of six stations in west Greece (Figure 1). In terms of mathematics, the students had to identify that the epicenter of the earthquake was the common point of three intersecting circles whose centers were situated on three seismic stations (Figure 2). In particular, they had to: substitute given quantities into the formula (1), to calculate the distance of the epicenter
from the different stations; model the situation through the use of map scales; conceptualize the calculated distances as radii of different circles; and design them with the use of ruler and compass.

Sta	Dist (km)	Phase	Time	Amp (micrometers)
LKD2	77.60	P_0	14:22:38.011	
LKD2	77.60	AML	14:22:57.030	33484.0
LKD2	77.60	AML	14:22:55.740	25412.6
PDO	82.00	P_0	14:22:39.117	
PDO	82.00	AML	14:23:00.010	53468.1
PDO	82.00	AML	14:22:59.040	71045.4
RLS	85.90	P_0	14:22:40.039	
RLS	85.90	AML	14:22:57.300	25157.1
RLS	85.90	AML	14:22:56.550	28409.4

Figure 1. Data sheet from seismic stations

Figure 2. Students' actions as seismologists

Katerina's attempt to integrate the workplace of seismology into her teaching was followed by a number of actions such as (a) her own familiarization with the workplace context through discussions with the geology teacher in the PD group and her involvement in teaching mathematics and geography in the same classes, (b) her decision to connect the topic of earthquakes included in the geography curriculum with aspects of the mathematics curriculum (e.g., scales, properties of geometrical figures), (c) the use of authentic workplace worksheets and tools and (d) the assignment of the role of a professional to the students simulating the actual workplace practice. In the case of Katerina, we see that the two activity systems are strongly connected forming and a new object started to be formulated in the intersection of the two systems. In this case, sharing of artefacts, goals and actions between by mathematics teaching and workplace appeared through the simulation of the workplace activity in the classroom.

4. Conclusions

The presented case study indicates the nature of interaction between the activity system of workplace and the one of science and mathematics teaching. We address these forms of interaction by focusing on two dimensions: the process by which the teacher attempted to integrate workplace into her teaching and the factors that supported this integration. As regards the process of integration, we notice teacher's attitude in terms of familiarizing herself with the workplace context and her actions in terms of engaging students in modelling activities, familiarizing them with the corresponding professional contexts and assigning them a professional role and task. Modelling is a process that triggers teachers' interest and as Wake (2015) argues it operated as a means of building connections between mathematics teaching and workplace. This process was adopted by Katerina who engaged students in mathematizing workplace situations such as identifying geographical maps' scaling and viewing modelling embedded in a process of simulating authentic workplace practice in the classroom. Her students engaged in workplace working with authentic contextual or scientific representations such as diagrams of sun's route or geographical maps and assigned them a professional role (i.e. seismologist) and a task (i.e. to find the epicentre of an earthquake) strongly related to the workplace practice. On the other hand, her collaboration with teachers from different disciplines in the PD group in co-designing a task was definitely a supportive factor in constructing an activity through interaction between workplace and mathematics teaching activity systems. The initial idea of a geology teacher was the basis for Katerina to extend her experiences. Her teaching experiences of geography supported a smooth integration of the workplace practice of a seismologist in her classroom teaching of mathematics. Based on the existed material, she inquired further the rules of the workplace underlying mathematics teaching. This supports recent research findings that acknowledge workplace as a fertile ground for science and mathematics teachers' collaboration (Potari et. al. in press).

Van der Valk, T. (Utrecht University), Mooldijk, A. (Utrecht University), Duifhuis, P. (Hogeschool Utrecht) — Practice-based presentation on personal dimension

Educating physics educators in Surinam: the NiNaS project

Monday, 17:30-14:45, Room KA 102

1. Introduction

The secondary school physics curricula in Surinam, a small country (500,000 inhabitants) in South America and a former Dutch colony, are based on the Dutch syllabi and textbooks from the seventies, the time of the independence. So the curriculum is outdated. In general, physics teaching in Surinam, as in other developing countries (O-saki, 2004) can be characterised as frontal, teacher centred and abstract, using few contexts from daily life. It does not reflect the experimental character of physics, does not use computer-aided methods and is not sufficiently geared to the needs of nowadays Surinam society and students' future studies (Nextgen, 2016).

At the start of the project, the Surinam government, aiming at modernizing the junior and senior physics curricula in the near future, planned to introduce new textbooks in September 2015. The Surinam Institute for Teacher Education (IOL) contacted the Freudenthal Institute of Utrecht University and the Archimedes Institute for teacher education in the Netherlands to start a two-years project, called New Physics in Surinam (acronym NiNaS). Funding for the project was supplied by the UTSN, an organisation for cooperation between Surinam and the Netherlands. In January 2015, the project was launched and it will last until January 2017. The aim of the project is to educate the educators in Surinam that will prepare the physics teachers for implementing the new textbooks.

In our presentation, we will highlight the personal dimension: the roles of politicians, administrators, teacher educators and teachers in the project. The central question of the paper is: 'what are the conditions for a cooperation project between a developed and a developing country that aims to educate the educators for a successful curriculum change?'

The presentation format we will use is an oral presentation about the project and the research connected, followed by a discussion.

2. The design of the project

Like in other reform/professional development projects (see e.g. O-saki, Ottevanger, Uiso & van den Akker, 2002), four groups participate in the project. First, the group of Surinam teacher educators who will prepare the physics teachers in the schools how to implement the new physics textbooks. Second, two experienced physics teacher educators from the Netherlands, who educate the educators. Third: the group of Surinam teachers that has to implement the new curricula and methods in their classes. And fourth, a commission that guides the project, consisting of school principals, representatives from the Surinam university and from the Ministry of Education.

A significant contributor to the project is the Project Advisor. This is a Dutchman with roots in Surinam, who was a physics teacher and curriculum developer in the Netherlands. After his retirement, he moved to Surinam and has become an advisor at the Institute of Teacher Education IOL. He has been the locomotive of the project proposal. He has linked the IOL to the Dutch Universities and has many contacts in the Ministry and in the educational field.

Along with the project, the Surinam Ministry was supposed to prepare new physics curricula for junior and senior secondary school: to develop new examination syllabi and to provide new textbooks to be used for the implementation of the new curricula.

The project is planned in three parts. The first part (January – July 2015) is to select the educators for the new curriculum and to train them in pedagogical content knowledge and skills in Utrecht. An implementation plan was to be written.

In the second part (July 2015 – August 2016), along with the introduction of the new textbooks, the Surinam educators, coached by the Dutch project members, train the teachers in implementing the textbooks.
In the third part (September 2016 – January 2017), a plan for further implementation will be developed in order to ensure that the results of the project should be consolidated and developed further.
Along with the three parts, Utrecht University has planned to investigate to what extent the project reaches its aims, by means of questionnaires and classroom observations.

3. The first part of the project: a good start

The project started with a visit of the Dutch project members to Surinam, to the Teacher Education Institute, to schools and to the Ministry of Education. Everybody was enthusiast and expressed to intend to cooperate. To relate the Surinam teachers to the project, a short teacher conference was organised by the Project Advisor, in which the IOL staff and the Dutch partners explained the plans for the curriculum change. The teachers expressed to support the project and to be happy with the approach, as some earlier efforts to change the curriculum had failed.
After this visit, the Project Advisor composed the 'implementation group', headed by a IOL staff member. As IOL physics staff was too small (three persons), four experienced junior secondary education teachers were invited to join.
These seven teachers came to Utrecht and were trained in new methods. These methods include Predict-Observe-Explain (White & Gunstone, 1992), Think-Share-Discuss, handling misconceptions, demonstrations, practical activities for the classroom, using concepts for developing understanding and motivation and other activities that support argumentation (Osborn et al., 2004).
In July, the Dutch project members came to Surinam. They trained the Implementation group members. At a two-day conference the Implementation Group started educating the physics teachers, using the new textbooks. The conference was opened by the Minister of Education, who fully supported the project and promised that the new textbooks would be present in October 2015. The implementation could start!

4. The second part of the project: redesign because of financial problems in Surinam

Unfortunately, in the summer of 2015, the Surinam government declared that Surinam had serious financial and problems. The Minister decided that there was no money to buy the new physics textbooks. The implementation of the new curricula had to be postponed to an unknown date. As a consequence, the project plan had to be adapted. At the same time, the IOL – physics staff was reduced to two persons.
The project was redesigned in a discussion between the implementation group, the Advisor and the Dutch teacher educators. The main adaptations were:

- the goal of the project was confined to educating the educators, the members of the implementation group, to be prepared for training the Surinam teachers at the moment that the textbooks would be available
- that group was extended with four senior secondary school physics teachers
- all teacher members of the implementation group would test some new methods in their classes, however using the old textbooks
- to support them, (1) the teachers would be paid for their time investment by the project, not anymore by the Ministry; and (2) they would be supplied with modern apparatus, in particular a beamer, to be used in their classrooms.

These adaptations were broadly supported, but it cost a lot of time for the new plan to be approved by the financer of the project, UTSN. In March 2016, the plans were approved and now, the project can progress. At the time of the conference, the project will be further underway and results will be reported.

5. Some preliminary conclusions

A first main conclusion is that the present of a person like the project advisor, who knows the ins and outs of both the developing country (i.c. Surinam) and the expertise providing developed country (i.c. the Netherlands) is crucial for a good design of a cooperation project and for getting the project approved by the financer.

A second conclusion is: the project, the funding organisation and the project members have to be flexible as political and economic circumstances may change during the project period, urging a change in the project design.

A third conclusion is that the educators being trained do not need to be exclusively the teacher trainers from a teacher training institute, but can as well be experienced teachers in the schools who can be the 'advanced adopters' in the curriculum change.

A fourth conclusion is: the educational approach we applied, did change the way the advanced adopters and teacher trainers teach. Whether this means that they can educate their colleagues in implementing new methods is not clear yet.

A fifth conclusion: concrete successful new activities in the classroom motivate students as well as teachers.

Van der Valk, T. (Utrecht University), Kleijer, C. (Utrecht University), Michels, B. (Utrecht University) — Practice-based presentation on structural dimension

Scaling-up in a secondary/higher education STEM network: U-Talent

Tuesday, 15:45-16:45, Room KG4 222

1. Introduction

At the 2014 Educating the Educators' conference, we reported about the scaling-up in the Dutch talent development programme called Junior College Utrecht (Van der Valk, Tromp & Kleijer, 2015). In the years since, the programme has broadened and got a new name: U-Talent. This paper relates to the main conference topic structural dimension, finding an answer to the question: how can the structure of a regional secondary/higher education network be effective in scaling-up talent development in their participant schools?

2. Scaling-up the number of U-Talent Academy participants within the schools

In 2004, Utrecht University started a programme, called Junior College Utrecht (Van der Valk, van den Berg & Eijkelhof, 2007), aiming at STEM talent development with students (Taber, 2007)
and professionalization in schools. Since then, it has developed towards being a regional network of secondary schools and two universities, Utrecht University and Hogeschool Utrecht.

From 2004 to 2013, about 100 motivated students grade 11/12 students a year from 25 schools participated in the programme at the UU campus. About 50 STEM teachers participated in the connected teacher programme. For reasons of scaling-up, the programme design was changed, as was reported in Van der Valk et al. (2015). The main changes were:

- the grade 11/12 student programme, now named 'U-Talent Academy', got a campus part and a school part
- U-Talent student programmes for grades 7 to 10 were added
- the U-Talent teacher programme supports teachers in developing their school programme
- a new, 'lighter' Connection programme was started along with the existing Ambition programme.

In the new arrangement, the regular secondary school STEM curriculum is enriched with additional topics, comprehensive modules and doing research in an academic environment. Half of the

programme is provided on Utrecht University (U-TA campus programme) and the other half is taught at school (U-TA school programme).
Now, the number of students participating in the U-Talent Academy has increased to 300 grade-11/12 students. However, the introduction of the U-Talent Academy school programme had an unexpected effect: about another 300 students participated in the student programme only (so, not in the campus programme). Moreover, 1000 grade 7-to-10 students also were involved. That makes a total of 1600 students that get the chance to develop their talents.
The partner schools have agreed that their U-Talent school programmes must have four parts: STEM enrichment projects, differentiation in STEM lessons, assignments preparing for the campus programme and community-forming. The school programme urges STEM teachers in the schools to pay attention to differentiation in their classes and to contribute to the U-Talent school programme. By that, the number of teachers involved has increased to about 300. They are supported by the U-Talent professional development programme, aiming, among others, at applying lessons learnt t to all students in the school (Renzulli, 2005). In addition, schools share experiences and exchange ideas and parts of their programmes.
Moreover, the non-STEM subject departments in the schools (and in the universities) also feel a need for having a talent development programme. Some of them already have realised it or take part in projects like Cambridge English, Goethe (German), Delf Scolaire (French). So there is also a scaling-up to other subjects.

3. Scaling-up the number of schools

The number of schools that can participate is limited, because of restriction of capacity. Other schools noticed that U-Talent was successful and wanted to participate. However, there was no room for. Moreover, full participation requires big efforts of the schools. As a solution, we have introduced a three level model of participation.
The first, highest level, Ambition, includes sending students structurally to the campus (e.g. in the U-Talent Academy). 26 schools are now in this level.
The second level, Connection, is less intensive. Connection schools can send a number of students incidentally to our campus. In the 2016/17 course, 14 schools will participate in this level. The Connection schools share the teacher programme with the Ambition schools.
Ambition and Connection schools signed a cooperation agreement with Utrecht University and Hogeschool Utrecht and pay for their participation.
Schools at the third level, U-Talent Open, can participate in some of the student and teacher activities. They do not pay for a programme, but for the activities they choose to do.
We have experienced that some schools from the open level aim to go to the Connection level, and that some Connection schools want to join the Ambition level. So there are possibilities of further scaling-up the number of schools in the future.

4. Scaling-up the number of regional secondary/higher education STEM networks

When we started in 2004, only one other Dutch university had a programme that somehow was comparable to ours. Now, in 2016, the Dutch Government supports the secondary/higher education STEM networks, resulting in a total of 11, all over the country, with most Dutch universities involved. These networks have very different programmes and approaches, but share the aim of STEM professionalization in the schools.

5. Conclusions and discussion

We conclude that the U-Talent network has been, as a secondary/higher education network, effective in scaling-up talent development in participant schools by the structures chosen.
The Ambition – Connection – Open structure enables schools to choose a level in which they want to participate in U-Talent. this has resulted in scaling-up the number of schools.
Main aspects of the effective structure at the Ambition level are (1) the focus on talent development of motivated students and so on differentiation in STEM education, (2) the combination of developing

enrichment programmes for students and teacher professionalization and (3) the combination of teaching an exemplary campus programme and school programmes geared to the campus programme. This has resulted in scaling-up the number of students and teachers of the Ambition schools involved in U-Talent activities.
The success of the Utrecht network has inspired universities and schools in other regions to form secondary/ higher education network.

Wassong, T. (Universität Paderborn), Biehler, R. (Universität Paderborn) — Research-based presentation on personal dimension

What are the challenges of being a math teacher educator? Results of an interview study

Tuesday, 11:30-12:00, Room KA 102

1. *Introduction*
In 2012 and 2013 both authors developed and implemented a 5-month Continuous Professional Development (CPD) on teaching statistics for secondary school mathematics mentor teachers. The CPD was organized by the German Center for Mathematics Teacher Education (DZLM). The participants were mathematics teachers from North-Rhine Westphalia, who have an additional role as regional PD facilitators.
The CPD objectives were to deepen the professional knowledge for teaching statistics using digital tools on one hand and to elaborate fundamental dimensions of facilitators' knowledge and competencies needed for training teachers in statistics themselves on the other hand. In our talk we will concentrate on the first objective. The design of the CPD was conducted by a theoretical framework of professional knowledge for teaching statistics (e.g., Blömeke 2013; Wassong & Biehler 2010) and assumptions concerning the self-concept of the participants in their role as facilitators based on literature (e.g., Tzur 2001; Zaslavsky & Leikin 2004). The CPD was intended as the root in a pyramid design. The concept was to spread the ideas of how to teach statistics combined with the necessary professional knowledge through the work of the participants as regional PD organizers and trainers.
The CPD was evaluated mainly based on intensive interviews with the 12 participants two to three month after ending the course. The evaluation focuses on the concrete implementation of the course in respect of the theoretical framework of professional knowledge for teaching statistics.

2. *Theoretical Framework and objectives of the CPD*
The first part of the theoretical framework discusses a knowledge/competence structure model for professional knowl - edge of teachers (Wassong & Biehler 2010) and extended for facilitators. The model aims to four main facets of professional knowledge: Common and Practice oriented Content Knowledge, Content and Pedagogical Knowledge of Curriculum, Pedagogical Knowledge of Teaching and Learning, and Common and Pedagogical Technological Content Knowledge (cf. Wassong & Biehler 2010) and is based on the ideas from Ball, Thames & Phelps (2008) and Mishra & Koehler (2006).
The second part of the theoretical framework discusses the content structure for structuring the course. The content structure consist of the five subtopics Data: Where from and what for?, Representing, summarizing, and interpreting data, Trends and relationship in data, Statistical literacy: critical dealing with statistics and data in the media, and Statistical projects and presentations with digital tools and reflects the current discussion about statistics education in Germany (e.g. Burrill & Biehler 2011; Biehler & Hartung 2006). With this framework and the objectives of the CPD based on the framework in mind the course was concretely planed day by day.
The third part of the theoretical framework contains assumptions concerning the participants based on literature and on analysis of the participants prerequisites based on the experiences of the authors

(e.g., Tzur 2001; Zaslavsky & Leikin 2004; Elliott et al. 2009; Borko, Koellner & Jacobs 2014). Besides others we assumed that the participants were experienced mathematics facilitators and teachers for mathematics. We assumed that the participants in their role as facilitators has a commitment for self-improvement and a willingness for deepening in mathematical topics. In their role as math teachers we assumed a extensive experience in using digital tools for supporting the learning of mathematical topics. We also assumed that the participants had no or only low statistics education in their pre-service university courses, hence they are interested in a systematic introduction into this topic.
One important aspect of the framework is the use of digital tools for teaching statistics in secondary schools. Therefore the technological aspect was one focus during the implementation and for the evaluation.
The second important aspect of the framework deals with our initial conception of what math facilitators need to know in contrast to what "normal" mathematics teachers need to know. The evaluation of the CPD also deals with this aspect. This aspect also deals with the problem that the main topic of the CPD, statistics, is a math subject matter-related topic in contrast to teaching-methods or process-orientated matter-related topics. That means that the objectives of the CPD not only aim at the teaching of the participants but it also aim at the mathematical knowledge of the participants.

