MaSDiV final conference

EDUCATING THE EDUCATORS III

ICSE

ICSE Consortium

MaSDiV

Conference Book

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

7-8 October 2019

Freiburg, Germany

Pädagogische Hochschule Freiburg
Université des Sciences de l'Education · University of Education

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MaSDiV project – Supporting mathematics and science teachers in addressing diversity and promoting fundamental values (Erasmus+ GA no 2016-2927/003-001)

DZLM Deutsches Zentrum für Lehrerbildung Mathematik

FACE Freiburg Advanced Center of Education School of Education

FACE ist eine gemeinsame Einrichtung der Albert-Ludwigs-Universität Freiburg und der Pädagogischen Hochschule Freiburg.

Contents

Preface

Dear conference guests,

Research and experience reveal that innovative teaching approaches promoted by STEM education researchers differ significantly from the day-to-day practices of teachers in many countries. This clearly implies that research on implementing teaching approaches effectively is essential in order to bridge this gap. These investigations of scaling up should be broad in scope and attend not only to the practices of teachers and researchers, but also to the practices of other important stakeholders including school principals, teacher educators, educational administrators and policy makers.

Implementing innovations in one classroom can be a challenging endeavor, and it is even more demanding across a whole school. Logically, it becomes exponentially more challenging, when the effort of scaling up an innovation aims to reach many schools, a district, or even a state or nation. Therefore, scaling up has become a concern for STEM education research during the last ten years.

Against this background, this is the third international conference specifically devoted to the topic of educating the educators in mathematics and science education, such as teachers, teacher educators, the educators of teacher educators, as well as course leaders and institutions engaged in teacher professional development. The conference thus addresses approaches to scaling up professional development in STEM education. This time, the topic is treated in particular in relation to innovative teaching approaches like inquiry-based learning, intercultural learning and connections between STEM learning and fundamental values of our democratic societies. To approach the topic from different angles and to make different stakeholders in STEM education cooperate, we placed particular emphasis on bringing together teacher educators and researchers, course leaders and relevant networks, educators of course leaders and teacher educators as well as policy makers and teacher professional development centres and chose a variety of conference formats to support a vibrant exchange.

Building on the results of the first and second conference on this topic, 'Educating the Educators III' will serve as a lever and platform for international exchange about concepts and experiences. The aim is to discuss different approaches, which ensure a high quality of the education of educators:

- **Personal dimension**: Which roles, contents and activities have to be considered in the professional development courses for PD course leaders and facilitators in professional learning?
- **Material dimension**: Which role can materials play in professional development for maths and science teachers (classroom materials, face-to-face PD materials and e-learning PD materials)?
- **Structural dimension:** How can projects or initiatives for scaling up professional development look like and how can they be evaluated?

As the Conference Chairs, we would like to thank the countless people, not least the MaSDiV project project partners and the DZLM, 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 wish you interesting insights and fruitful exchanges. Thank you very much for attending the conference.

Kind regards

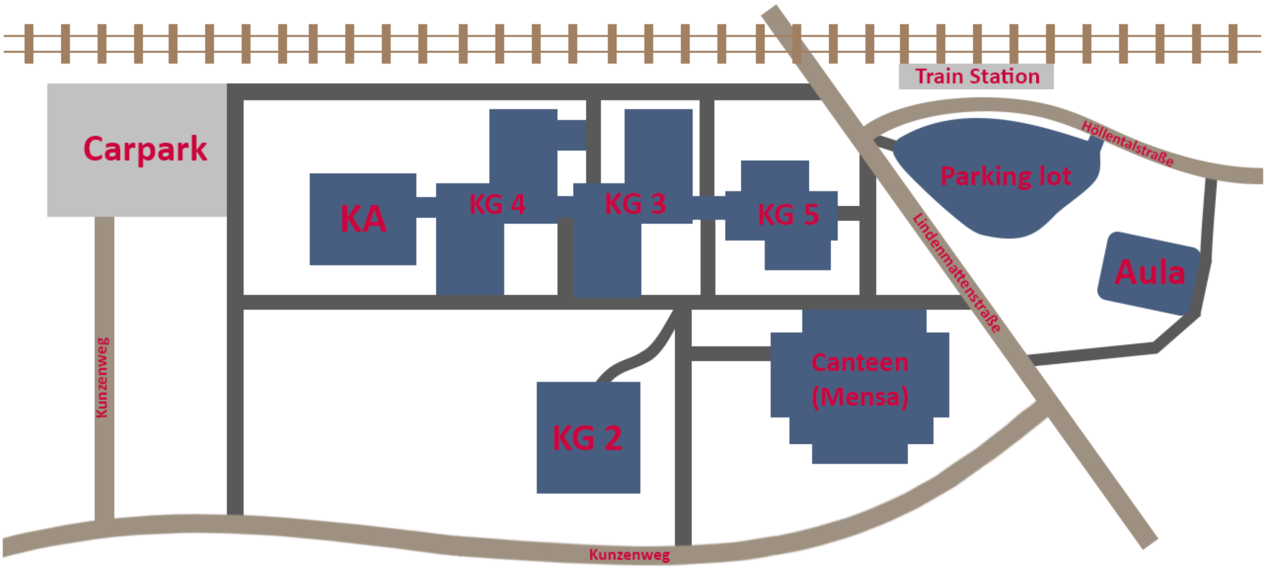
The Conference Chairs: Katja Maass, Michiel Doorman & Elena Schäfer

Location and site map

Location:

Kunzenweg 21, 79117 Freiburg im Breisgau, Germany

Site map:



Conference Overview

Aims and dimensions

This is the third international conference specifically devoted to the topic of educating the educators in mathematics and science education, such as teachers, teacher educators, the educators of teacher educators, as well as course leaders and institutions engaged in teacher professional development. The topic is treated in particular in relation to disseminating innovative teaching approaches like inquiry-based learning, intercultural learning and connections between STEM learning and fundamental values of our democratic societies. Scaling-up professional development is a specific challenge for dissemination on a large scale which involves qualifying the course leaders.

Building on the results of the first and second conference on this topic, 'Educating the Educators III' serves as a lever and platform for international exchange about concepts and experiences. The aim is to present and discuss different approaches which ensure a high quality of the education of educators:

- **Personal dimension**: Which roles, contents and activities have to be considered in the professional development courses for PD course leaders and facilitators in professional learning?
- **Material dimension**: Which role can materials play in professional development for maths and science teachers (classroom materials, face-to-face PD materials and e-learning PD materials)?
- **Structural dimension:** How can projects or initiatives for scaling up professional development look like and how can they be evaluated?

Target groups

Teacher educators and researchers, course leaders and relevant networks, educators of course leaders and teacher educators, policy makers, teacher professional development centres, maths and science education support centres, presidents and representatives of PD institutions, teacher associations and relevant networks, as well as policy makers in the field of maths and science education.

Conference formats

The conference uses both traditional and innovative formats to help bring out the specific benefit of gathering a circle of participants from research, practice and policy. Vivid exchange will be ensured by:

- discussion groups with different stakeholder groups
- workshops actively involving participants
- a materials market allowing participants to exhibit interesting professional development materials (including classroom materials) and learn about other materials.
- keynote lectures held by Kara Jackson (University of Washington), Susanne Prediger (TU Dortmund University) and Jim Ryder (University of Leeds)
- poster sessions and oral presentations in the three dimensions to report on projects, approaches and research

Particular conference features will be:

- contributions on scaling-up PD from teacher educators, teacher education researchers, teachers and course leaders, and policy makers
- a policy seminar on overcoming challenges in scaling-up teacher PD – researchers and practitioners engage in mutual exchange with policy makers
- involvement of the evolving STEM Professional Development Centre practice network