Methods: Data Collection and analysis

The CPD was implemented and evaluated in a Design Research study. The theoretical framework as described above and the resulting assumptions builds the basis on which the CPD was designed and implemented. The main research questions that leads the implementation and the evaluation were "What is a suitable framework for professional knowledge for math facilitators and which facets of knowledge are important?" and "What are the needs of math facilitators that can be satisfied in a math subject matter-related CPD?".
For the evaluation the first author conducted an interview with each of the 13 participants, which took at least 2h. These interviews contain the two main topics "objectives of the different actors" and "sustainability of the CPD". For the analysis of the audio-data qualitative data-analysis methods (Kuckartz 2012) were used. The main question of the interview that leads the analysis is "From your perspective: What are the additional requirements to your role as math facilitator in contrast to your role as math teacher?"

3. *Presented Results*

In the oral presentation, we will present some selected results of the finished data-analysis. We will focus on the second research question: What are the special needs of mathematics facilitators in contrast to mathematics teachers? Therefore we will contrast our conception of mathematics facilitators' needs with the mathematics facilitators self-concept, they described during the interviews. Based on this contrast we will present an adapted conception of facilitators' needs, based on both the facilitator educator's view and the facilitators' view.
The results will show four main dimensions of facilitators' need: (1) the need of knowledge advantage, (2) the role of school-practical experience, (3) the role of PD-orientated didactic and teaching and learning methods, and (4) the relationship between facilitators and participants. The relationship between these four dimensions will be discussed deeply.

Westwell, J. (The National Centre for Excellence in the Teaching of Mathematics, England) — Practice-based presentation on structural dimension

The English National Maths Hubs Programme

Monday, 16:50-17:20, Room KA 106

1. Background

In 2010, the new coalition government in the UK published an education White Paper, “The Importance of Teaching” (Department for Education, 2010). This policy document heralded a significant shift in system leadership. The emphasis was on leading schools and teachers being the key agents in change and development, the so-called “school-led self-improving system”. A range of policy initiatives followed, including the introduction of “Teaching Schools”. Drawing a parallel with Teaching Hospitals in the field of medicine, these outstanding schools would have the capacity to support professional development of teachers and leaders, research and development, initial teacher training, and school-to-school support (National College for Teaching and Leadership, 2015).

The National Centre for Mathematics Education (NCETM) already had a role to ensure high quality mathematics professional development within England. However, the changed policy context meant that the approach used to ensure high quality support need to adapt. Having worked with some of the early Teaching Schools in 2011-2013, especially those with mathematics expertise, the NCETM proposed a new structure to the government in 2013 and the National Maths Hubs Programme was launched in 2014.

2. The Maths Hubs

2.1. The structure

Each Maths Hub is a partnership, led locally by an outstanding school or college. The lead school identifies strategic partners, who help plan and evaluate the hub’s work, and operational partners, who help carry out the hub’s work. So, the hub is not just the lead school or college – instead it is more like a maths leadership network involving schools, colleges and other organisations with maths education expertise from across the hub’s area. There are now 35 Maths Hubs established that together serve all the regions of England. Each Maths Hub can work with any school or college, from early years providers to post-16 education, in the broad geographical area that it covers (see www.mathshubs.org.uk).

The programme is sponsored by the government with funding provided to cover both the structural costs and project costs. The NCETM co-ordinates the programme and facilitates the national network of Maths Hubs. Each Maths Hub working with its partners leads “Work Groups” to address various priorities. A Work Group brings together teachers from across a number of schools to work and learn together over time with a view to improving outcomes for students. Some Work Groups are common to all Maths Hubs as part of National Collaborative Projects and some are designed to address locally identified needs.

2.2. Leadership and expertise

Each Maths Hub is led by an experienced practitioner based in a school, who demonstrates strong practice both in mathematics teaching and in supporting collaboration. They also draw upon the expertise and leadership within other schools and organisations, such as universities and education consultancies. The NCETM also provides central specialist expertise with regards to both evidence about effective mathematics teaching and effective professional development.

2.3. Priorities for development and innovation

Maths Hubs have a wide remit to support all phases of education. In the first two years of the programme some of the priorities that Maths Hubs have addressed include:

- Primary schools – Introducing Teaching for Mastery linked to lessons learned from South-East Asia
- Secondary school – Strengthening pedagogy and departmental culture to support mathematical reasoning
- Post-16 schools and colleges – Increasing the participation rates in mathematics (not compulsory in England)

This work has combined both innovation and drawing from existing expertise within the system.

3. The presentation

3.1. The content of the presentation

In the presentation, further detail about the structure of the Maths Hubs programme will be shared as well as examples of the work carried out by Maths Hubs. More explanation about the cultural and policy context will be given. Lessons learned about the possibilities for effectively scaling up innovation and embedding new models of professional development will also be explored.

3.2. Questions addressed within the presentation

Some of the key questions to be addressed within the presentation and discussion will be:

- What can a design of an initiative aiming at a widespread implementation of innovative teaching and for scaling up professional development look like?
- Which structures prove to be effective in the context of a school-led system? Which do not?

Westwell, J. (The National Centre for Excellence in the Teaching of Mathematics, England) — Practice-based presentation on personal dimension

The NCETM Accredited Professional Development Lead Programmes

Tuesday, 15:15-15:45, Room KG4 222

1. Background

In 2011, the National Centre for Excellence in the Teaching of Mathematics (NCETM) in England introduced a new development programme for mathematics professional development leads. This was partly in response to a policy drive from the government to encourage transformation in mathematics pedagogy within primary (ages 5-11) and secondary (ages 11-16) schools. It is also set within the policy context of encouraging a school-led self-improving system (Department for Education, 2010).

Since 2011, the programme has continued to develop and has also been used with to support professional development leads linked to post-16 maths education. Around 1000 mathematics educationalists have completed the programme since it started and many are now working to support the professional development of teachers of mathematics within their own setting and in other schools and colleges.

2. The programmes

2.1. The participants

The intended participants for the programme are teachers of mathematics and other maths educationalists who have some experience of leading professional development activity for teachers of mathematics and want to develop further. They were all expected to commit to not only supporting teachers in their own schools but in other schools as well. Participants have included both teachers working in schools and other maths educationalists working in universities, local authorities, and independent maths education consultants. There has been a mix of experience amongst participants,

varying from limited experience, especially with some practice teacher, through to very experienced professional development practitioners.

2.2. The programme structure

The programme was designed with two 24 hour residentials separated by a period of about eight weeks. In the period between residentials participants were required to carry out a gap task. This involved the design, delivery and evaluation of a professional development activity. Reflection on this activity formed part of the second residential. Following the second residential, participants submitted a record of their planning, reflection and evaluation. The NCETM programme leads for each cohort then examined submissions in order to decide whether participants could be formally accredited as successfully completing the programme.

2.3. The programme content

The programme was designed to include a parallel focus on developing both:

- subject knowledge and pedagogical subject knowledge
- knowledge and understanding about professional development

The subject knowledge and pedagogical subject knowledge focus of particular programmes varied depending on the phase of education. For example, the primary programme examined the interplay between procedural knowledge and conceptual understanding, whereas the secondary programme considered multiple representations and forms of questioning. Learning about professional development was structured around participants some key questions:

- The CPD question – What is your understanding of professional development?
- The knowledge question – What does a teacher of mathematics need to know in order to teach the subject well?
- The activity question – What combination and sequence of activities are most likely to lead to both professional learning and practice development for teachers?
- The evidence question – What place does evidence have in supporting the professional development of mathematics teachers?
- The evaluation question – Was the CPD any good?
- The resource question - What kind of resource can you use to support the professional development of mathematics teachers?

3. The presentation

3.1. The content of the presentation

In the presentation, further detail about the design and content of the programme will be shared as well as examples of some of the materials used. More explanation about the cultural and policy context will be given. Lessons learned about the challenges faced in supporting practicing teachers as they develop in the role of professional development lead will also be explored.

3.2. Questions addressed within the presentation

Some of the key questions to be addressed within the presentation and discussion will be:

- What are the needs and experiences of the different target groups: Professional development leads – CPD practitioners; mathematics subject leaders; practicing teachers of mathematics?
- Are the NCETM professional development leads multipliers or facilitators or both and does it matter?

Zehetmeier, S. (University of Klagenfurt) — Research-based presentation on structural dimension)

How to scale up and sustain the impact of professional development programmes?

Tuesday, 11:30-12:00, Room KG4 222

1. Abstract

This proposal deals with two crucial topics: (How) Can the impact of professional development programmes be sustained? (How) Can the impact of professional development programmes be scaled up? Theoretical models and empirical findings from innovation research (e.g., Rogers, 2003; Cobb & Smith, 2008) and impact research (e.g., Zehetmeier, 2015) are combined to use them as a theoretical framework for a currently on-going impact analysis of a particular professional development programme in Austria. The proposal provides data and preliminary findings from questionnaires, document analysis and interview series to describe as well as explain this programme's various impacts on different levels. Finally, implications for upcoming PD programmes are discussed.

2. Relation to the conference theme

This proposal directly relates to the overall conference theme, since it addresses the education and professional development of educators in mathematics and science education; in particular, the professional growth of teachers, teacher networks, teacher educators, and multipliers in educational institutions is in the focus. The respective Austrian professional development programme is based on the principles of inquiry-based learning and action research.

3. Perspective on the topic

Teachers and teacher educators are playing a central role when addressing professional development programmes (Sowder, 2007; Zehetmeier, 2010). In this context, the question of sustainability is of particular relevance (Zehetmeier & Krainer, 2011; Zehetmeier, 2015): In most cases, evaluations and impact analyses of professional development projects are formative or summative in nature; they are conducted during or at the end of a project and exclusively provide results regarding short-term effects. These findings are highly relevant for critical reflection of the terminated project and necessary for the conception of similar projects in the future (Fullan, 2006). However, also an analysis of sustainable effects is crucial.

In this proposal, theoretical models and empirical findings from impact research (e.g., Zehetmeier & Krainer, 2011) and innovation research (e.g., Rogers, 2003; Cobb & Smith, 2008) and are combined, with the aim to use them as theoretical framework for the analysis of data. In particular, this framework is used to discuss the questions concerning sustaining and scaling up the impact of an Austrian professional development programme.

Cobb and Smith (2008) highlight networks, shared vision, and mutual accountability as key factors for the scale-up of changes and impact in mathematics teacher education: Teacher networks are described, for example, as groups of colleagues who provide social support in developing demanding instructional practices; this affords time built into the school schedule for collaboration among mathematics teachers and access to colleagues who have already developed relatively accomplished instructional practices. High quality mathematics instruction includes a shared vision concerning the question of instructional goals (what students should know and be able to do mathematically) and the question how students' development of these forms of mathematical knowing can be supported. Mutual accountability means, for example: if school leaders hold mathematics teachers accountable for developing high-quality instructional practices, then – in turn – school leaders are mutually accountable to mathematics teachers for supporting teachers' learning.

Rogers (2003) claims that the diffusion and scale-up of an innovation depends on different characteristics: Relative advantage, compatibility, complexity, trialability, and observability. Fullan

(2006) describes similar characteristics (need, clarity, complexity, quality, and practicality) that influence the acceptance and impact of innovations.

PFL (a German language acronym for "Pädagogik und Fachdidaktik für Lehrinnen und Lehrer", which means "Pedagogy and Subject Didactics for Teachers") is an Austrian professional development programme, which started in 1982, has undergone several adaptations, and is still running (for more detail, see Rauch, Zehetmeier, & Erlacher, 2014). This programme is designed for teachers from all types of schools across the nation, including all age groups of students. The overall focus of PFL is on the professional development of teachers in the fields of didactics and pedagogy, with particular emphasis on educational standards, competence-oriented teaching practices, classroom diversity, communication, cooperation, and quality evaluation and development. The focus is on the individual teachers' own reflective practice (Altrichter, Feldman, Posch, & Somekh, 2008). Participants are part of a community of practice (Wenger, 1998), since their work is embedded in a structure of mutual assistance and external support.

4. Relation to one of the conference topics

This proposal relates to Topic 3 (Structural dimension – Systemic project designs for scaling-up and their evaluation). It deals with mathematics teacher education and large-scale teacher professional development; it aims at scaling-up the implementation of innovative, research-based approaches to mathematics education (in the context of an Austrian Educational Competence Centre) and takes into account the contextual framing. The professional development programme in focus provides scaled-up and sustainable structures for supporting cooperative and inquiry-based learning and professional growth. Thus, in particular, the proposal addresses questions like

- What can a design of an initiative aiming at a widespread implementation of innovative teaching and for scaling up professional development look like?
- How can we investigate empirically the impact of different project designs?

5. Research questions

This proposal deals with the following research questions:

- Which impacts of the PFL programme could (not) be sustained?
- Which were the corresponding factors that fostered or hindered the sustainability of impacts?
- Which impacts of the PFL programme could (not) be scaled at large?
- Which were the corresponding factors that fostered or hindered the scale-up of impacts?

Zwetzschler, L. (University Duisburg-Essen) — Research-based presentation on personal dimension

How to educate the educators for mathematics –Design Principles for PD-courses for educators

Tuesday, 15:15-15:45, Room KA 102

While recent studies focus on PD-courses for teachers, only little is known about PD-courses for educators. The interest of the study is: how to educate educators. Therefore 16 semi-structured interviews with educators were conducted and four PD-courses for educators were observed. Whereby all interviewed educators first took part at PD-courses for educators and ran PD-courses for teachers afterwards. In the oral presentation consequences for the design of PD-courses are presented.

1. Theoretical Background

Lots of recent studies focus on the design and effects of PD-courses for teachers (e.g. Timperley et al. 2007). These results e.g. enabled the formulation of Design-Principles for effective PD (Barzel & Selter

2015). But however, only little is known about PD for educators as well as about the process of scaling up PD. Starting points for the design of PD-courses for educators are the results for PD-courses for teachers, but empirically grounded results about their effectiveness for educators are (still) missing. Further starting points are the results of cognate scientific disciplines and research fields like adult education: Typical for adults is, 1. that they already learned a lot during their life and have that in mind in new learning situations, 2. that they focus on the practical use of new knowledge and 3. that they have status specific behavioural expectation (Geissler 2001). But empirical findings about the adaption of these core principles for educators are also missing. Only some studies focus on educators (e.g. Borko et al. 2015).
One core challenge for educators are the expectations of the teachers, because they expect (exclusively) practically useful knowledge in PD-courses. Unfortunately several educators tend to fulfil exclusively these expectations (Wassong i.p., Zwetzschler et al. 2016). But this leads to the problem, that processes of scaling up won't happen. Coburn (2003) defines the following four quality criteria to evaluate this process of scaling up: 1. depth, 2. sustainability, 3. spread and 4. shift in reform ownership. The more the four interdependent criteria are fulfilled, the more successful the process of scaling up is. If only practically useful knowledge is taught in PD-courses, the teachers can't (e.g.) understand the topic in depth and implement the content sustainable.
Typical for educators in Germany is, that they are more or less experienced teachers and that they also work part-time as educators. Binding standards or an institutionalised education for them doesn't exist (yet). So educators are quite often marginally upskilled and work in two roles at once, which can lead to role conflicts – a further challenge. Especially situations in which the expectations as teacher and as educator are mutually exclusive are problematic (typical role-conflict). But even if the two roles are not problematic for the educator, the evaluation of PD-courses for educators should always take this double-role into account. Table 1 exemplifies this aspect: the adaption of Lipowsky & Rzejak's (2012) model for the effects of teacher PD for educators, by adding the role as facilitator to the role a a teacher.

Table 1. Adaption of Lipowsky & Rzejak's model (PD for teachers) for educators

Educator in the role as…		
…educator:		**…teacher:**
F1: the response of the educators		T1: the response of the teacher
F2: the learning process		T2: the learning process
F3: the planning of PD-courses	←→	T3: the planning of lessons
F4: the facilitation of PD-courses		T4: the facilitation of lessons
F5: the learning of teachers		T5: the learning of students

The empirical finding, that educators tend to reflect their PD-courses on the same level as they reflect their lessons at school, supports the relevance of these two roles. So effective PD-courses for educators should focus on both roles (Zwetzschler et al. i.p.).
Lots of authors try to differentiate what teachers should learn by differentiating types of knowledge relevant for PD (e.g. Fenstermacher 1994, Shulman 1986). Cochran-Smith und Lytle (1999) differentiate between knowledge-in-practice (practical knowledge), knowledge-for-practice (categories for practices) and knowledge-of-action (reflection knowledge). In the study this differentiation is used.

2. Research Question

Taking this background into account, the presentation focuses on the formulation of Design-Principles for PD for educators.