Organisational structure of the conference

Conference chairs

Katja Maaß, ICSE, University of Education Freiburg, Germany

Michiel Doorman, ICSE Consortium & Utrecht University, Netherlands

Elena Schäfer, ICSE, University of Education Freiburg, Germany

Programme committee

Digna Cousa, Autonomous University of Barcelona, Paul Drijvers, Michiel Doorman, Vincent Jonker & Monica Wijers (Utrecht University, Netherlands), Josette Farrugia, University of Malta, Konrad Krainer (Alpen-Adria University Klagenfurth, Austria), Antonio Quesada & Marta Romero Ariza (University of Jaén, Spain) and Ragnhild Lyngved Staberg (Norwegian University of Science and Technology, Norway).

Organisation committee

Christiane Fischer, Laura Wanckel, Barbara Becker, Sabine Mickler, Oliver Straser, Katharina Flößer, Dita Betere, Assiyeah Joers (ICSE, University of Education Freiburg, Germany).

Special Thanks to our Helping Hands

Jacqueline Fajkovic, Marina, Maria, (IMBF, University of Education Freiburg, Germany), Jenny, Maria, Hannah and Natascha (ICSE, University of Education Freiburg, Germany)!

Keynotes

Keynote 1: Specifying and centering equity-specific learning demands in the improvement of mathematics teaching at scale

Kara Jackson, University of Washington, United States of America
Monday, 7 October 2019, 13:45-14:30, Aula

Abstract:

Colleagues and I recently partnered for a number of years with several large educational jurisdictions in the U.S.A. to investigate and support improvements in mathematics teaching. In doing so, we generated an empirically grounded theory of action for instructional improvement at scale that includes three top-level components: a coherent instructional system for supporting teachers' improvement of their instructional practices, school leaders' practices as instructional leaders in mathematics, and educational system leaders' practices in supporting the development of school-level capacity for instructional improvement. In this talk, I will focus on the importance of ensuring that equity-specific learning demands, including perspectives and practices necessary to support a broad range of students to participate in meaningful mathematical activity, are at the core of a coherent instructional system. I will then attend to the implications of centering these learning demands in the design and implementation of systems of professional learning. I will end by highlighting what I view as especially fruitful possibilities for deepening our efforts to center issues of equity in improving instruction at scale.

Biography

Kara Jackson is an associate professor of mathematics education at the University of Washington, Seattle, USA. Her research focuses on specifying forms of practice that support a broad range of learners to participate substantially in rigorous mathematical activity and to develop productive mathematical identities, and how to support teachers to develop such forms of practice at scale (e.g., the development of systems of professional learning across role groups and contexts, the role of system leadership). She currently leads a research project aimed at developing tools, routines, and data representations that practitioners can use to engage in frequent, disciplined inquiry regarding the implementation of instructional improvement strategies in middle-grades mathematics. The project consists of research-practice partnerships with multiple school districts in the U.S. pursuing ambitious reform. She taught secondary mathematics in Vanuatu, South Pacific as a U.S. Peace Corps volunteer and was a mathematics specialist, supporting both youth and their families, for the Say Yes to Education Foundation in Philadelphia, Pennsylvania, USA.

Keynote 2: Policy to support teacher engagement with education research knowledge: Implications for scaling up professional development

Jim Ryder, University of Leeds, UK
Tuesday, 8 October 2019, 09:00-09:45, Aula

Abstract

There is a growing call for teachers to engage with education research to inform their practice. Professional development of this kind can take many forms, e.g. involvement in a university-led curriculum development project, school-based lesson study networks, teacher-led action research in schools. Such research engagement has the potential to enhance student learning and impact

positively on teacher well-being and retention. However, international surveys show that a minority of teachers say they have engaged with education research. This talk explores how engagement with education research can be developed as a powerful mode of professional development across school systems. Recent empirical studies will be used to demonstrate successful examples of research engagement as teacher professional development. I will then present a conceptualization of research engagement that sees teachers operating within an 'ecosystem' of influential factors, highlighting the role of multiple education policies, differential authority, social interaction and research mediation within school settings. Finally, this framework will be used to identify recommendations for policy and practice that can support teacher engagement with education research as effective professional development across school systems.