1. What are relevant Design-Principles for PD-courses for educators?

3. Methodology of the case study

To answer these research questions eleven semi-structured interviews (of 45-120 minutes each) were conducted. These interviews were part of a project about educators in cooperation with the author,

Kim-Alexandra Rösike, Bärbel Barzel and Susanne Prediger. All interviewees took part at a PD-course for educators and facilitated PD-courses for teachers afterwards. All forms of knowledge (in-, for- and of-practice) were part of the PD-course for educators. The interview questions dealt with the general design of their PD-course for teachers, their knowledge of the content "dealing with heterogeneity in mathematics classrooms", their experiences in the PD-course for educators and their experiences with the topic as teachers. To get further insights, we also simulated parts of a planning process of a PD-course for teachers. These interviews were complemented by five further interviews by the author to a second content with a comparable group. Furthermore, four PDcourses for educators were observed. All interviews were audio recorded. A qualitative content analysis (Mayring 2015) was conducted by paraphrasing aspects according to the research questions. Selected parts were transcribed and analysed in depth with Vergnaud's (1996) theory of conceptual fields, because the theory enabled a deeper understanding of educator's thoughts.

4. Results

In the presentation the following Design-Principles are empirically grounded presented (the empirical insights are skipped here because of space limitations):

1. All types of knowledge should be taken into account for both roles (table 2).
2. Teachers' expectations in PD (knowledge-for-practice) and their consequences for processes of scaling up are discussed.
3. Although correlations between both roles of an educator exist, knowledge-in-practice for educators is more than the knowledge-in-practice for teacher.
4. Connections between contents in PD-courses that represent different types of knowledge are focused.
5. Cooperation between educators is fruitfully stimulated (Zwetzschler 2016).
6. Materials for educators are balanced in a way, that processes of shifts in reform ownership are encouraged and that the materials also support educators' preparations.

Table 2. Forms of knowledge in PD-courses

Educator in the role as…		
…educator:		**…teacher:**
Knowledge-for-practice		Knowledge-for-practice
Knowledge-in-practice	←→	Knowledge-in-practice
Knowledge-of-practice		Knowledge-of-practice

7. Materials Market

Tuesday, 8 November 2016, 12:00-15:00, KG 103 and KG 104

A materials market will allow attendees to look into a broad range of PD materials and classroom materials supporting PD in the area of STEM (primary, secondary and vocational education) exhibited by European projects, educators and PD course participants in maths and science education.
The materials market will continue as an open exhibition and forum for all conference participants. An accompanying poster exhibition will display current developments in scaling-up teacher professional development in STEM education.

Armenteros, A. Q., Abril, A. M., Ariza, M. R., García, F.J. — Classroom materials supporting Professional Development

Inquiry in primary Science Education using immersions tasks for pre-service teachers

We will present hands-on activities developed by the Spanish team and used with over 150 hundred prospective teachers in a Science Education subject as part of a Primary Education Degree. It may be considered a good way for widely supporting Mascil pedagogies through teacher initial education and thus, an interesting example about how to scaling.

It introduces a world of work (WoW) context where teachers have to take the role of different professionals and inquiry on forces and energy to find a solution for the problems posed to them (studying the mechanical and thermal properties of different materials with applications in the building trade).

Through these immersion tasks, primary education prospective teachers had to raise questions, make assumptions, plan, design and conduct experiments and discuss their findings with others, in order to better understand core concepts and facts in primary Science. The use of these inquiring tasks, connected to the WoW, provided a sense of purpose and meaning to science students' activity raising their engagement and motivation. Moreover, they served as inspiration and good practices for prospective teachers in regards of the designing tasks using inquiry and world of work contexts. Materials are available on-line in both languages, Spanish and English through Spanish Mascil Website.

Kapelari, S., Lindner, W., Scheuch, M., Varga, J. — Classroom materials supporting Professional Development

The price of soybeans: a topic accompanying students during the course of their school career

Soybeans, their history and agricultural career are a fascinating story. When it comes to answering question such as: How does a soy plant look like and how does it grow? Should the European soybean market become more independent from global economic developments? Should we prefer to grow genetically modified soy plants to “natural” ones or shall we replace meat and eat soybean products instead?

Science and society has to deal with these and many more questions when it comes to decision making on an individual as well as on a societal level. This multifaceted topic asks us as teachers and educators to support our students to gradually develop a deep understanding about the interplay between science, economy and society. They need to understand the complex web of interactions between diverse factors that influences not only the local, regional and global economy and but our local and global environment.
“The price of soybeans” teaching material is based on the idea to start with grade 5 and to support students to gradually build up knowledge and inquiry skills about soybean cultivation, research, economy and their impact on human health and the environment during their school career. These students will finally be able to adopt an informed position and put forward evidence-based arguments when it comes to participated in a “role-play based” decision making process in grade 12.
This teaching material will be available in German and English on the Mascil website (www.mascil-project.eu) and will not only be useful for classroom teaching but for those educating science educators. It gives a good example for constructive and cumulative teaching and learning and offers activities that gradually built upon each other and thus highlight the fact that it makes sense for learners to sustainably memorize knowledge even if it is available on the internet.

Stampfer, F. — Professional Development materials

Chocolate Bar Machine Scheduling: Dunking into IBT and WoW

The task *Chocolate Bar Machine Scheduling* was designed to provide a fast and effective tool involving pre-service and in-service mathematics teachers in a *mascil* learning environment. *mascil* – mathematics and science for life – is an EU-project which aims promoting inquiry-based teaching (IBT) and the connection to the world of work (WoW) in primary and secondary schools. The task was developed within the project in the preparation of a professional development course.
In the introduction of the task, the work place of a machine scheduler at a chocolate bar manufacturer is presented. For a customer order, five products have to be processed on two machines: on machine 1 the melted chocolate is poured into bars and on machine 2 the chocolate bars are packed. The processing time for each product on each machine is given. The job of a machine scheduler is to determine the order of the products such that the total processing time – the interval between the time when the first product starts on machine 1 and the time when the last product leaves machine 2 – is the shortest. The final result is the order of the products in form of a machine schedule. The machine schedulers have to develop their own strategies to tackle the problem. They have to identify the constraints and to find conditions for feasible solutions. Strategies like reduction (less products) allows for checking hypothesis on proposed heuristics down to algorithms to solve problems with more products.
The task was used in many professional development courses to face teachers with problems from the world of work in the framework of a guided inquiry. In addition, the trainer supported the learning outcome with well-considered questions during the group work. This scaffolding was then discussed as one important component of inquiry-based teaching.
The task is available on http://www.mascil-project.eu/classroom-material/classroom-material-2 and a translation in German on http://mascil.science-edu.at/file/task/mascil-Maschinenbelegungsplanung.pdf.

Zsombori, G., András, S. — Classroom materials supporting Professional Development

Developing reasoning skills using IQ games

Developing reasoning skills is one of the major aims of mathematics teaching, but many difficulties occur if reasoning is directly approached within mathematical contexts. This is mainly because difficulties from handling mathematical concepts and difficulties from constructing mathematical proofs can overlap. For this reason it can be useful to support developing reasoning skills in less formal contexts which allows/needs complex reasoning processes. The following materials were developed by SimpleX Association (Romania) and were also used in European projects PRIMAS (Promoting Inquiry in Mathematics and Science) and MASCIL (Mathematics and Science for Life). Moreover they are related to the MASCIL material "**IQ-game design**", they were tested in several different settings (from primary school to upper secondary and even university and PD courses).

It is based on variants of the famous Zebra puzzle, the complexity of the reasoning is controlled from the tasks (missions) and the students can use specially designed cards to handle the information.

The original Happy Cube puzzle was analyzed in András et. al. (2011) and some possibilities for classroom adaptations in András (2012). There are also a lot of other possibilities to use these puzzles for educational activities that support developing of reasoning skills: analyzing the difficulty level of given puzzle sets, designing your own puzzle which satisfies some requirements (is very hard to solve, or it has at least two different solutions, etc.). In addition the Impuzzables (and similar 3D puzzles) offer the possibility of a more complex inquiry and a more difficult process in designing and manufacturing the end product.

The quiz framework is widely used in education at different levels, but usually needs a lot of extra effort from teachers to explore and to use it's full potential in regular classroom activities. At SimpleX Association we used quiz on several occasions and with several different contents and we've developed a software for supporting quiz based activities. Our experience is that these kind of games model real life much more accurately then most of other school activities and have the tendency to upset the usual group hierarchy.

Reitz-Koncebovski, K., Weihberger, A. — Professional Development materials and Classroom materials supporting Professional Development

PRIMAS / mascil

Introduction

The projects PRIMAS (Promoting inquiry-based learning in mathematics and science education across Europe, 2010-2013) and mascil (mathematics and science for life, 2013-2016) are both international projects within the 7th Framework Programme of the European Union. 14 resp. 18 universities from 12 resp. 14 different countries have worked together over four years to promote the implementation and use of inquiry-based learning in mathematics and science. Beyond that, the focus of the project mascil has been on connecting maths and science learning to the world of work. PRIMAS and mascil

have developed materials for direct use in class and for professional development. Both projects have been awarded: Whereas PRIMAS has been identified as success story by the European Comission, parts of the work of mascil has been awarded with the COMENIUS SIEGEL.

Presentation of PD course material
In both projects a wide range of PD course material for primary and secondary schools has been developed. The materials have been explored, evaluated, improved and finally implemented in many different countries.
Primas PD modules (online available at http://www.primas-project.eu/artikel/en/1221/professional-development-modules/view.do) explore the pedagogical challenges that arise when introducing investigative, non-routine problem solving activities to the classroom. The modules are activity-based; built around a collection of examplary classroom activities. The intention is that, as part of the PD process, teachers will plan inquiry-based lessons to use with their own class and, at a later meeting, report back on their experiences. Each module includes a PD session guide and handouts for teachers, as well as sample classroom materials and suggested lesson plans. Several of the lessons include the use of simple computer software and/or video sequences from classrooms.
In mascil, two "toolkits" were developed for use with (i) groups of teachers and (ii) those on courses leading to becoming a teacher: the toolkits for Teacher PD (http://mascil-project.eu/professional-development/teacher-pd-toolkit) and Pre-service teachers (http://mascil-project.eu/professional-development/initial-education-toolkit). The toolkits have been designed to support groups of teachers working in collaborative communities of inquiry by providing a flexible resource. This will allow members of the group to explore new and innovative teaching practices, in particular inquiry based learning and connecting school to the world of work.

Presentation of classroom material supporting PD
Within both projects, PRIMAS and mascil, large collections of classroom materials have been created and made available on the project websites (http://www.primas-project.eu/zoeken/search.do resp. http://mascil-project.eu/classroom-material). These materials encourage and support teachers to implement inquiry-based learning (IBL) and contexts from the world of work (WoW) in their daily practice. Simultaneously, many PRIMAS and mascil teacher PD activities are stimulated by individual tasks from these collections.

Weihberger, A. — Classroom materials supporting Professional Development

Smartphones in class?! Please turn them on!

Introduction
Smartphones are getting more and more important to teenagers. Besides that, they can substitute many electronical devices. Therefore it is a good option to use smartphones in class – of course as much as the teacher allows them. While it is obvious that they can be used as dictionaries in classes for foreign languages – in mathematics and physics they can be used for measuring in many ways. With the skills gained in mathematics and physics classes, it is also possible to understand how the apps function. Using smartphones in this way in class makes maths and science learning more meaningful for students. They experience, that this knowledge is, for example, relevant for programmers of smartphone apps.

Material
The material has been developed by a researcher and a teacher together with his students. They looked at apps that can be used especially in physics classes for doing measurements. They tried to

understand how the apps work and then looked for examples on how they can be used. The result was a broad range of materials that you can see on http://mascil.ph-freiburg.de/aufgabensammlung/experimente-mit-dem-smartphone/einfuehrung-in-das-schuelerprojekt.
Some apps require a deeper mathematical knowledge to understand the task.
In Germany those tasks are very popular. The website started about a year ago and since then there were more then 18000 clicks only on the introduction site, and the PD courses about smartphones in maths and science classes are all booked up.. Since most of the tasks enable inquiry learning and have a connection to the world of work, this classroom material is highly relevant to the conference.

Jonker, V., Wijers, M. — Professional Development materials and Classroom materials supporting Professional Development

IBL and WoW materials from the Netherlands

The Freudenthal Institute for Science and Mathematics Education (FI) is a part of the Faculty of Science of Utrecht University (UU). Together with partners both within and outside the UU the FI makes an important contribution to innovation and improvement of science and mathematics education in the Netherlands, with special attention for inquiry based learning and connections with the World of Work.
Our contribution to the Materials Market consists of:

- a nationwide overview of PD-support in the STEM area, where IBL (and the WoW) is an important issue. This overview (english flyer) shows the activities from the different PD-centers for a better fit between secondary and higher education: www.vohonetwerken.nl
- an excerpt of math activities for the Math A-lympiad, Math B-Day (inquiry-based activities)
- Examples (upper secondary education) from the new curriculum discipline 'NLT' (Nature, Life, Technology) where physics, biology, chemistry and mathematics come together in IBL-based activities, with a good look-through to the World of Work.
- One example from the Big Mathematics Day for primary level. This is a dutch initiative to have an annual Mathematics Experience for all students and teachers in primary schools, with support for the professional development of teachers.

Dalby, D. — Classroom materials supporting Professional Development

'Mathematics Assessment Project'

Background
The Mathematics Assessment Project is part of the Math Design Collaborative initiated by the Bill & Melinda Gates Foundation and is the result of on-going collaboration between the Universities of Nottingham (UK) and Berkley (California, USA). The project sets out to design and develop well-engineered tools for formative and summative assessment that expose students' mathematical knowledge and reasoning, helping teachers guide them towards improvement and monitor progress. The tools include classroom materials in the form of lessons, tasks and tests but are supported by professional development modules to help teachers understand and develop appropriate pedagogies. The materials are relevant to any curriculum that seeks to deepen students' understanding of mathematical concepts and develop their ability to apply that knowledge to non-routine problems.

Overview of materials

The full set of materials is available on-line in English at http://map.mathshell.org. Samples will be displayed that focus on the professional development aspects of the project but also show how these work together with the classroom materials to develop teachers' conceptual and pedagogical understanding. The full set of materials comprises:

- *Professional Development Modules* that encourage groups of teachers to explore the practical and pedagogical concepts behind the materials, such as formative assessment and collaborative learning.
- *Formative Assessment Lessons* that focus on either developing math concepts or solving non-routine problems.
- *A set of exemplar summative assessment tasks* that include scoring rubrics and examples of scored student work.
- *A set of summative test forms* and rubrics designed to help teachers and students monitor their progress using a range of task types similar to those in the summative assessment tasks section.
- *The TRU maths suite of materials* (The Teaching for Robust Understanding of Mathematics), which is a set of research based tools around a framework for characterizing powerful learning environments, with applications in Professional Development.

Hyland, M., McCLure, L. — Classroom materials supporting Professional Development

Underground Mathematics

Underground Maths is a UK Government-funded project, based in the University of Cambridge. We offer free, web-based resources that support the teaching and learning of post-16 mathematics. We intend to make mathematics a richer, more coherent and more stimulating experience for students and teachers alike.

The structure of our website reflects our perspective that mathematics is a coherent and connected enterprise. The mathematics content has been organised along a system of thematic tube lines. Alongside lie 'pervasive ideas', mathematical ideas that permeate topics throughout mathematics, such as transformations, symmetry and averages. We want to build awareness of these ideas so that it can lead to insight and opportunities to make connections.

Each station on our tubemap features an overarching question. In addition, there are key questions that students should be able to answer by the time they leave the station. At each station there is a range of teaching resources, usually with teacher notes to support their use in the classroom. Within a resource we may provide additional insight into the problem, suggest alternative approaches or highlight links to other areas of mathematics.

Workshops in Cambridge provide an opportunity for the Underground Mathematics team and teachers from partner schools to work together over three or four consecutive days. Teachers give detailed feedback on the website, share their experiences of using the resources and engage with wider aspects of the project. In response to feedback we have designed additional PD resources involving video and associated support.

Schuler, S., Haug, R., Reuter, D., Wittmann, G. — Classroom materials supporting Professional Development

MATHElino

Kindergarten and primary school children experiencing mathematics together

In Germany, there exist differences between kindergarten and primary school concerning curricula, teachers' qualification and the organisation of (mathematical) learning. In kindergarten children learn mathematics in heterogenous age groups (3 to 6 years old) along and during daily routines, free play and open assignments. In primary school children learn mathematics in homogenous age groups during their mathematics lessons. Kindergarten teachers in contrast to primary school teachers often do not have a special training in mathematics education. (cf. Schuler et al., 2013) Due to these differences the connectivity of kindergarten and primary school, and the development of new forms of collaboration are common themes in German educational policies: Kindergarten and primary school teachers must collaborate with respect to mathematical education to support the transition from kindergarten to primary school. Therefor they need joint professional trainings.

The MATHElino-Project aims at the connectivity between kindergarten and primary school (cf. Haug et al., 2012). This connectivity is achieved by the collaboration of the teachers **and** the children. Children attending the last year of kindergarten and first graders meet repeatedly. The kindergarten and the primary school teacher prepare these meetings together and scaffold and enhance the children's learning (cf. Royar, Schuler, Wittmann & Streit, 2016). The basis of the meetings are materials that meet central criteria of both institutions: (1) high affordance for the use during free play and open assignments on the one side; (2) high mathematical potential concerning the main content areas "Number and Operations", "Geometry" and "Algebra" on the other side (cf. Clements, 2004; Van de Walle et al., 2014). The project consequently aims at fundamental competencies in mathematics during the transition from kindergarten to primary school. First the children use the materials in a quite non-regulated way and second they work on open tasks like e.g. developing, identifying, describing and extending number and geometric patterns. During the work on these open tasks one kindergarten child and one first grader work together in order to enhance each other's learning. Both teachers observe the children, notice and document their mathematical activities, pose open questions, give supporting prompts and discuss these findings after the meeting.