Biography

Jim Ryder is Professor of Science Education in the School of Education, University of Leeds, UK. His research explores the role of the teacher in improving educational outcomes for all students. He has studied teachers' experiences of education policy reforms and their engagement with education research. He has a specific interest in the context of science teaching, but his work also explores the role of the teacher in other subject areas. Most of his work has been in the context of secondary schools in England although he has also researched primary school and higher education contexts, with some international comparative studies. His work is informed by sociocultural perspectives on teachers' working lives. He is Director of the Centre for Curriculum, Pedagogy and Policy at the University of Leeds. Further details at: http://www. education.leeds.ac.uk/people/academic/ryder/

Keynote 3: Towards a research-base for supporting and Educating the Educators

Susanne Prediger, Technische Universität Dortmund, Germany

Tuesday, 8 October 2019, 16:30-17:15, Aula

Abstract

The preparation and support of PD facilitators is an educational task which requires a research-base, just as mathematics classroom education and as teacher education. The talk presents a model and a research agenda for successively developing this research base in content-specific ways that were developed within the DZLM (the German Center for research in Mathematics education). By providing examples from a big PD research project on language-responsive math teaching, the material and personal strategy (for supporting and education facilitators) and their underlying theoretical models and research needs are presented. Preliminary findings show the high complexity of facilitator expertise which can be unpacked on the facilitator level, the PD level and the classroom level.

Biography

Susanne Prediger is full professor for mathematics education research at the Institute for Development and Research in Mathematics Education at TU Dortmund University. She is an expert in secondary mathematics education research and has specialized on dealing with heterogeneity and language diversity. Her PD research activities are embedded in the DZLM, the German Center for research in Mathematics Education and comprises two international and four national, externally funded projects. Currently, she is president of the European Society for research in Mathematics Education.

Workshops

Increasing the engagement of STEM Educators through theatre methods – Personal Dimension

Brunello, Andrea, Jet Propulsion Theatre – Arditodesio Company, Trento, Italy | Physics Department University of Trento, Trento, Italy

Echard, Pierre, Jet Propulsion Theatre – Arditodesio Company, Trento, Italy

Monday, 7 October 2019, 15:00-16:00, KA 101

1. Overall description of the Workshop

We propose a one-hour interactive workshop that introduces participants to the tools of theatre as means to becoming more engaging and inspiring educators. We will help participants incorporate critical ingredients of a stage play, such as storytelling, in their lesson plan, as a way to improve structure and delivery of content.
The workshop is geared towards STEM educators of all disciplines and school levels, and its objective is to provide practical tools enabling educators to engage their students, raising their curiosity and interest in the topics they deliver.

2. Structure of the workshop

The workshop will be split in 4 segments:

Segment 1 (15 minutes). In this segment we will provide a concise introduction to the structure of the ideal story and how this can be applied to the construction of a lesson plan. We will offer a brief overview on topics like the identification of the theme, the simplified hero's journey and the importance of including questions and wonder in generating curiosity.
Segment 2 (10 minutes). Topics are pitched by participants and grouped in clusters. 4 topics are chosen among those that have been pitched.
Segment 3 (15 minutes). The participants are split up in three groups. Each group is given a topic on which to construct a 3-minute "lesson" that should incorporate the elements given in Segment 1. One of the facilitators, Andrea Brunello, will do the same with one of the topics provided in Segment 2. At the end of this segment there will be four brief 3-minute "lessons".
Segment 4 (20 minutes). Each of the three groups identifies one presenter and the 3-minute lessons are delivered in front of the audience.

Feedback and take-home information will be given to all participants.

3. Organizational issues

In order to be able to devote as much individual attention as possible, the workshop is open to a maximum of 30 people. Auditors are welcome.
The workshop will be facilitated by Andrea Brunello and Pierre Echard.

Classroom and PD materials for dealing with diversity in STEM classrooms – Material Dimension

Boerée, Claire, Utrecht University, Freudenthal Institute, Utrecht, Netherlands
Mol, Amy, Utrecht University, Freudenthal Institute, Utrecht, Netherlands
Jonker, Vincent, Utrecht University, Freudenthal Institute, Utrecht, Netherlands
Wijers, Monica, Utrecht University, Freudenthal Institute, Utrecht, Netherlands
Doorman, Michiel, Utrecht University, Freudenthal Institute, Utrecht, Netherlands
Monday, 7 October 2019, 15:00-16:00, KA 106

1. The MaSDiV project

In the MaSDiV[1] project, a EU funded project that aims to support maths and science teachers in accommodating cultural, socioeconomic and performance related diversity in their classrooms (2017-2020), by the use of inquiry-based learning, we developed both classroom materials and materials for professional development. With those materials we support teachers (and teacher trainers) to foster students' understanding of fundamental values of our society through their maths and science lessons. In MaSDiV the teacher training was evaluated in a number of European countries, and the evaluation was used to update both PD and classroom materials. In this workshop we will show the development of those materials, the design principles used, the ways in which the materials were used in both PD and classroom, and an overview of the final products.

2. The development

Professional Development for STEM has a long tradition in the Consortium group of MaSDiV with partners from Malta, Cyprus, Germany, Spain and the Netherlands (Doorman, 2014; Maass, 2011). During this three-year project we agreed on the following steps:

2017 - Design of a professional development course and evaluation tools
2018 - Partners will run the professional development courses and collect data
2019 - Evaluation of data and promotion of material

So, we started working on the PD course, and decided to develop three modules presenting inquiry-based learning (IBL): 1) as an approach for addressing achievement-related diversity; 2) in real-life, relevant contexts so as to promote fundamental values of our societies; 3) as a tool for intercultural learning. We call this three-tier approach "inclusive science education". The Dutch team from Utrecht University was responsible for the first versions of the materials, and during two Consortium Meetings with all partners we worked interactively to update and strengthen the materials.

3. The actual use

In 2018 (and also in the first half of 2019) all partners involved organised their own PD course, making use of the three MaSDiV modules. We used the following scheme (Figure 1).

[1] Supporting **Ma**thematics and **S**cience teachers in addressing **Di**versity and promoting fundamental **V**alues.