The following materials and open tasks are examples we used in teacher trainings and in the classrooms. These materials and tasks can be tested in the exhibition at the conference (cf. Reuter & Wittmann, 2015; Haug & Wittmann, 2013; Reuter, 2013; Royar & Streit, 2010):

- Mugglestones – plastic stones with a high haptic affordance – promote sorting, counting, and creating concrete pictures and abstract patterns. Open task: "How many mugglestones of each color are in the tin? Estimate in advance and then find out exactly. Arrange the mugglestones so you can see how many there are."
- Commercial dice – coloured red, yellow, blue and green – promote building two-dimensional and three- dimensional objects and abstract patterns, as well as sorting and counting. Open task: "Build a pattern of coloured dice. Can your partner extend the pattern? Check: Is the pattern consistently extended? Document your pattern on paper."
- Pattern blocks are wooden discs in basic geometric forms (triangle, square, rhombus, trapezoid and hexagon) which encourage creating geometric patterns, mosaics and other geometrical arrangements. Open task: "Copy and extend the given pattern. Describe your pattern to another child so that he or she can rebuild it."
- Equilateral felt triangles in three colours encourage creating symmetric figures and patterns as well as tiling a plane. Open task: "Develop a symmetric figure. Can you complete the given figure so that it becomes a symmetric figure? Can you find the mistake in the figure given?"

Schulze, J. — Classroom materials supporting Professional Development

Science on Stage Europe

Football in science teaching, explaining planets to blind children, developing methods to control a solar balloon or spotting honey bees online: Science on Stage Europe is the network of and for STEM teachers of all school levels. It offers STEM teachers from 29 countries a stage to exchange their teaching concepts and to share ideas.
At the materials market Science on Stage will present teaching materials such as Football in Science Teaching, about the use of smartphones in STEM lessons, promotion of language skills in primary school or videos of experiments – all developed by teachers for teachers. Furthermore, an overview about the activities, benefits and possibilities for teachers to participate will be given: the Science on Stage festival 2017 in Debrecen, Hungary, the teacher exchange programme and teacher trainings about e.g. Smartphones in Science teaching or promoting language skills through science teaching.
Science on Stage Europe reaches about 100,000 teachers and teacher trainers in Europe1. It is the umbrella organisation that supports the 29 member countries with the realisation of their activities and organises the biannual European Science on Stage festival. By spreading good teaching concepts among Europe's science teachers the network aims to encourage more schoolchildren to consider a career in science or engineering.

Dinse de Salas, S., Werner, J. — Professional Development material

Coaching teachers using technology with cognitive apprenticeship

This paper shows the design of cognitive apprenticeship and professional learning communities which were part of a continued professional development program for secondary school teachers. Participants of all subjects have been coached in using digital media in classrooms, especially by implementing the flipped classroom and using wikis. The cognitive apprenticeship model was adapted for adult learners and connected with strengthening a professional learning community at school. These two concepts are supposed to provoke changes in self-efficacy and attitudes which are necessary for using technology in the classroom. The design patterns which were developed with the educational design research method will be presented in the materials market: design patterns of some professional development methods as well as patterns for using flipped classroom and wikis in class. Materials will be available online on http://flipyourclass.de/ and on http://educationaldesignresearch.de/. Another aspect of the materials market will be the presentation of first results of a study reconstructing the process of cognitive apprenticeship. Part of the related classroom project is already presented on http://projektwiki.zum.de/wiki/Mathe.forscher. The professional development material can be adapted for any STEM subject and combined with other concepts like inquiry based learning or problem solving.

Lampert, P., Kapelari, S. — Classroom materials supporting Professional Development

Experience Pollination

Focus & Background
Pollination is an essential stage within the life cycle of plants. Recent studies have shown that students have major difficulties in understanding this cycle (Benkowitz & Lehnert 2010; Quinte et al. 2012).

While these studies investigated general ideas about the life cycle, our study focussed on students' concepts of pollination. Our study revealed two main difficulties in understanding pollination. Firstly, students often see pollination as a deliberate act of insects. Secondly, students struggle to differentiate between pollination and seed dispersal (Lampert 2012).

Description of the learning materials

In answer to our findings about students' concepts of pollination, learning materials for young learners (age 6-12) were designed. These materials have been implemented at schools, at the Botanical Garden of Vienna and have been published (Lampert et al. 2012; Lampert et al. 2015). Key elements are self-

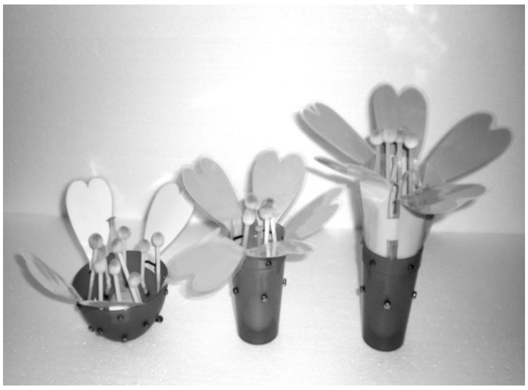


Figure 3: ***Flower models***

made flower models (see figure 1).

Students interact with the models in a "Nectar search game", in which the students play "insects" that are searching for nectar in these flower models. While the "insects" try to reach the nectar, they get "pollen" attached on their faces. Since "insects" focus on foraging, they do not notice that they are now carrying "pollen" from one flower to another. Experiences from the "Nectar search game" are discussed and knowledge is applied in follow-up worksheet activities.

Aims

Colony Collapse Disorder (bee mortality) is discussed in the media frequently. Therefore knowledge about pollination has a great potential to visualise the link between biology research and the world of work (e. g. agriculture, food industry, chemistry and politics). Besides that, the presented materials provide direct experiences with the abstract phenomenon of pollination. On a PD-level, these materials trigger teachers' awareness for learners' concepts, which should be considered while planning lessons in general and about pollination in particular.

Cakmakci, G., Yildiz, B. — Professional Development materials

A modular teacher professional development programme for gender balance in STEM

STEM Teacher training innovation for Gender balance (STING) is an Erasmus+ project funded for 3 years (Erasmus+ 2014-1-ES01-KA201-003688 Period: 2014-2017. https://stingeuproject.com). The STING project aims to promote gender awareness within Science, Technology, Engineering and Maths (STEM) education. Involving transnational cooperation between teachers and schools, teacher trainers, science centres, other educational stakeholders, companies and policy makers, this innovative teacher development programme seeks to share best educational practice for gender

balance. By fostering international cooperation, the ultimate goal is that teachers will integrate gender awareness into their practice to improve STEM Education.

As part of the STING project, a Modular Teacher Professional Development Programme was developed, trailed and modified so as to help STEM teachers to work more gender inclusive and to finally restore the gender balance in STEM vocations. The STING-project wants to bring existing experiences, resources and tools together into a meaningful Teacher Professional Development Programme (TPDP) that actually makes teachers' work more inclusive, effective and satisfying. The modular programme and some samples that were used during the trainings will be presented at the conference. All materials are in English.

Cakmakci, G., Kaya, G., Yalaki, Y., Akkovunlu, B., Sardag, M. — Classroom materials supporting Professional Development

Strategies for Assessment of Inquiry Learning in Science (SAILS)

Strategies for Assessment of Inquiry Learning in Science (SAILS) project has received funding from the European Union's Seventh Framework Programme for research technological development and demonstration under grant agreement no 289085 (2012-2015). The aim of this project is to support teachers in adopting an inquiry approach in teaching science at second level (students aged 12-18 years) across Europe. The SAILS project has demonstrated how inquiry approaches can be used for teaching a range of scientific topics, and has helped science teachers become confident and competent in the assessment of their students' learning through inquiry. More than 2500 science teachers in 12 countries have participated in SAILS teacher education programmes. These teachers have strengthened their inquiry pedagogy and assessment practices by developing their understanding of the role of assessment.

SAILS Inquiry and Assessment Units book, which includes theoretical framework of the projects, and 19 units in different subjects and education levels were developed, trailed and modified throughout the project. The book contains ready-to-use learning aids, greatly enriched by models of how teachers may support their students with frequent and personalised feedback when they are engaged in biology, chemistry and physics inquiries. The book is available online in English (http://results.sails-project.eu) and a modified version of it is available in Turkish (http://www.hstem.hacettepe.edu.tr/tr/sails-12). Hardcopy and online versions of the book in English and in Turkish will be presented at the conference. The book showcase the benefits of adopting inquiry approaches in classroom practice, exemplify how assessment practices are embedded in inquiry lessons and illustrate the variety of assessment opportunities and /or assessment processes available to science teachers. They show how evidence of student learning can be collected and evaluated using a variety of methods such as classroom dialogue, teacher observation, presentations, peer-assessment, self-assessment, student artefacts, and use of assessment rubrics.

Gultekin Cakmakci, G., Yalaki, Y. — Classroom materials supporting Professional Development

Promoting Student Teachers' Ideas about Nature of Science through Popular Media

Science-Teachers Education Advanced Methods (S-TEAM) project has received funding from the European Union's Seventh Framework Programme for research technological development and

demonstration under grant agreement no 234870 (2009-2012). The project aims to disseminate inquiry-based science teaching methods (IBST) to the widest possible range of teachers and teacher educators across Europe and associated countries. During the project different PD materials and classroom materials that support PD have been developed. A book entitled “Promoting Student Teachers’ Ideas about Nature of Science through Popular Media” was among these materials. The book provides a training package to enhance scientific literacy among student teachers by using research papers and media reports of scientific research, which contribute to the development of understanding of the Nature of Science. The book is available online and hardcopy and both versions will be presented at the conference. Media reports of scientific research can be used to develop skills associated with aspects of scientific literacy that students need to play a full part of a modern democratic society where science and technology play a key role in shaping their lives-as active and informed citizens.

Cakmakci, G.,Yildiz, B., Kaya, G., Sardag, M., Idin, S., Sonmez, I. — Classroom materials supporting Professional Development

Science News Hub: Public Engagement with STEM

Science, technology, engineering and mathematics (STEM) teachers who have an informed and coherent understanding of STEM can play a vital role in promoting STEM literacy in schools and society. Therefore, promoting STEM literacy among teachers would enable them to teach these ideas to their students. We use media reports about scientific research as a context and instructional tool for promoting STEM literacy among students and teachers. We will present a free of change news aggregator for science, technology, health, business and education (www.bilimiletisimi.com/en) and discuss how to make use of such resources to enhance public understanding of STEM. The citizens make their decisions based on their knowledge, beliefs, social values, worldviews, as well as based on the understanding about STEM. Therefore, dissemination of scientific research results to the public is important to draw evidence-based conclusions about STEM-related issues. In addition, the participation of public in policy debates about STEM-based social issues is essential to maintain a healthy democracy. Accordingly, it becomes clear that the public understanding of STEM is a necessity for making informed decision-making on STEM-related issues. In that case, how can we increase the number of scientifically literate people who can take part in societal discussions and decision-making processes? We propose that we can promote public understanding of STEM and STEM literacy by utilising mass media as an instructional tool for both students and the public. That would also help them to see the relevance of STEM to their lives and the material world.

Idin, S., Dönmez, I. - Classroom materials supporting Professional Development

A Creative Drama Workshop Regarding Women Scientists

A creative drama workshop related to women scientist was run at European Researcher’s night, in İzmir, Turkey (2012). Researchers’ Night is a European Commission - Marie Curie Action has received funding from the European Union’s Seventh Framework Programme. Developed activities were carried out with pupils, who were at primary and secondary schools. The aim of the activities was to promote students’ attitude and motivation to science, positively. Another aim of the activities was to emphasise that both women and man do careers in science and both do remarkable discoveries in science. The workshop lasted 90 minutes. In this context, firstly three women scientists were discussed. Students Final Kaptan knew the Turkish science educator, Fitnat Kaptan, did not know Marie Curie and Hypatia

before this project. Prepared activities were about scientists' life, their conditions, their successes and so on. It was aimed to be known scientists are human and they can live like you in their daily life. So, we wanted for students, who attended to this workshop, have fun, love science and to have more positive attitude and motivation towards science, without gender role. At the end of the workshops there were done some interviews with students and were carried out some observations to understand whole the process that based on creative drama. We tried to understand that after our workshops student could know these scientists and had some information on their studies within science. It was seen that the students had fun; they had positive motivation towards science.

Nistor, A., Gras-Velazquez, A. — Dissemination materials

Scientix

Scientix materials

Scientix, the community for science education in Europe has been running for over six years (since 2010). Funded by the European Commission and coordinated by European Schoolnet, Scientix promotes and supports a Europe-wide collaboration among STEM teachers, education researchers, policymakers and other STEM education professionals.

The materials presented will include:

- Newsletters on different topics on Science education from space education, to networking.
- Copies of the latest comparative study on national measures "Efforts to increase students' interest in pursuing science, technology, engineering and mathematics studies and careers" (Kearney, 2016)
- Brochures and information from a number of other Science Education projects from across Europe

Pendrill, A., Arvidsson, Å., Ekström, P., Hansson, L., Kozma, C., Ouattara, L., Reistad, N., Theve, A. — Professional Development materials

Physics for the whole body – in amusement parks and playgrounds

Force and motion – a dynamic learning objective

Forces are often considered a difficult and inaccessible topic. In this project, we make use of the experience of the body, in combination with mathematical descriptions, measurements and modelling, adapted for different age groups. The assignments and activities have been developed over many years, in CPD, as well as in large-scale amusement park physics days, supported also by social media interactions, in particular closed Facebook groups.

Playground physics

Playgrounds are a natural learning environment in preschool, but can be used throughout school to support physics learning. Slides and swings illustrate the textbook inclined plane and pendulum and climbing racks offer opportunities to study falling objects. Activities and teacher support material, as well as a presentation to be used by other CPD institutions, are available at fysik.org/lekplatsfysik. In addition, we have published a few articles (including video abstracts), about a group of 11-year olds trying the experiments. (Pendrill et al, 2014a,b)

Amusement park physics

A school visit to an amusement park represents a considerable logistical challenge but also offers many educational opportunities. To support the educational use of amusement parks, the teacher material

developed includes tips and worksheets for first-time visitors, suggested group activites, as well as more elaborate exercises and material for experienced amusement park teachers, including a number of published articles (a list is available at http://tivoli.fysik.org/english/articles). The material is also used during annual teacher workshops. Educators in different parks collaborate in the development and share materials. The development of the project over many years is described by Pendrill et al. (2013). All the material is available at the project www site tivoli.fysik.org.

During the Materials Market, we will present worksheets, assessment sheets, teacher support material, as well as published articles with more detail. English versions will be available for a majority of the matarial. We will also bring simple equipment used for experiments in the different assignments.

Protopsaltis, A., Hetzner, S., Leen-Thomele, E. — Classroom materials supporting Professional Development

Equipping the Next Generation for Active Engagement in Science - ENGAGE

ENGAGE is a European Seven Framework Programme that aims to raise youth awareness to Responsible Research and Innovation (RRI) through Inquiry Based Science Education. It supports the EU's ambition of future citizens embracing the potential of science and technology. It reaches 12,000 teachers, and over 2 million students, across 11 different countries. The ENGAGE Materials combine relevant, topical contexts, and ease of use, as well as good curriculum coverage.

ENGAGE has produced three different kinds of materials (I.Topicals, II.Sequences and III.Projects), to support teachers at each stage: adopt, adapt and transform. The materials are available in 8 different languages (English, German, French, Spanish, Greek, Romanian, Lithuanian, and Hebrew) and can be retrieved online from the project's website (http://www.engagingscience.eu/) and some of them from Lehrer Online (http://www.lehrer-online.de/).

The ENGAGE Topicals aim to get teachers onto the path of RRI science by engaging them in topical issues, with personal relevance to the students and fit to science 11-16 curricula. The materials are short and highly structured supported with pedagogical strategies for RRI-teaching. These strategies are embedded within the Materials, with clear instructions and all the presentation material and student sheets to help teachers to take the first step.

Sequences are longer than Topicals, and generally occupy around 2 lessons, enabling a more in-depth inquiry. They are designed to offer an effective approach to teaching one 'big idea' about the nature of science rather than just apply it. Sequences are less prescriptive, but still provide a lot of guidance to minimise the preparation time.

Projects mimic the conditions under which students will meet science issues beyond school - the most 'authentic' way to learn. The materials do not prescribe but stimulate and support with 'teaching ideas' more than mapped out lesson. The teachers' notes will show the learning principles more than the details, to aid customisation.

8. Poster Presentations

Ariza, M.R. (University of Jaén), Quesada, A. (University of Jaén), Abril, A. M. (University of Jaén), García, F. J. (University of Jaén) — Research-based poster related to material dimension

When teachers build parachutes: materials for scaling up teacher professional development

This contribution aims at teacher educators interested in effective ways of supporting teachers in their development of meaningful and motivating science and mathematics learning.
In order to address some of the key questions related to the topic 2 of the conference Educating the Educators II, the contribution will focus on the discussion of the quality criteria for promoting effective teacher professional development, as well as the key features of classroom resources to foster inquiry skills and provide learning opportunities connected to the real world.
The contribution intends to offer an oral presentation covering two different dimensions closely interwoven, the classroom dimension and the teacher professional development dimension.
In relation to the first dimension, we will describe the development and use of the classroom activity entitled 'Parachute food drop'. The task presents a setting in which students take the role of specialised engineers, who have to design appropriate parachutes for providing humanitarian aid. We will critically analyse the characteristics of the classroom materials being presented in order to evaluate to what extent they meet the design guidelines proposed by xxx. These guidelines are an interesting tool for the design of classroom materials, which link mathematics and science with the world of work. Looking for connections with the real world provides learning with a sense o meaning and purpose, enhancing students' motivation and knowledge application.
In relation to the second dimension, we will describe how this task has been used for teacher professional development to offer an immersion strategy (Loucks-Horsley et. al., 2003). We will analyse and discuss the intervention trying to identify those key features related to efficient teacher professional development (Ariza et. al., 2016; Luft, & Hewson, 2014; Penuel et. al, 2007).
Finally, implications for teacher education and teacher professional development will be discussed.

Bracke, M. (University of Kaiserslautern), Neßler, K. (University of Kaiserslautern), Siller, H.-S. (University of Koblenz-Landau) — Research-based poster related to personal dimension

Research-based learning versus subject-matter-orientated teaching for supervising complex interdisciplinary modelling tasks: what are the advantages and disadvantages?