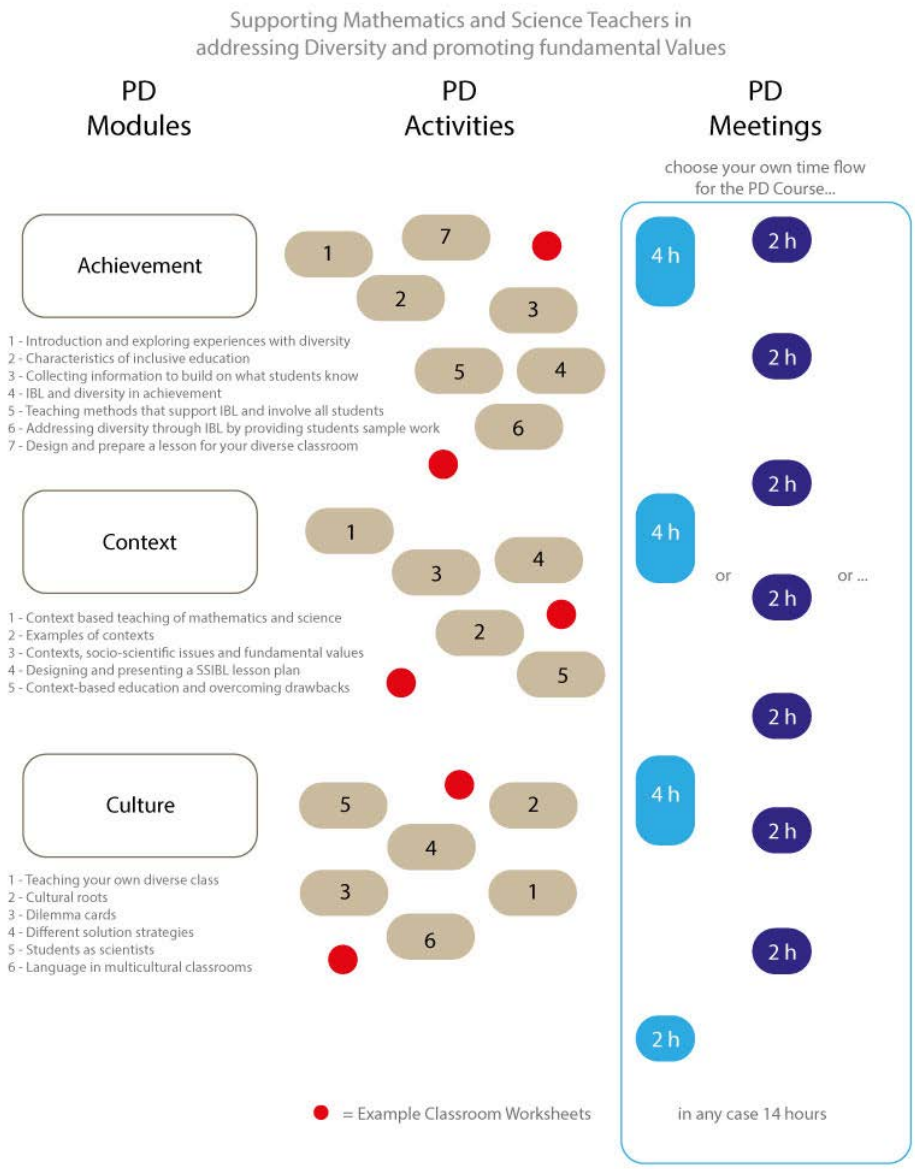


Figure 1. Overview of the MaSDiV approach (professional development and classroom materials).

In the workshop we will outline how we managed to come from design principles to the actual materials, in a setting of different European countries, dealing with different national curricula, and different approaches in teacher training.

4. Examples from PD and classroom materials

In spring 2018 we organized the PD course for the Netherlands (Figure 2), a 4-meeting approach, each meeting 2,5 hours, with a group of 18 teachers from science and mathematics.

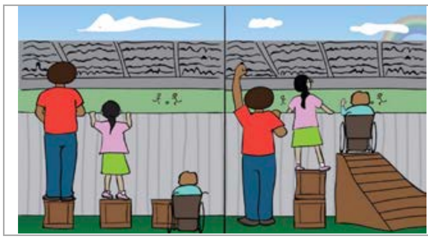
	Inclusive science education in four meetings. Introduction Diversity and achievement Diversity and contexts Diversity and culture And homework between the meetings.

Figure 2 – The MaSDiV PD Course in the Netherlands, spring 2018[2]

[2] https://elbd.sites.uu.nl/2017/05/07/masdiv/

‘Multicultural meal’ (Figure 3) is an example of an inquiry-based classroom activity, with cultural differences as a starting point for collaboration and discussion.

Figure 3 – The MaSDiV classroom activity ‘Multicultural Meal’[3]

5. Reflection and discussion

The MaSDiV designers and educators that were involved learned about how to develop a clear didactical approach for diversity in STEM lessons (in combination with rich contexts, and special attention for socio-scientific issues) in order to get a dedicated source for inclusive science education that suits the different European countries and curricula.

The teachers that were involved in the PD course were enthusiastic about this approach of inclusive science education. They reflected that they can use (parts of) the MaSDiV ideas to enrich their lessons with culture-related contexts, socio-scientific issues and make use of new teaching strategies that were used in the course.

Acknowledgements

We like to thank all Consortium Partners of MaSDiV for their actual support and contribution to both PD and classroom materials, and the European Union (Erasmus+) to make it possible.

References

Doorman, M., Fechner, S., Wijers, M. and Jonker, V. (2014). Mascil. Guidelines for teachers for developing IBST-oriented classroom materials for science and mathematics using workplace contexts. Retrieved from Utrecht: http://www.fisme.science.uu.nl/en/mascil/

Maass, K. (2011). How can teachers’ beliefs affect their professional development? ZDM, 43(4), 573-586.

A European reference framework for STEM Education

Griebel, Stephan, Business Development and Alliances Europe, Texas Instruments

Monday, 7 October 2019, 15:00-16:00, KA 209

Workshop description

A common European framework of reference is well established for languages. For STEM education nothing comparable is available. Wouldn’t it be good to have something like that? Still it is difficult to move with children from one country to another and select the best fitting school type. It’s even more difficult to apply for a job in another country as the marks don’t tell much about the actual

[3] http://www.fisme.science.uu.nl/toepassingen/28638/

qualifications. If everybody in Europe would know what – analog to languages – B2 in mathematics or A2 in biology would mean, wouldn't it immensely facilitate mobility between schools and countries? In the workshop the participants will discuss the idea of a common European framework of reference for STEM subjects. In particular we want to carve out arguments 'pro' ("Super idea, because…") and 'con' ("Dumpest idea ever, because…").

Professional development materials for preschool teachers – Material Dimension

Tirosh, Dina, Tel Aviv University, Tel Aviv, Israel
Tsamir, Pessia, Tel Aviv University, Tel Aviv, Israel
Barkai, Ruthi, Tel Aviv University, Tel Aviv, Israel | Kibbutzim College of Education, Tel Aviv, Israel
Levenson, Esther, Tel Aviv University, Tel Aviv, Israel
Monday, 7 October 2019, 16:15-17:15, KA 102

1. The need for preschool teachers' professional development

Recently, there has been increased attention to the mathematics young children learn before entering primary school, and the need to assist teachers in engaging children with mathematics. The teacher has an active and multi-faceted role in promoting children's mathematical knowledge. She must take into consideration children's past experiences and knowledge, be able to teach mathematical concepts in a variety of ways, and encourage children's mathematical reasoning, language, and communication skills. Yet, in many countries, attention to mathematics teacher education is mostly given at the elementary and secondary levels. Studies have shown that in some preschools, less than one percent of class time is spent on mathematics-related activities (Farran et al. 2007).

Taking all of the above into consideration, there is a clear need for professional development (PD) that will both promote preschool teachers' knowledge for teaching mathematics, as well as develop positive attitudes towards engaging children with mathematics. For several years, we have been providing PD for preschool teachers guided by the Cognitive Affective Mathematics Teacher Education (CAMTE) framework (e.g. Tsamir et al. 2014). Many of the materials we bring to our program are designed by us and have been implemented both with teachers and with children in preschools. In the next section, we describe tasks and materials used in our program, principles for designing these tasks, and how they were implemented in our programs. Although our focus is on preschool, these principles may be adapted for PD programs for primary, as well as secondary teachers.

2. Focusing on tasks and materials

Our PD program takes into account teachers' interest in planning and teaching lessons (Watson and Sullivan 2008), or in the case of preschool teachers, their interest in activities that can be realistically implemented in classrooms with young children. As such, we design tasks and materials that teachers can implement with children, but at the same time, we use those tasks and materials to promote teachers' knowledge of mathematical content, their knowledge of children's conceptions, as well as their knowledge of tasks. For example, when focusing on repeating patterns, we may bring two patterns (see Figure 1) and ask teachers to compare the patterns.