1. Introduction
Mathematical modelling is the process of using mathematical terms and methods to represent, describe and solve a problem. There exists a huge range of different types of modelling problems, depending on the aims and goals of the activity. It is known that participating in mathematical modelling activities is very beneficial for high school students' mathematical development (Maaß, 2006, Kaiser, 2005). Not only do they learn how to apply the mathematics that they have learnt in a traditional classroom setting, they also see how mathematics is essential in solving numerous important problems in our society (Winter, 1995), and is an essential underpinning for many of the other STEM (Science, Technology, Engineering and Mathematics) subjects (Siller, 2015). Well-posed problems can be used for a variety of ages and abilities of pupils, allowing even students who do not

enjoy mathematics lessons or find them hard to feel that they have something to bring. Furthermore, by working in teams, students develop team-working and interpersonal skills.
Due to the benefits of mathematical modelling, it has been, is currently being or will be introduced into the curriculum of a number of countries including France, Germany and the United States of America. However, it has been reported that teachers often find the teaching or supervision of modelling problems very hard for a number of different reasons (Cabassut and Palomares, 2015). There is a need for appropriate personal development courses which can help educators learn how to run and supervise modelling activities (LEMA, 2006). We believe that there is no one "perfect" method of teaching or supervising a mathematical modelling exercise, but that, depending on the complexity of problem being considered and the goals of the modelling activity, different strategies will have certain advantages and disadvantages. We distinguish between three main different types of teaching/supervision strategy, as follows.

1. In subject-matter–orientated teaching the teacher or supervisor wishes to practice a specific part of the curriculum (a method, a concept, etc.) and leads the students down one particular path to a given solution to solve the modelling problem. The supervisor has complete responsibility for the problem progression.
2. Using study and research paths (Winsløw et al., 2013, Jessen, 2014) the teacher/supervisor initially poses a generating question, with the aim that this question will promote a cascade of further questions and answers from the students. Subsequent probing questions where needed lead the students along branches of inquiry. Our focus is on a strategy where these branches of inquiry are specified a priori, and students are only allowed to progress along these given possible lines. The supervisor has some responsibility for the problem progression.
3. In research-based learning, or teaching-by-researching, the students are given an initial problem outline, and the supervisor is on hand when students require help. The supervisor has no preconceived idea of what methods the students will use to solve the problem, or what approaches they will take, and has very little responsibility for the problem progression.

To date there is no consensus on the most appropriate strategy for supervising different types of modelling activities. At a naive level, one could imagine that the supervision strategy should move from subject-matter-orientated teaching to research-based learning as the modelling problem moves from being defined completely to ambiguously (Kang and Noh 2012, Galbraith and Clatworthy, 1990) as illustrated in Figure 1. However, to our knowledge, there are no studies on the impact of the teaching strategy on the pupils' mathematical modelling competencies and their understanding of the methods used during the modelling process. Such research which will support the creation of appropriate teacher personal development materials and sessions.

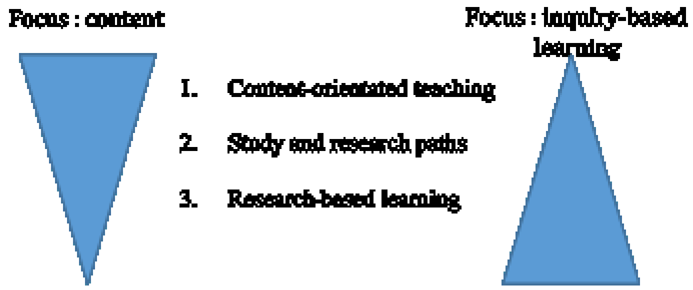


Figure 1. Hypothesised "best" supervision practice depending on the aims and goals of the modelling. However, does this hold in practice?

2. Methods and Results

The aim of our research is to study the impact these three teaching/supervision strategies have on pupil development and, in particular, their mathematical modelling competences (Maaß, 2006)

depending on the type of problem under consideration. For the purposes of this research-based oral presentation, we will focus our attention on modelling problems which are open-ended, complex and unstructured, and based on real life processes or systems in one or more of the STEM disciplines.
To attempt to answer our research question of "What are the advantages and disadvantages of different supervision styles used during complex mathematical modelling activities, and how do they impact on what students learn during the process?", we use a design-based research method (Wang, 2005). This methodology is both systematic and flexible, and can be used to advance educational practices and theory through collaboration of practitioners and researchers. It is characterised by iterative cycles of design, implementation, analysis and then redesign.
In this research-based oral presentation we will present results from the first iteration of the design phase of our research. We will compare the results from three separate modelling sessions, where teams of pupils from year 11 in the German school system (age 16/17) work in teams to solve open-ended and complex problems over a few days. To evaluate the students' mathematical modelling competence, depth of thinking, and their ability to analyse and critique the modelling method and results, we will present results from individual interviews with the students where they are asked the following questions.

1. What is the problem you are trying to solve?
2. How did you do this?
3. What is the main result?
4. Does it make sense in terms of the original question?
5. Are there restrictions/limitation?
6. How do you know your result is "correct"?
7. If you have more time, what would you do next?

Combined with recordings of the sessions and questionnaires, we will compare the effect of the three different teaching/supervision strategies on the pupils' development and opinions, and discuss their various advantages and disadvantages.

3. Conclusion and Further work

As the first part of our design research, we will discuss our results and the impact they could have. Furthermore, we discuss our future plans for further refining and improving our research into appropriately tailors teaching/supervision methods. We believe the results will be very illuminating in developing personal development strategies for facilitators, and interesting for both teachers of the STEM subjects, teacher educators and researchers in the field of mathematical modelling.

Bronner, P. (Friedrich-Gymnasium Freiburg) — Practice-based poster related to material dimension

Inquiry based mobile learning with smartphones

1. Smartphones in the classroom

In many school buildings smartphones are prohibited - but nevertheless omnipresent: SMS messages are written under the student's bench, during the class work WhatsApp is used to discuss the right solution ... But there is another way: Smartphones can enrich school lessons! Especially in science and math classes the smartphone can be used as an absolute high-end meter. Numerous built in sensors allow countless experiments. Students of the Friedrich- Gymnasium Freiburg explored as part of a collaborative project with the University of Education Freiburg (Dr. P. Vogt, project mascil), how much math and science is possible with mobile devices. More than 60 different experiments were presented in an exhibition at the PH Freiburg, revised and finally published on a website.

2. Experiments with the BYOD concept

The smartphone experiments represent the concept of BYOD (Bring Your Own Device), are associated with free apps, integrate the context of everyday life of pupils, work independently of the internet and can be performed with different operating systems (Android, iOS, Windows).

3. Inquiry based learning and smartphones

Due to the high variability of smartphone models existing in one classroom as well as different operating systems and apps, any "recipes" to do the experiment in exactly one way will fail. Therefore, the formulation of smartphone tasks should be open and inquiry based: students ask their own questions, formulate hypotheses, plan experiments with smartphones, implement, find explanations and communicate the results. Such work can be carried out with the smartphones not only in the classroom but also in the everyday life of the pupils, in the world of work and at home.

With an open formulation of a smartphone task both underperforming and powerful learners can be promoted according to their previous knowledge and their performance in heterogeneous learning groups. Pupils experience a high degree of practical orientation and self-determination. The connection of smartphones and inquiry based learning thus makes an important contribution to the individualization and differentiation in the classroom.

4. Scaling up professional development in two ways

Due to the new physics curriculum of the federal state of Baden-Württemberg, claiming smartphone or tablet measurement competences for students, teachers have a high interest for professional development (PD) about the use of mobile devices in the classroom. To support those teachers, we disseminate the concept of inquiry based mobile learning with smartphones and tablets in two approaches: An online teacher education platform and a face to face professional development course, which was included into a governmental multiplier concept.

Online platform: We establish the website http://mascil.ph-freiburg.de/smartphone for teachers and teacher educators, which contains over 60 experiments with mobile devices, worksheets for the classroom and student solutions. In addition, the website gives educational and technical instructions for the implementation of a mobile learning school concept. In June 2016 the website was awarded with the Comenius-Education-Seal for an exemplary high quality education resource.

Face-to face PD: First of all, we establish several single day PD-courses, which were organized by the regional council of Freiburg. Within the course it was shown that teachers need many proved and tested examples directly from the classroom so that they are convinced and able to show their students what is really possible with their smartphones. With this experience the concept was further improved and new examples from the classroom were integrated. As second step the PD-course and the homepage was presented consultants for physics-education of Baden-Württemberg at their annual meeting. The consultants act as multipliers and are responsible for the governmental in-service-training of all physics teachers within the federal state. The consultant decided, that the smartphone experiments in connection with the concept of inquiry based learning will be part of the governmental physics PD-courses for the new curriculum in the whole federal state.

5. *Acknowledgements*

The idea for the student experiments with mobile devices are based on the development and research of Dr. Patrik Vogt (Department of Physics, University of Education Freiburg), who has supported the students project. The pupils exhibition and the website was also promoted by the EU project mascil headed by Prof. Katja Maaß (IMBF, University of Education Freiburg).

Cabassut, R. (Strasbourg University) — Research-based poster related to structural dimension

Professional development on modelling and national conditions and constraints: examples from France

1. Problematic: how to scale up professional development on modelling in a French context?

As pointed in (Cabassut 2013), in the last ten years different European projects about modelling, inquiry based approach or resources for mathematics and sciences have been encouraged a priori by European Parliament recommendations or European Commission reports. On one hand, a transnational approach brings advantages. In the evaluation of piloting of teachers training course on modelling Cabassut & Villette (2011) have shown that transnational teachers' types can be defined about beliefs and practices on teaching of modelling: teachers' heterogenity exists in every country and every teachers' type is represented in every country. A transnational approach can explain the different types with transnational variables and in some countries some types can be explained by national conditions (Ibidem). On the other hand, a posteriori, specificities of national conditions and constraints can explain the difficulties to scale up professional development as illustrated by (Garcia et al. 2007) about teachers training course on modelling. In this presentation we will illustrate on different French examples of professional development on modelling how to scale up the implementation of innovative, and research-based approaches on modelling from a French perspective. We will show that it is necessary to take in account the national contextual framing and to fit with the French educational policy. We will conclude by examining some conditions and constraints to scale up professional development on modelling in the French context. We will use the theoretical frame of anthropological theory of didactics (Bosch et al. 2006) and of double approach (Robert et al. 2005) that we will precise in the presentation.

2. Example of a secondary school prospective teachers' course on modelling

This course on mathematical modeling is for French trainee teachers in vocational school. In their fifth year of university, they must ensure half the weekly schedule of a high school teacher and the rest of the time they take courses at the university to complete their Master's degree. For this course trainees have to conceive a modelling activity and to implant it in a class. The trainees' priority is to be ready to teach and to solve the problems they meet in class. Most of the training courses are being useful for this short term priority and are organised at the level of training institute that is independent to set up the con - tents, even if a national framework specifies common trends. Because of these constraints, the present modelling course is trying to balance long term and short term aims. To acquire notions on didactic of mathematics and particularly on modelling, to make links with research on mathematical education and particularly on modelling, to acquire a reflective behaviour on teaching are long term aims. To conceive, to implant, to evaluate a modelling activity in one of the trainee's classes and to report on it are short term aims. Every trainee is assessed on the written and oral reports of the implantation of his modelling activity in his class.

Knowledge related to modelling is presented through analysis of modelling tasks: notions of experience, simulation and modelling in probability (Batanero et al. 2005), modelling cycle, design, implementation and analysis of modelling tasks (Cabassut 2013, Maass 2006), equiprobality model (Gauvrit et al. 2014). To help to analyse the design of class sequences we use devolution and didactical contract from theory of didactical situations (Brousseau 1997) or praxeologies and educational co-determination levels from anthropological theory of didactics (Bosch, Gascon, 2006). The didactical contents are most of the time introduced as an answer to a need expressed by the trainees during sessions on conception or evaluation; sometimes there are planned through training tasks based on homology situations (Kuzniak, Houdement, 2002) or video analysis (Robert et al 2005).

In (Cabassut 2015) we observe many conditions and constraints of institutional context, outside of mathematics, that influence the development of the course. In the conception of implantation in the

class, didactic competences are dominant al - though than in the reflective phase after the implantation, pedagogical and professional competences are dominant (Robert et al. 2005).

3. Example about primary school teachers' in-service training on modelling

An in-service training course must complete the following institutional constraints. Training course is offered in the regional teacher training course frame organized by the regional education authority (Rectorat or Inspection d'Académie). It must meet the criteria of regional and national educational policy (priorities for training plans). The teacher takes note of in - formation on training and should register the course through an institutional web application between September and October. The teacher must be authorized to attend this training by the local institution (the secondary school headmaster or the inspector in charge of the primary school district). The primary school teachers are replaced by other teachers for the duration of training. The course is cancelled if there are not enough teachers to attend it. It is also interesting to note that it is difficult to obtain a 5-day training course in high school: first, teachers are rarely replaced, and second, teachers are often allowed to participate only in three days training per year. At the last moment the institution has limited participation in training to teachers in charge of the classes of grade 0 to 2, age 5 to 8 years. This involved changes in the content of training to adapt first to the primary school teachers and second to consider tasks for pupils who are just beginning to learn reading and writing. The above description shows the importance of institutional conditions.

(Cabassut et al. 2009) points the role of the different levels of didactic determination in modeling. The organization of the in-service training was heavily constrained by institutional framework. In French curriculum problem solving is an object to be explicitly taught, and modeling is a part of problem solving. Teachers focused on ‘teacher praxeology’ (Bosch & Gascon, 2006). An example of this dimension is related to their concerns on how modeling can be progressed throughout the whole mathematics curriculum, how fruitful assessment on modeling can be developed, and the integration of the modelling competencies.

4. Conditions and constraints to scale up professional development on modelling in a French context

In an ongoing research about French teachers' conceptions on modelling (Cabassut et al. 2015) has pointed heterogeneity about position on modelling and on difficulties to teach modelling. A majority of teachers is positive about modelling. Some difficulties about modelling can be explained more generally by difficulties in mathematic teaching. For some teachers, difficulties are specific to modelling, especially those related to time, students' involvement and resources. It is also possible to identify positive aspects related to evaluation, lesson organization and students’ support or promotion. Statistical analysis suggests that some variables (gender, country, difficulties in mathematic teaching, type of school, type of education, type of job) could play a role in the difficulties to teach modelling.

To scale up professional development on modelling, different conditions have to be taken in account. First, training and resources have to offer solutions to difficulties expressed by the teachers, specially time difficulties. When the ingredients to build models are introduced for the first time? When are they exercised? How to build a long term study and research path fulfilling the curriculum and involving modelling? Second, the training and resources have to meet the priorities expressed by the national educational policy.

From 2016 a new curriculum will be developed in compulsory education (primary and lower secondary schools). Mathematics education is affected by three major changes: informatics will be teach by mathematic teachers; two hours per week will be allocated to practical interdisciplinary teaching; projects have to be encouraged. In France, professional development on modelling has to integrate these priorities in the frame of institutional conditions and constraints.

Criado, A.M. (Universidad de Sevilla), García-Carmona, A. (Universidad de Sevilla), Cruz-Guzmán, M. (Universidad de Sevilla) — Practice-based poster related to Material dimension

An experience with soap films in preservice Primary teachers training on inquiry based Science learning

1. Abstract

This work is set within a wide project directed to the initiation of prospective Primary teachers (PPTs) to the processes of scientific inquiry throughout experimental activities (ExA)i. Particularly, it deals with the successive implementation of inquiry-based ExA so the demanded autonomy grows as well as the level of openness of the inquiries they have to carry out. In the case we introduce, the students have to perform an investigation in which, once the teacher has chosen the topic, they have to decide on the research questions, design the procedure to validate / refute their hypotheses, draft conclusions, etc.

The results show that most groups have opted for designing inquiries of exploratory type. The differences since the first ExA lie in the fact that nearly all the groups have included control of variables explicitly and the majority of them know what to do to verify / refute their hypotheses. The writing of the research questions, the identification of which is the problem they have investigated, is still one of the facets that has taken a lot of work to some groups. The same happens with the drawing of the conclusions.

2. Introduction and objectives

The inquiry-based learning (IBL) strategies and the design of learning materials are dealt with in our project of research about ExA in PPTs Science training. One of our concerns lies in finding out how the progress must be from an activity presented to the students in a very closed way to an inquiry activity where they are the ones who take a great part of the initiative in the investigation. In other papers (Cruz-Guzman, García-Carmona y Criado, in press), we have detected the difficulties of our students to pose questions that are researchable in the processes they tackle with. We have also found that in confirmatory inquiries, it involves an intense and continuous scaffolding from the teacher to get students to make hypotheses beyond the descriptive aspect and which are based on scientific knowledge (García-Carmona, Criado y Cruz-Guzman, in press). In the case we present, we have gone a step forward. In the same way, we have encountered that this PPTs make it through university not being able to develop a control of variables. Knowing about these difficulties, in this paper we have devoted to finding out what developments are taking place after the PPTs have been trained in the inquiry process. To find it out, results from analyzing their reports are collected, when an ExA is carried out with a great level of autonomy (Banchi & Bell,2008) and they have to face the designing of the process making more decisions.

3. Methodological aspects (participants and instruments)

Sixty-six (66) students of the subject of Didáctica de las Ciencias Experimentales of 2nd year of Primary Teacher education Degree (PPT), of the University of Sevilla. There worked seventeen (17) groups of about four students per group. A previously validated rubric was used as an instrument of analysis of the inquiry reports. (This rubric is missing here because of lack of space).

4. Methodological aspects of implementation

After the experience and training received in the year, the students were asked to investigate on soap films or bubbles (Cox 2001). A 1-hour-video (Segura, 2016) was provided as well as the photocopies of an old book of Recreative Science (Estalella 1918) where complementary practical works to those of the video are presented. In the video, the speaker asks the people attending to make predictions about what is going to happen in the subsequent formation soap films (on wire 3D frames) he makes in front of the audience. He ends by verifying that the Plateau rules and Laplace´s laws of bubbles are fulfilled.

The old book also shows how to produce plane soap films. After having studied these resources, students asked the teacher to clarify the surface tension and minimal surfaces concepts. In the instructions to perform the ExA, they were requested to go on with the dynamics established in the previous inquiring ExA except that in this case the teacher would not suggest what the investigation questions should be. Besides, they were explicitly reminded that we had studied that a research may be exploratory (then there are hardly arguments to support the hypothesis) or confirmatory (when the design just checks some principles known beforehand). In this way, groups of students were encouraged to inquiry those questions they were interested in, even though they were not provided with well founded solid knowledge to make predictions. But also, comfort was provided to those groups less bound to undertake an innovative path.

Results and conclusions

The results show that most of groups have chosen to design exploratory inquiries, though many have verified Plateau rules in the inside of the 3D frames (Figure 1). The optimal composition of the soap solution was the aim of many of the investigations. The most frequently investigated variables refer to those which influence the time of duration of a soap film: the temperature of the solution, the different proportion of soap and additives, as hair lacquer (source of glycerine), sugar and others. Comparisons between 2D and 3D soap films have also been made. Some groups have performed a full crossing of variables (i.e. temperature of the soap solution - different additive proportions). New aspects have also been investigated, for example testing if the bubble rules are verified when new bubbles are blown within de tetrahedral and prism frames. These rules initially give an inner point (tetrahedral frame) and an inner segment (square base prism) as it is seen in figure 1, but not a 3D bubble, but students wanted to test if new possibilities can exist. We conclude that quite a lot of achievements have been made in comparison with the first ExA of the year. The differences lie in the fact that nearly all the groups have included a control of variables to their design in an explicit way. And most of them know how to verify / refute their hypotheses. Surprisingly, the writing of the research questions, the accurate identification of the questions they have addressed is still one of the sides which many groups have taken hard work on. The same happens with the drawing of the conclusions. Regarding these aspects some of the groups forget to take up the posed questions one by one to summarize which the answered ones are, which of them have inconclusive results, or which the issues emerging are.

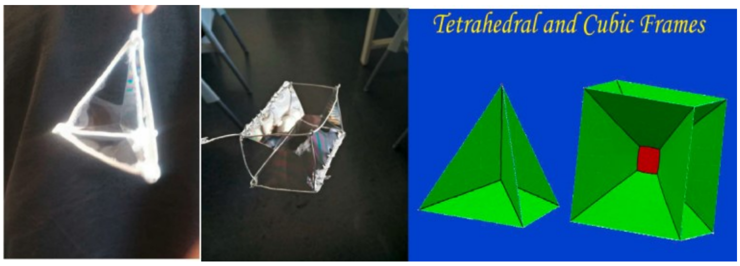


Figure 1. Soap films within the tetrahedral, prism with a square base and cubic frames. Left: some of our frames photos and right: figures from Cox (2011).

De Villiers, L. (Durban University of Technology), Wessels, D.JC. (Stellenbosch University) — Research-based poster related to material dimension

Investigating engineering students' mathematical modelling competencies

1. Background

This research-in-progress is a study that focuses on the mathematical modelling competencies of first-year Civil engineering students studying at the Civil Engineering Department of Durban University of Technology (DUT), Pietermaritzburg campus, South Africa. The students under investigation are all enrolled for a bridging course, as they did not comply with the academic standards for direct enrolment

into the mainstream program, but, because of the history of weak schools in the rural areas, it was decided to give these students a second chance. The class sizes will be approximately 100, students will be divided into small groups in order to allow for the emergence of interactions, communication and reflection (Biccard & Wessels 2011, 382). This longitudinal study attempts to understand the holistic progression of students' mathematical understanding, focusing on their cognitive, meta-cognitive and belief dispositions. The outcome of this study will contribute to a better understanding of the importance of classroom norms, as well as the refinement of instructional tasks and materials for use in classrooms.

2. Rationale of this study

Mathematics contributes significantly towards engineering education. Professional engineers constantly need to evaluate, analyse and interpret real-world problems. In the current mathematics education literature, mathematical knowledge often focuses only on the content aspect, leading to a narrow orientation what Skemp (1976, 22) calls instrumental understanding. While instrumental understanding involves the memorising of meaningless and disconnected rules, relational understanding requires a holistic picture of mathematics education that focuses on a greater cognitive connectivity of the mathematical knowledge. Students' levels of understanding increase continuously together with increased complexity and richness of knowledge while attending to interpretations and sense-making (Schoenfeld 1992, 360). Businesses demand smart, adaptable and well educated problem-solvers who are to meet the challenges of their fast-changing workplaces.

However, research has indicated a mismatch between the mathematical learning in high schools and the competencies needed in university as well as in the professional workplace (Singh & White 2006, 51). Even final year mathematics undergraduates tend to rely on their memory and rote learning to solve examination questions. Colleagues at DUT complain about students' inability to reflect on their work to judge their solutions in terms of meaning, context and adaptability. Students struggle to communicate clearly and effectively on their solution processes, resulting in difficulties in validating and generalising their work. These struggling students also appear to adopt a belief-system that hinder them from reaching their full potential. Educators need to consider the role of the teacher, the student, the classroom norms, the type of curriculum and the place of technology are all inputs into the working whole as changes in the one affects outcomes in the other (Brown 1992, 141). Teaching approaches must be renewed in order to guide students toward independent and competent users of mathematics as required by today's workplace.

3. Mathematical modelling and modelling competencies as a tool towards mathematical understanding

The mathematical proficiencies requested by the workplace and universities are in agreement with many proficiencies required for mathematical modelling. Galbraith (2007, 60) believes that mathematical modelling has the potential to address the gap between applying mathematics in the real world and addressing mathematical concerns in the classroom, without preparing the students for a focused agenda dictated by the workplace. Mathematical modelling allows for opportunities to link knowledge acquired from one domain to another due to students' development towards stronger engagements and motivation. Mathematical modelling is a tool to facilitate conditions for learning how to formulate, solve and make decisions about engineering problems in context. During the process of mathematical modelling, students learn to develop competencies to abstract critical information, to mathematise, reflect, verify and communicate solutions to others. In this study, the modelling competencies will be examined while students are actively engaged with mathematical modelling activities. Blomhøj and Jensen (2003, 125) explain a typical modelling process comprising of the following stages: understand the real world problem, simplify, mathematise, find a mathematical solution, interpret the solution and validate the solution within the context of the real world problem. This cyclic process is repeated until a satisfactory mathematical solution is obtained. In terms of this study, modelling competencies will be defined as follows: Mathematical modelling competence refers

to being able to 'autonomously and insightfully carry through all aspects of a mathematical modelling process in a certain context' (Blomhøj & Jensen 2003, 126). An important aspect is the fact that a mathematical modelling competence indicates the readiness as well as the willingness to perform a certain activity within a particular context (Maaß 2006, 117) and is acquired over a period of time by intuition, experience and common sense.

3.1. Realistic Mathematics Education (RME)
This study's approach to mathematics education is based on Realistic Mathematical Education (RME). The philosophic underpinning of RME is that students develop mathematical understanding by working with contexts that are 'real' to them, as well as the idea that mathematics is a human activity. Through a process of 'guided reinvention', students experience a similar process in comparison to the process by which mathematics was invented. Their own intuitive methods are refined through carefully chosen sequences of examples that can elicit growth in understanding and appropriate teacher guidance to progress toward more formal mathematical understanding. When a student is guided to reinvent mathematising, along with being able to take part in abstraction, schematisation, formalisation, algorithmatisation and verbalisation, valuable knowledge and abilities will more easily be learned and retained, and as such motivate the student. Reflecting on work empowers students to progress to a level where they finally gain the insight into the principles of the problem and are able to understand the 'big picture' (Freudenthal 2002, 47-9).

4. Problem Statement
This study will seek to provide insight into whether and how first year engineering students develop mathematical modelling competencies through mathematical modelling activities. It will in particular focus on the necessary mathematical modelling competencies for enabling these engineering students to perform better in problem solving and modelling. The researcher undertook these investigations with the aim to include modelling – and thereby foster the development of mathematical modelling competencies – in the mathematics curriculum of the first-year mathematics course at DUT.

5. Methodology
Traditional methods of educational research and development have not experienced the callibre of intellectual breakthroughs when comparing to fields such as medicine, engineering and science and no measureable large scale improvements in teaching or learning practices has been noted. In fact, the South African Institute of Race Relations' publicised statistics show that the average numeracy scores of 2014's Grades 4 and 5 learners were 37%, while the Grade 9 learners' scores amounted to 11%! Reeves (2006, 53) blames part of these poor performances on research that focuses too much on scientific proofs and hypotheses, in stead of employing experimental trials to reveal what works - hence this study's motivation for design-based research (DBR) methods. The purpose of DBR is to develop theories of the processes of learning as well as the means designed to support that learning in naturalistic settings (Gravemeijer & Cobb 2006, 18). Research questions result in knowledge that is both exploitable and open to validation with the aim to find a practical and effective solution to a real teaching and learning problem. The design research process incorporates interactive learning environments and within a particular context for developing effective educational interventions.
The focus of this research study is to investigate and support first year engineering students' efforts to develop mathematical modelling competencies. DBR is characterised by the following qualities: iterative, intertwinement, shareable, contextual and connecting processes to outcomes. The iterative cycles of design, evaluation and analysis lead to the refining and adapting of a local instructional theory. Throughout the experiment, emergent behaviours of students in response to activities drive the further development of both the intervention as well as the development of theory. DBR allows for the opportunity to improve curriculum design, and simultaneously yield findings concerning aspects of students' understanding of mathematical modelling, their abilities to delve in argumentation and reflection, as well as the role that mathematical modelling activities and the social interactions around them play in such processes. These findings provide insights over time into the

complex process of developing modelling competencies and help to understand and improve on the role of the teacher and the learning materials.

Diakonou, M. (Model Lyceum Evangeliki School of Smyrna), Siopi, K. (Model Lyceum Evangeliki School of Smyrna) - Practice-based poster related to material dimension

The input-output criterion of data in design of task activities

This article focuses in the design of an activity with tasks which have as criterion input-output of data, in line with the model of the investigation of learning and teaching, within the program Mathematics and Science for Life (Mascil) and was implemented at a high-school class in Greece in 2014-2015. All parts of the activity are in line with the current analytical syllabus of the Physics course in Greek high-schools and their goal is to challenge students' curiosity and to make students vigilante enough, being able to answer in practice their questions about the necessity and usefulness of Mathematica and Physical sciences in everyday life. The results show that the successful implementation of such activities requires careful and suitable design.

Theoretical Background of the Article
Within the socio-cultural perspective, teachers' professional development is conceived as "learning in practice" (Jaworski & Goodchild 2006). For teachers, learning occurs in many different aspects of practice, including their classrooms, their school communities, and professional development courses or workshops (Putnam & Borko, 2000). Recent research result highlight the contribution of the Inquiry-based learning (IBL) in the increase of incentives for learning and the quality of the learning objective (Bruder & Prescott, 2013; Maaß & Artigue, 2013). As part of a broader treatment of IBL for mathematics and science, the workplace offers a framework that can be used to introduce authentic practices in class (Mathematics and science for life-Mascil) while offering incentives for professional development for teachers. (Gilbert, 2006; Bennett et all, 2007). The inquiry learning model that adopts the Mascil focuses on the active student's involvement in the construction of knowledge, with emphasis on creativity and collaboration (Doorman, 2009). The teacher and the materials used play a key role in the design and development of the learning process (Hmelo-Silver, Duncan & Chinn, 2007). In this context, our assumption is that the functionally teaching issues such as the teaching time are treated, while the student learning and creativity is enhanced through the chosen teaching strategy which relies on the design of activities involving different interrelated tasks. The activities combine different professional workplaces through teamwork and collaboration, promoting pupils' involvement in data management strategies and developing their research capabilities.

The activity
Within the continuous development of educational skills and knowledge for high-school teachers, as supported from the Mascil program in Greece (2015-2016) and in line with the investigational teaching and learning, the subject of the activity designed and implemented for the teaching of Physics and was about electrification of a mountain village near habitats, in the area of a large power unit in Greece. The main goal of the activity was the exposition of students to the investment of real situations and through the teamwork collaboration to compose a study on them. This activity lies in the intersection of many different professions, such as electricians, surveyors, statisticians, journalists and economists. The involution of great number of areas required the study and design of a variety of task. The whole activity should be completed in 2 teaching hours (95 min), in order to avoid modifications of the schools schedule. In order to be less time consuming, at the stage of design of the activity the different tasks was composed such that the hypothesis data of one group being the results of another group, a fact that was, of course, not known to the students. In this manner, if the students of each group were working together in a right way, they should draw similar conclusions, so that the composition of the

final project would be a unification of the separate. For the implementation of each task, a comprehensive understanding of certain topics of the curriculum of Physics course was needed it.
In this activity 26, 16-years old students participated in total, who distributed in 6 groups, where each group had 4-5 students, and a distinct role from the other groups. The materials available to the students were maps, photographs, newspaper articles, statistics and scientific studies but also simple everyday tools and materials such as straws, scissors, cardboard for draft constructions devised by them in order to help in the development of project management been assigned to them. The groups of electricians had at their disposal resistors, polymeters, generators and cables to build simulations that would help them to carry out their own conclusions, and tables with technical data. The data and materials provided to each team involved a discreet guidance necessary to start their work.
Specifically group tasks were about:
GROUP 1: Determination of electrical requirements of the settlement, based on the last census, ages and professional activities of residents and statistical studies of annual climatic conditions (statisticians, sociologists, meteorologists) –*Task1*.
GROUP 2: Topographical study the broader region with detailed altitude features and design of possible of cables network (surveyors, engineers) – *Task 2*.
GROUP 3: Specification of the optimal power transmission path and composition of a document, presenting and demonstrating their choice using the data from the second group, local press reports, environmental studies and statistics (environmentalists, journalists, statisticians) -- *Task 3*.
GROUP 4: Implementation of the power transmission line taking the results of groups 3 and 1 as hypothesis and with the use of experimental devices of the group to select the appropriate wiring and systems to be used based on specific regulations (electricians A) –*Task 4.*
GROUP 5: Deciding how to distribute power in the settlement, taking the results of third and fourth group as data, as well as the experimental results of the group (B electricians)– *Task 5*.
GROUP 6: Financial report results according to the results of fourth and fifth group (economists)- *Task 6*.

Result-Conclusions
The teacher's role was crucial in the design phase of the activity, supportive during implementation, allowing students to investigate the matter themselves, and decisive in the coordination phase for integrating the results and defining joint learning benefits from application activity with specific characteristics. The main difficulty encountered by the teacher was the choice of the subject to be directly related to their teaching course (physics), being consistent with the course curriculum, having research characteristics, covering a broad spectrum of different professions which use scientific areas of physical and mathematical sciences. As the composition of a complete and documented study and the composition of the proposal for the realization of the project should contain complete technical and economical data, the activity enabled involvement, both in design and in its implementation of teachers from other fields (in addition to physics and mathematics) such that of linguistics, economics and computer science. As the preparation and implementation time was limited this collaboration was not feasible.
The strategy of guided inquiry of the inquiry-based teaching (Kremer et al, 2007) and the features of the activity brought the students at the centre of the learning process. The students were involved in these activities through specific roles directly related to the workplace, acquiring an experience beyond their previously exposure to conventional teaching and learning. During the implementation of their projects it was necessary to look for data management strategies, to design plans to use them, to find solutions, and draw scientifically documented results with respect to the environment and the related social requirements. Meanwhile, they were invited to recall relevant knowledge and to utilize them to solve problems thus gaining a deeper understanding of the subject. Although the students were initially reluctant, progressively they responded perfectly in their roles. They developed initiatives, they had interesting ideas and they managed to complete their tasks on time. They were particularly impressed during the process of jointly preparing their final work when they realized that

the results of their group were the data of another team and that each group was able to present a comprehensive proposal.

In conclusion, the chosen teaching strategy, the specific features and structure of the activity and the element of input and output of data, were decisive for the successful implementation of the activity, and contributed in highlighting the role of exploratory learning and teaching as a fundamental component of quality education which provided many incentives to teachers to further develop professionally through their exposure to new creative teaching practices.

Grapin, N. (University Paris Diderot), Lazaro, C. (Spanish Federation of Mathematics Teachers' Societies), Maracci, M. (University of Pavia), Moussavou, F. (French Association of Public School's Mathematics Teachers) Pope,S. (The Manchester Metropolitan University), Recio, T. (University of Cantabria), Robutti, O. (University of Turin), Silvia, J.C. (University of Coimbra), Vieira, A. (Portuguese Association of Mathematic Teachers) — Research-based poster related to material dimension

Inclusive MAthematical LIteracy (IMALI): collaborative teacher development

1. Rationale

The goal of this poster is to announce the proposal of a project on INclusive MAthematical LIteracy (IMALI): developing teachers through a collaboration of several European mathematics teachers' societies, with the cooperation of some universities and using the design of a multilingual MOOC as a leitmotif.

The outcomes of European countries in international comparative studies (such as PISA and TIMSS, see Bodin, 2012) and in national surveys, suggest that the mathematical skills of most European young people are far from adequate, (OECD, 2012). Hence, the European Union is committed to the development of mathematical literacy (MALI) for all learners. The IMALI project aims to better understand what is meant by mathematical literacy for teachers, learners and end users, what the current situation is in Europe in this issue, as well as to develop, led by several European Mathematics Teachers' Societies, some joint remedial actions and materials (see Figure 1).

	Mean score in PISA 2012
OECD average	494
Shanghai-China	613
Singapore	573
Hong Kong-China	561
Chinese Taipei	560
Korea	554
Macao-China	538
Japan	536
Liechtenstein	535
Switzerland	531
Netherlands	523
Estonia	521
Finland	519
Canada	518
Poland	518
Belgium	515
Germany	514
Viet Nam	511
Austria	506
Australia	504
Ireland	501
Slovenia	501
Denmark	500
New Zealand	500
Czech Republic	499
France	495
United Kingdom	494
Iceland	493
Latvia	491
Luxembourg	490
Norway	489
Portugal	487
Italy	485
Spain	484
Russian Federation	482
Slovak Republic	482
United States	481
Lithuania	479
Sweden	478
Hungary	477
Croatia	471
Israel	466
Greece	453
Serbia	449
Turkey	448
Romania	445
Cyprus[1, 2]	440
Bulgaria	439
United Arab Emirates	434
Kazakhstan	432
Thailand	427
Chile	423
Malaysia	421
Mexico	413
Montenegro	410
Uruguay	409
Costa Rica	407
Albania	394
Brazil	391
Argentina	388
Tunisia	388
Jordan	386
Colombia	376
Qatar	376
Indonesia	375
Peru	368

Figure 1. Mean Score in PISA 2012 (retrieved from PISA Results 2012)

This project will draw on the expertise and cooperation from universities and networks of teachers through professional subject associations across Europe (Spain, Portugal, Italy, France and England) to share and further develop strategies and approaches that nurture MALI for all learners, regardless of their background and previous academic achievement. Researchers and teachers will work together to design instruments to collect views about MALI, to assess MALI and to trial tasks and approaches. This will lead to the design of a massive teachers' educational programme (IMALI) delivered via a MOOC, linked
to accreditation in the participating countries and which will be widely publicised through existing professional networks to maximise participation in the MOOC (Taranto et al., 2016). Moreover, the project will develop an instrument to assess mathematical literacy, in order to measure the impact of the project on learners.

2. Consortium

The project is unique in involving both universities and professional associations of teachers of mathematics, the former providing research and development expertise and the latter ensuring wide participation and dissemination to practising teachers, and long-term sustainability.

The working team will be led by The Spanish Federation of Mathematics Teachers' Societies (FESPM), a more than 25 year old non-profit organisation that comprises 21 Mathematics Teachers' Societies with a total of about 5000 members, mainly teachers in Secondary Education. The consortium also includes universities from England, France, Italy, Portugal and Spain, as well as the main professional associations of teachers of mathematics from France, Portugal and England. This distinctive collaboration will ensure the realisation of the project ambition: INclusive MAthematical LIteracy: collaborative teacher development.

3. Foreseeing implementation and relevant expected results

Mathematical literacy, (see Niss, 2015; Stacey and Turner, 2015) is not a mathematical topic by itself; it is primarily a sociological, political, educational and cultural issue related to citizens' needs: for themselves, for the society to which they belong and of the workforce in the short, medium and long term. The project will start by collaborating with well-known experts to analyse the main features which – besides any (pseudo-) institutional definition – constitute the core of mathematical literacy for the European citizen. These features will be specified and clarified in the light of mathematics education research. Hence one will choose the "priority" features on which to focus in school practice and in teacher professional development. These priorities will also take account of the distinct cultures and contexts of the participating countries, as well as their current position in mathematical literacy tests.

We will develop instruments that allow us to capture the opinions of teachers, learners and stakeholders about mathematical literacy. This will help us to refine our own understanding of mathematical literacy and the way it will be used in the proposed MOOC. We will also develop an instrument to assess learners' mathematical literacy, so that the impact of the MOOC on learners' can be measured.

The MOOC will be tutored by representatives from each country, ensuring full engagement with materials and tasks. Teachers will be encouraged to seek academic accreditation based on the MOOC experience.

Engagement with the MOOC, completion rates and numbers gaining accreditation will be recorded. The MOOC will be fully evaluated and teachers who volunteer will be invited to an evaluation seminar where they can discuss their experience and the impact on their practice. The same approach to evaluation will be used in each country, giving designers feedback on the various actions of the MOOC. The revised MOOC will be made available in the third year with greater participation. This will be with a view to developing a sustainable model when the project ends.

The outputs of this programme are

i. A research and evidence informed articulation of what is meant by mathematical literacy, how it can be nurtured and evidenced,
ii. A teacher development MOOC and
iii. Tools for evaluating learners' mathematical literacy.

All these outputs will be available to any teacher in the EU who wants to develop inclusive approaches to teaching for mathematical literacy contributing in this way to the final goal of increasing Mathematical Literacy in Europe. Materials in the MOOC will include classroom tasks, teachers' narratives of their experience with these tasks, examples of student responses to the tasks with commentary from teachers and researchers.

The evidence of impact on learner outcomes as well as teachers' practice will be thoroughly analysed and summarised. In fact, rates of early school leaving are higher than 17% in partner countries like Spain and Portugal. So, focusing mathematics teaching on competences may contribute to reducing not only school leaving but also unemployment.

Kunchev, M. (Baba Tonka High School of Mathematics), Sendova, E. (Bulgarian Academy of Sciences) — Practice-based poster related to material dimension

Climbing the stairs: implementing the IBL from students' explorations to teachers' motivation

1. Introduction

The experience of implementing the Inquiry based learning in a Bulgarian mathematical high school is considered through the eyes of a math teacher who is also responsible for the professional development of his colleagues in his role of a principal. These responsibilities could be combined successfully as it will be shown by a specific example.

A problem of exploring the dimensions of stairs from different architectural traditions is presented in two aspects – as a long-term project activity of students and as a model of how the IBL could be implemented by other teachers possibly modified according to the specifics of their subject and the age of their students.

2. Stimulating the students to work in IBL style

The world around us provides a lot of options for us, as teachers, to show the students how it is related to mathematics and science. Usually we are so used to the surrounding objects that we do not think how they have been created. Take for example the stairs. They could be characterized by their rise (R) and their Going (G) measured for instance in centimetres.

At the beginning of the Mascil project (Maaß, 2013) I assigned my students (9-graders) the following practical task, organized as a field trip:

> Task: Go to the central area of the town. Split in 3 groups. Each group has to take a pictures of the stair of a particular building (the courthouse, the municipality and the theatre), to measure the steps and determine their rise and going. Then the groups have to describe the material the stairs are made of, the number of the steps and anything they consider important. The captains of the groups present the results.

The pictures taken by each group are shown in Figure 1. I myself carried out the same task for the school stairs.

Figure 1 Measuring the stairs of the town's Courthouse, Municipality, and Theatre, respectively.

The students got as homework to explore and prepare a presentation about the stairs of their home. The class session for analysis and generalization of the data was as follows:

- The three groups demonstrated their presentation about the buildings in the centre of the town.
- We put the results of the measurements in a table and focused on the expression 2R + G since according to the expert (as I had checked in a specialised journal) its value should be between 55 and 70 (Table 1).

Table 1. Title of the table (Caption style)

Building	R cm	G cm	2R + G cm
Municipality	14	40	68
Courthouse	13	35	61
Theater	9	34	52

As seen from the table only the theatre's stairs do not fit the standard requirements. After that several students presented the stairs of their homes and discussed if they were "right". This time the problem for homework was:

Homework: Design two stairs for a total rise of 1 m. For each stair determine the number of steps, the rise and the going.

Some students got so enthusiastic about exploring the stairs in different locations that they went on this activity during the summer holiday, including abroad (Figure 2). They demonstrated their findings in the first days of the next school year.

Figure 2. Measuring the stairs of the Central railway station in Bolognia, Italy.

3. Sharing the IBL experience with the teachers

I don't require from my colleagues to implement IBL in their classes. Instead, I organize on regular basis sessions of sharing our good practices. This turns out to be a better idea than the traditional visits of the principal in a class setting which might create discomfort among the students and the teacher alike. At such a "Share-your-practice" session I presented the two lessons on measuring and designing stairs and discussed the advantages of IBL in relation with students' motivation. Furthermore, I emphasized the role of tasks of this type for the development of key competences such as making choices and decisions, justifying and defending them and comparing different solutions (Kenderov et. al., 2015).

Other teachers shared their own good practices and we as a community discussed when and how IBL is applicable. The presentations of good practices are collected in the school archive and could be used in the future by younger colleagues.
Recently I found the Mascil Problem of January 2016 on designing a staircase and the guidance for teachers (http://teacher-communication.mascil-project.eu/mod/resource/view.php?id=22914). It gave me ideas of further investigations and explorations leading to a construction design. When working with new students (again in 9th grade) I am planning to discuss the problem of finding a relationship between the formula about the steps and the size of people. Such an approach of modifying, extending and enriching a problem when considered in a new context, with new students, is extremely important when working in IBL style.

4. Conclusion
My endeavour when working on the Stairs problem has been for the students to develop competences for observation, interest to investigations and explorations of the surrounding world of work, sense of initiative, cultural awareness and expression – all of them related to the key competences for the citizens of the knowledge/creativity based society.
In a system like the Bulgarian one in which teachers are expected to cover a relatively large volume of mathematical topics (even more so in a specialized school like ours), it is not very easy to convince the teachers that IBL would not be in a conflict with the results shown at standardized tests (Chehlarova et. al., 2015). But sharing the positive effects of my personal experience I feel optimistic, since the principal and his colleagues in the school are like-minded people and climb the stairs of the professional development together. In this climbing we are not alone as discussed by Kenderov et. al. (2016) − we are part of a community which grows and becomes stronger in its endeavour to integrate the IBL with WoW in mathematics and sciences education in Bulgaria.

Manshadi, S. (The arctic university of Norway) — Practice-based poster related to Material dimension

Digital tools and meaning making in mathematics

This poster concerns using educational technology as tablet computers in order to improve children's mathematical achievements in grades 1-4 in a Norwegian primary school. In a modern and rapidly changing society, the use of Data technology is important and valuable tool in the learning of mathematics (Zhang, Trussell, Gallegos, & Asam, 2015). In addition to exercises and problems in textbooks, several Norwegian mathematics textbooks for elementary school have developed online tasks in which pupils can work with mathematical concepts. The development of PC-based software and use of tablet computers (iPad, iOS system and Android-based) and mobile phones with touchscreens has been enormous the recent years. Both Apple and Google Play (Android based) together have developed over one million Apps (Zhang et al., 2015) in different contexts within several subjects such as math, science, language etc. This development has led to a large availability of Apps, which teachers can apply a variety of learning purposes.
This presentation is based upon a school-initiated project: with open doors to the world - A pilot on the use of technology in education at school. The project is interdisciplinary and involves 1. – 4. grade at an elementary school in Northern Norway. Researchers from the Arctic University of Norway have collaborated closely with the participating teachers, in particular researchers from mathematics education, Norwegian language, and general education. The project aims to increase pupils' achievement in both Norwegian language and mathematics by applying educational technology extensively in teaching classroom at grade 1-4, four classes totally.
Mathematical concept is by its nature abstract. In order to achieve a richer understanding of mathematical and scientific terms, it is essential that children themselves attach meaning to these

concepts (Steinbring, 2005). This process requires an active participation in a learning environment in which they make own meaning and dialogic interactions facilitates communicating different ideas and thoughts. Pupils are mostly familiar with using digital tools such as tablet computers in early age. It is interesting to investigate its potential for flexible forms of learning where they can actively participate and communicate their opinions with each other.

In this study, we focus on the interaction in classroom activities where they use tablet computers in learning mathematics. We chose pupils’ verbal and written utterances as unit of analyses. This because meaning making in mathematics and science are based on sociocultural principles (Ernest, 1994; Mortimer & Scott, 2003). Steinbring (2005) asserts that abstract mathematical concepts are mediated through semiotic symbols and characters. The meanings pupils make of mathematical concepts (objects) takes place mostly in a social setting as classroom, home and other social areas. Thus, communication in and about mathematics necessarily bring about students' thoughts and beliefs of scientific concepts through conversation, text and images. Therefore, I focus on pupil’s interaction in order to identifying indications of learning in mathematics.

The research question in this study is *”To what extent will pupils’ use of tablet computers in classroom activities influence their meaning making process of mathematical concepts?”* Data gathered for our study consist of video recording of pupils' activity when using different educational apps and the pupils’ written work from these episodes. Ongoing analyses of the videos is based on work by Alrø & Skovsmose (2002) and Mortimer & Scott (2003).

Relevance for teacher’s practices and teacher education.

Preliminary analysis of the data indicates that teachers can get information on pupil's mathematic work in a way that was not possible in their practice before. Students can attach their arguments and explanations orally to written calculations in worksheet files on IPad. Teachers have the opportunity to read the students texts, hear their oral explanation to their calculations and respond to utterances directly in a worksheet. We do not know to what extent teachers apply this technical function in the communication and feedback process and how they can benefit this usage in their practice. In further researches, it would be interesting to investigate whether or not using touchscreen devises in teaching have impact on teacher’s approach to learning mathematics, which can be a traditional approach, or a more inquiry based approach.

This study intends to investigate possible benefits and disadvantages of applying touchscreen devices in learning mathematics. Therefore funding from this research can have important relevance to the development of teacher practice in school. This will in turn have implications for teacher-training education where learnings-perspectives and didactical views for teaching mathematics and science is a central theme.

Mooldijk, A. (Freudenthal Institute for Science and Mathematics Education), Jonker, V. (Freudenthal Institute for Science and Mathematics Education) — Practice-based poster related to other dimensions

Professional Learning Community on Interdisciplinarity

1. Relation to the conference theme

The Professional Learning Community (PLC) on interdisciplinarity focuses on themes in which science disciplines and mathematics work together to start at their schools an approach to interdisciplinary themes like sustainability, arithmetic or evaluation of research reports from students. There is also a link with the knowledgebase (Ottevanger W. etal, 2014), a similar initiative in the Netherlands as ‘The next Generation of Science Standards’ in America. The desired outcome of the PLC are articles to relevant journals and materials, so other schools can benefit.

2. The presented work

The PLC is now halfway in the fixed time of four years. The poster will show a part of the subjects within de PLC:

- The approach of a school to get the level of arithmetic to a desired standard within several disciplines. The school has made a poster with solutions for several major problem areas with arithmetic. The students also get the information on a little card that fits in their agenda. Teachers from different disciplines are asked to pay attention to the poster. Students that score poorly on the compulsory assessment in arithmetic can ask for additional support. A little research about the impact on teachers and students will also be presented.
- A thematic approach for learning is tried in one school. Students choose a topic within a broader one to investigate. Examples are extra-terrestrial life, the bionic man or the task to diagnose someone with health problems. With this way of IBL the teachers also try to incorporate the idea of cross cutting concepts (NGSS, 2014)
- In two schools teachers are trying to make an interdisciplinary assessment tool throughout the school, in which the students and the teachers see the growth of the students in research skills. They are constructing a rubric with research skills for use in different disciplines and different forms.
- An outline of the approach the PLC is using with five meetings of the participating schools a year with a mix of more theoretical themes, practical exchange, group discussion and in between contact with one of the participants of the institutions.

3. Perspective of the poster

Eight schools are involved in the PLC. About sixteen teachers do visit the sessions on the institution. The Freudenthal Institute of the Utrecht University and The Archimedes academy of the University of Applied Sciences Utrecht also participate and support the schools with their specific knowledge. The approach assures that the participating teachers get knowledge of a wide variety of interdisciplinary themes they can use in their own schools.

Apart from the other teachers at the participating schools, the benefits from the PLC will be relevant for other schools in the Netherlands.

As the approach of the PLC is not standard, with participating schools that do have their own project within an umbrella of interdisciplinarity, we expect various discussions around the different topics on the poster as well as about the used approach.

4. Relation to the dimension 'Other'

The PLC about Interdisciplinarity does not fit regular into one of the dimensions. Material for problems with arithmetic will be spread among other schools. For the thematic approach we hope to find a way of constructing and using the themes that gives good results and can be used by other schools.

Popov, O. (Umeå University) — Practice-based poster related to structural dimension

Better later than never: science teacher professional competence development following curriculum reform in Sweden

The current curriculum reform of the Swedish school system was implemented in 2011. The curriculum documents suggest the implementation of many modern didactical ideas in school practice. One of the generic perspectives adopted is a holistic competence-based approach to be used in all subjects. Additionally, a new evaluation system has been introduced. However, the teachers working in schools were barely offered any opportunity to upgrade their professional competence to meet the challenges presented by the new curriculum. On the whole, if teachers received any external pedagogical support it was focused on evaluation issues. Finally, five years after the reform was initiated, it became obvious for educational bureaucrats and politicians that teachers need more systematic support to internalise the new curriculum ideology and implement the required pedagogical practices.

In 2016, the Swedish National Agency for Education started a project aiming to raise the didactical competence of science teachers. The project capitalises on the previous experience gained in a professional competence development model created for mathematics teachers (Popov, 2015). It relies to a great extent on teachers' collaborative work. The teachers are conceived as internal experts who, in part, can professionally develop each other through regular collegial work within the project.
The SINUS project (Germany) was one of the sources of inspiration for the teacher professional development (TPD) model, in particular in aspects of scaling up through the use of study modules, facilitators and an Internet based platform (Ostermeier, Prenzel, Duit, 2010). The teachers are expected to work with one module per term. Each module consists of eight parts each with a focus on a specific topic. In each part participants carry out activities in four steps with the following allocation of time: individual preparation (45 – 60 min), collegial discussions (90 – 120 min), practical activities/lessons (one lesson), and shared follow up and reflections (45 – 60 min). The teacher collaboration initiated within the module work is envisioned to have the potential to continue on a regular basis in schools with some support from municipalities.
The author has been involved in the production of material for the first module for high school science teachers called "Teaching science through socio-scientific issues". The work with this module material development will be the focus of the presentation. The new syllabus for science education provides broad opportunities for using socio-scientific issues in science classes which benefit and are benefited by the development of argumentation and an understanding of the nature of science. Cultural and historical aspects of science are also clearly articulated in the new vision of science teaching. However, these content areas are poorly presented in teacher education and in school practice. They therefore came to be the focus of our material development concept for TPD. The developers' route through dilemmas and contradictions will be highlighted and illustrated with concrete examples. The material will be published on the web portal of the Swedish National Agency for Education just before the start of the ETE2 conference.

Stampfer, F. (University of Innsbruck, University of Vienna), Sendova, E. (Bulgarian Academy of Sciences) — Practice-based poster related to material dimension

How a bicycle insurance task connected Austrian and Bulgarian students

1. Introduction

An important strategy in the EU-project MaSciL – Mathematics and Science for Life – is to enhance teacher collaboration by stimulating them to work on a so-called Problem of the Month (PoM). The project – running since 2013 and coordinated by Prof. Katja Maaß from Freiburg– aims at promoting the inquiry-based learning (IBL) in connection with the world of work (WoW) in primary and secondary schools (Katja Maaß, 2013). The PoM is a specially designed task, which can be easily adjusted to various age groups and to different educational systems. Since October 2014, the project partners have published 17 problems of the month on their websites, each in 12 different European languages
We focus in our presentation on a specific PoM and show how this task was the starting point of a very fruitful international collaboration between teacher educators, teachers and students from Austria and Bulgaria. In more details, we identify some factors, which might promote the implementation of innovative materials in the classroom in the Austria and Bulgaria cases. Our experiences would hopefully encourage other teacher educators to facilitate similar collaborations between their teachers/students and hence foster an exchange of ideas among students. The collaboration was initiated out of the curiosity for an additional approach to the task and led to a content-based and method-based discussion and exchange. In the presentation, we report our experiences from the Austrian and the Bulgarian perspective on the three different levels: teacher educators, teachers and students. It is important for us to demonstrate how a well-designed material offers a huge variety of links between mathematics teachers from different countries.

2. The task: Bicycle insurance

The Bicycle insurance task was developed by the Norwegian partner as the PoM for November 2014 and is available on http://www.mascil-project.eu/classroom-material?adresse=toepassingen/28226. The description for teachers reads:

The task is to create a manual for an insurance company on how to calculate a 'fair' insurance rate for a bicycle and a 'fair' compensation for a stolen bicycle. The students have to consider different variables, such as:

- the likeliness for a bicycle to be stolen (in this area),
- the value of different bicycles,
- the age of the bicycle and how this affects its value.

The product is a written document or manual for the insurance company where the suggested calculations are described and reasoned for, which may or may not (depending on the students' age) include tables, graphs, diagrams, formulas etc. The task involves making choices, justifying and defending decisions and comparing different solutions.

The specifics of this task is that it allows for modelling on different levels of simplification from the estimation of theft rates by data down to the simulation of randomly distributed bicycle thefts and randomly distributed bicycle prices. Furthermore, the task opens the classroom to the world of work. The students have to think about how an insurance company works and what kind of information or assumptions are needed.

3. Different stages of collaboration

We briefly present the different steps from the independent discussion of the task in Austria and Bulgaria to a face-toface meeting of the teachers in Sofia, Bulgaria.

3.1. Individual discussion of the task

In spring 2015, the Austrian and the Bulgarian teacher discussed the task bicycle insurance as they were involved in the MaSciL project. The Austrian teacher tried out the task with year 9 students and focused on the description of the revenues and expenditures of the insurance company with simple functions. The Bulgarian teacher worked with 11-graders from a mathematics high school, who had already a larger repertoire of functions and strategies to model the situation. The Austrian students wrote a manual on how to set up a bicycle insurance, meanwhile the Bulgarian students designed slides to advertise their own bicycle insurance company and provided some additional slides with their assumptions and calculations for a profitable company. In order to check the results of his students, the Austrian teacher wrote a simple simulation programme in R (www.r-project.org) to test the students' solutions with randomly generated data. This simulation was quite fruitful due to the visualisation of the propositions' outcomes and the way these were influenced by the contributing factors (e.g. salary, annual premium and indemnifications).

3.2. Meeting of the teacher trainers

During the fifth project meeting of the MaSciL consortium, experiences with the PoM were exchanges. So the Austrian and the Bulgarian teacher educators discussed the implementation of the same task by their teachers. Since the approach in both countries was quite different, it seemed to be a good idea to exchange the findings. Thus, the manuals and slides had to be translated into English, which was an additional task for the students and was supported by the teacher trainers.

3.3. Exchange of ideas and virtual meeting

The exchange material was then discussed in the classes again with the aim to find out how the assumptions and the calculation had been done. The students had to analyse critically the product of the partner-country team of students and to prepare written questions. Due to the technical support of the Norwegian partner, we could organise a virtual meeting, in our case a video conference, on July 2014 whereby the students could ask their questions and get some supplementary explanations from the other team.

3.4. Continuing exchange and face-to-face meeting

Fascinated from the results of the Bulgarian students, the Austrian teacher adapted his simulation programme to handle also the more demanding strategies of the Bulgarian company. The results and the programme was the sent to the Bulgarian teacher who forwarded it to her students.

In the meantime, more Bulgarian teachers worked with the task and shared their experiences with their teacher educator. Since the sixth consortium meeting took place in Sofia, the Austrian teacher and the Bulgarian teachers could meet face-to face within a National conference on IBME in December 2015 (IMI-BAS, 2015) and the exchange of ideas goes on.

4. Conclusion

As stated by the founder of the constructionism, Papert (1993) the kind of knowledge children most need is the knowledge that will help them get more knowledge. And the constructions of knowledge, he continuous further, happens especially felicitously when it is supported by construction of a more public sort in the world" [...] – a product that can be shown, discussed, probed and admired.

Our experience in the context of the Bicycle insurance problem strengthens our beliefs that such international cooperation illustrates well the constructionistic ideas behind the Mascil projects – promoting the inquiry based learning in a connection to the world of work is in fact promoting the construction of knowledge leading to the need of more knowledge and to the production of a public entity – a product that could be shared, discussed, tested, refined, enriched and... admired!

Van Dijk, E.M. (Universität Hildesheim) Meisert, A. (Universität Hildesheim) - Research-based poster related to other Dimension

Development of pre-service teachers' lesson-planning strategies in relation to their self-efficacy

Recently, a number of large-scale studies, foremost in the domain of mathematics, indicate that teacher education programs have a positive effect on the development of content knowledge (CK) and pedagogical content knowledge (PCK) (e.g., Kleickman et al., 2013; Schmelzing et al., 2013), and that both types of knowledge affect instructional quality and student learning (Baumert et al., 2010).

Regarding the knowledge base for teaching there is widespread agreement on the nature of PCK as a unique knowledge domain that lies at the heart of teachers' professional competence. PCK refers to specific topics, and is therefore to be discerned from general pedagogical knowledge (PK), and PCK concerns the teaching of specific topics, and will therefore differ considerably from content knowledge (CK) (Van Driel et al., 1998). Various sources for the development of PCK have been identified: (1) prospective teachers own school experience, (2) teacher education programs, and (3) teaching experience. Regarding teacher education programs, a major role has been attributed to teaching experience, however there are indications that this alone does not suffice (Friedrichsen et al., 2009). First, reflection on these teaching experiences is also a critical element of teacher education program. Second, there are indications that adequate CK is a necessary prerequisite for the development of PCK, although it does not necessarily lead to the development of PCK (Kleickman et al., 2013). Third, there are some indications that curriculum materials explicitly designed to promote teacher learning ("Fachdidaktik" courses) can promote the development of PCK. Fourth, it has been suggested that PK constitutes a supporting framework for the development of PCK. Teacher who do not have acquired enough PCK seem to rely primarily on their PK and CK in their lesson planning (e.g., Friedrich et al., 2009).

Lesson planning is a core element of pre-service teacher education programs (e.g., König et al., 2015). It is a process in which general educational theories, principals, and instructional strategies are brought to bear on particular contents and students. The development of lesson plans prepares teachers for the implementation of instruction and affects their instructional performance. Moreover, a lesson plan

offers a basis for reflection and can support student teachers in developing their thinking skills. It makes their thinking explicit to themselves and others (Friesen, 2010). Lesson planning has therefore been used to study teachers' thoughts and decision-making (e.g., Friedrichsen et al., 2009; König et al., 2015).
Regarding the development of the student teachers' competence for lesson planning, the reasons that underlie their planning decisions are of special importance. In particular the type of knowledge (PCK, CK or PK) that student teachers rely on regarding specific planning decisions.
In our study we aim to analyse the development of student teachers' competence for lesson planning in detail at different points in time during the first phase of teacher training. We use a lesson preparation method (cf. Van der Valk & Broekman, 1999) to collect audio-data on student teachers' planning decisions. The aim is to analyse the features and quality of the student teachers' planning. A first analysis concerns the knowledge resources (PCK, CK or PK) that the student teachers rely on in their arguments. A second focus with respect to these arguments is whether they are relevant and justified (Kuhn, 1997). In addition, we aim to analyse the corresponding development of the student teachers' self-efficacy regarding lesson planning at different points in time. Research has shown that self-efficacy affects students' achievements, motivation and learning. Given this substantial role, it is important to gain insight in the development of students' self-efficacy (Van Dinther et al., 2011) and to identify planning and decision strategies with high potential to foster students' selfefficacy with respect to lesson planning.

Wetterstrand, F. (Örebro University), Knutsson, M. (Örebro University) — Research-based poster related to structural dimension

Research Circles in Mathematics Education

What is a research circle?
Research circles can be seen as a venue for researchers and practitioners, this venue could bridge the gap between academic research and practice (Holmstrand and Härnsten, 2003). Research circles are a form of participatory action research (PAR), in which a researcher researches together with practitioners. An important feature in PAR is that the researcher explores together with the practitioners (Lahdenperä, 2014). The practitioners ability to affect, change and participate in the research is of utmost importance (Storfors, 2014). In research circles 6-8 practitioners and one researcher meet regularly for a minimum of one year (Persson, 2009) to solve a specific problem, to elaborate school practice or to develop teacher competence. Together, the group investigates their own practices to find answers to a jointly formulated research question. It is important that the practitioners own experiences form the basis of the research question. Consequently, the difficulties and challenges experienced by the teachers motivate the aim and the question/questions.
Both the practitioners and the researcher are seen as participators in the research circle, and thus have a mutual responsibility to contribute with their specific knowledge and competences. The practitioners contribute with practical experience, and the researcher contributes with scientific knowledge (Holmstrand and Härnsten, 2003). The idea in this research model is to capture a variety of knowledge and experiences, and through their combination create new knowledge (Andersson, 2007). A successful research circle should lead to knowledge that helps the practitioners improve their practice. Andersson (2007) means that the knowledge created in research circles is unique since it cannot be created solely by research or by the teachers. Rather, knowledge is created through the interactions between researchers and teachers. Therefore this research method is highly relevant for this conference venue since it represents an innovative method for teacher's professional development. Particularly, in the municipality of Örebro, research circles are used as a continuation of a Swedish national large scale professional development program called Mattelyftet.

The research circles in mathematics education at Örebro University

For the past year, Örebro University has arranged research circles on the behalf of the municipality of Örebro. The theme of the circles has been centered around teaching methods that could increase student activity in mathematics teaching. Three groups with eight teachers in each group have been studying their own practice. The research circles began in the autumn of 2015 and ended in the spring of 2016. During this time, the groups have met on eight separate occasions for two hours each. Each group derived its own research questions that finally were formulated as:

- How can the teacher increase the student activity during whole class discussions?
- How does personal accountability affect student activity in problem solving?
- How does team composition (homogenous/heterogeneous) affect student activity in problem solving?

All participants collected data through video recordings of their own practice during lessons in mathematics. In that way all the groups received data to analyse. To be able to answer their research questions, each group first defined what constitutes student activity. This required both reading of suitable articles, that was provided by the researcher in each group, and a simple analysis of classroom films. Their own descriptions were then transformed into different set of frameworks which they used during the data analysis. For example, they looked for answers to different types of analysis questions such as "what questions are asked?", "what answers are accepted?" and "who asks the questions?".

The results of the research circles indicated that both personal accountability and heterogeneous groups increase the student activity. In particular, the results suggested that the ability to reason mathematically is affected in a positive way with high personal accountability and high heterogeneity.

Effects from the research circles

Via the research circle methodology, it was possible to observe at least three different processes that resulted in different types of effects. Firstly, an increased ability in the teachers' way to describe and analyse student activity in a more concrete and cohesive manner was observed. They were also able to give research-based examples of factors that increased student activity in different settings. The research circles have in other words had an effect on the teachers' individual competences.

Secondly, the process of seeking and partly finding an answer to research questions by investigating their own practices has given the teachers tools for improving their own practice.

Thirdly, the supervisors own process as supervisors and researchers has resulted in many questions worth reflection. How can a supervisor in a research circle increase teachers' own learning? How can a supervisor effectively supervise teachers in a research circle? What can the supervisors learn from the teachers' experience?

Together, the processes demonstrates that research circles as a research model, and as a model for teachers professional development, can increase teachers' individual competence and develop school practices as well as researchers' competence.

Wittmann, G. (University of Education Freiburg), Schuler, S. (University of Education Freiburg) — Practice-based poster related to personal dimension

Primary school teachers running in-service trainings for fellow teachers – an investigation of activities and expectations

This poster deals with primary school teachers who additionally run in-service trainings for fellow teachers in their region and reports the results of two surveys. First, we will give an insight into their professional context and the number and kind of their in-service trainings. Second, the evaluation of a course for the teacher educators retrospectively shows their expectations towards courses for teacher educators.

1. Professional context and activities of teacher educators

In Baden-Wuerttemberg (a state in the south-west of Germany), about fifty primary school teachers additionally act as in-service trainers for fellow teachers on mathematics education. A survey in November 2015 provides an insight into their professional context and the number and kind of in-service trainings (N = 37 participants). In most cases educating other teachers is only a minor part of the job. Mainly they are e.g. class teachers, headmasters or supervisors of prospective teachers. Their in-service trainings aim on pedagogical content knowledge (Baumert & Kunter, 2013), e.g. on the use of manipulatives in elementary classrooms, diagnose of poor arithmetic and prospects of support, or individualisation in mathematics classrooms. Most of the trainings are single half-day events what is seen as an inadequate condition for a meaningful learning process (cf. Korthagen, Loughran & Russell, 2006). Summarising, the survey emphasises that teachers training fellow teachers seem to be a group neglected by school government, and that the potential of the double role of being a teacher and a teacher educator is nearly unexploited.

2. Expectations towards courses for teacher educators

The project *math.expert* running since 2012 aims on the professionalisation of educators on mathematics education in primary schools in Baden-Wuerttemberg. Twice a year the educators themselves receive a training that lasts three days. In November 2015 there was a full-day training on "Measurement" as one of the big ideas for primary school mathematics. The training was evaluated by a questionnaire with open items (N = 39 participants). The evaluation shows that there is a dilemma: Some educators describe the information given (didactical knowledge about "Measurement") as very useful while others wanted to get more materials for their lessons (e.g. tasks) or their teacher trainings (e.g. students' solutions of tasks), and others wish to have more time to prepare future trainings. Obviously, the participants have different expectations which therefore cannot be satisfied at the same time. This result can be estimated as an effect of the double role – being a teacher and a teacher educator coincidentally – and shows a lack of research about this group (cf. Evan & Krainer, 2014).

9. Company Visit

Innovation in STEM educational and vocational education in the context of a large company producing sensor technology

Participation by confirmation only

Tuesday, 8 November 2016 (15:45 – 17:45 in Waldkirch). Transfer organised, meeting point: stairs of KG5 / main entrance at 2:55pm

mascil promotes science education approaches with a world-of-work context. We develop materials that allow students to experience how maths and science are applied by professionals on a day-to-day basis in ways that link to our life – to improve food safety, to manage metropolitan transport systems or to allow industry to produce individually customized products. Maths and science also have a particular role to play in vocational education, especially in the professional areas that rely heavily on the STEM subjects. mascil therefore puts emphasis on connecting maths and science education to the world of work in both general and vocational education. Cooperation with companies and first-hand contacts with the professions and industries have helped mascil to understand the needs of industry in the 21st century and transfer it to maths and science education at school.

As part of our conference we offer you the unique opportunity to visit a world-leading company in sensor technology and to enrich your experiences in the endeavour to improve STEM education with a first-hand insight into STEM education in the industrial context; to find inspiration seeing how „pure“ maths or science knowledge transforms into intelligent solutions using sensor technology; and to see which role work-based learning plays in this context vis-á-vis school-based learning and how the renowned German dual system of vocational education is implemented in this company.

Capacity is limited and <u>participation is only possible for attendees who have received a confirmation that they have a place and who have confirmed their participation!</u>

Transfer organised per bus to Sick AG (meeting point: stairs of KG5 / main entrance at 2:55pm); back transfer organised per bus to arrive in Freiburg again.

10. Early Career Researchers' Day

Satellite Workshop for the Conference on international approaches to scaling-up professional development in maths and science

Wednesday 9 November 2016, 09:00-16:00, KA 102

An increasing number of young researchers in mathematics and science education is working in the field of research on teachers' professional development. The Early Career Researchers' Day initiates communications and cooperation between young researchers across borders and disciplines. Different methods, approaches and typical research questions are presented and discussed in different formats.

Time Table

9.00-9.30	Opening and Socio-mapping of participant's project
9.30-11.00	Workshop I: Rebekka Stahnke: Qualitative methods for research on educating educators: Conducting and analyzing Interviews
11.00-11.20	Coffee break
11.20-12.50	Workshop II: Susanne Prediger: Specifying Topics for Professional Development Courses - The WHAT is equally important as the HOW
12.50-14.00	Lunch (Mensa)
14.00-15.30	Workshop III: Michael Besser: Quantitative methods for research on educating educators: Designing, conducting and analysing control trials
15.30-16.00	Open Questions

Notes