Figure 1. Comparing pairs of patterns

This promotes teachers' awareness of pattern structure and the unit of repeat. Then, together with the teachers, we design similar activities for children, discussing the physical materials to be used (beads, blocks, or coins), the structures of the pattern we wish to engage (AB, ABB, ABA), and the specific questions we will ask children. Teachers then implement these activities in their preschools, and we discuss results. In other words, the same materials we use in our PD program, may be used by the teachers in their preschool classrooms.

Several principles guide the design of our tasks and materials. First, the mathematical concepts and competencies we plan to promote with the materials, stem from the national curriculum. Second, the same materials may be used in a series of tasks but varied in such a way as to highlight separate competencies. For example, we differentiate between counting and enumerating skills, where counting refers to saying the number words in the proper order and enumerating refers to counting objects for the purpose of saying how many. While a task may promote more than one competency at a time, a key principle of our design is that it should be clear which of the competencies is being targeted at each point of the task. A third design principle is that the materials used be readily available to the preschool teacher and familiar to children. This allows teachers to share activities with other teachers, without concern for finding specific materials. The fourth design principle is that modularity, adjustability, and extendibility are inherent to task design and materials. For example, an enumeration task may include placing eight identical bottle caps in a row. This task can be adjusted by using a different amount of caps, or by placing the caps in a different configuration (such as in a circle with no obvious beginning or end), by varying the color of the caps, etc. By adjusting the materials (using the same coloured caps or different coloured caps), we may vary the challenge to children.

3. The aim and activities of the workshop

The aim of the workshop is to demonstrate how tasks and materials can be used to promote different aspects of teachers' knowledge, and to discuss with participants of the workshop possible affordances and constraints of the materials and task designs. The mathematical content will stem from three key domains: numbers, geometry, and patterns. In our program, we often simulate playing with children with these materials. This type of simulation allows teachers to confront, in a gentle and respectful manner, their own conceptions and serves as a springboard for a thorough discussion of common errors, promoting also their knowledge of children's conceptions. We will demonstrate such simulations during the workshop. As in our program, workshop participants will be invited to take part in these simulations, and then reflect on how such simulations may promote teachers' knowledge of mathematics, tasks, children, and teaching. Participants will be afforded opportunities to actively engage in writing their own scripts to accompany materials, and discuss how the tasks and materials, along with the scripts, may be used in PD for teachers of different aged children, allowing for possible scaling-up. For example, how may the task and materials be used if we are working with teaches of three-year-olds, as opposed to teachers of five-year-olds.

References

Farran, D.C., Lipsey, M., Watson, B., & Hurley, S. (2007). *Balance of content emphasis and child content engagement in Early Reading First program*. Paper presented at the American Educational Research Association Annual Meeting, Chicago, IL.

Tsamir, P., Tirosh, D., Levenson, E., Tabach, M., and Barkai, R. 2014. "Developing preschool teachers' knowledge of students' number conceptions", Journal of Mathematics Teacher Education, Vol 7, pp. 61-83.

Watson, A., and Sullivan, P. 2008, Teachers learning about tasks and lessons. In D. Tirosh & T. Wood (Eds.), The international handbook of mathematics teacher education (Vol. 2, pp. 109–134). Rotterdam: Sense Publishers.

Mathematics B-day: Promoting students' and teachers' inquiry and creativity – Material Dimension

Bos, Rogier, Freudenthal Institute, Universiteit Utrecht, Utrecht, Netherlands
Mol, Amy, Freudenthal Institute, Universiteit Utrecht, Utrecht, Netherlands
Monday, 7 October 2019, 16:15-17:15, KG5 104

1. Introduction

The Mathematics B-day[4] is a yearly one-day event consisting of a mathematics assignment for teams of three or four students designed by the Freudenthal Institute of Utrecht University in the Netherlands. The teams work a full day on an assignment - a very open-ended problem situation - in which mathematical inquiry, creativity and higher order thinking skills must be used to make progress and solve the problem. The result of the assignment is a report written on the day itself. In the Netherlands, Belgium (Vlaanderen), Germany and Slovakia, teams can also participate in a national competition, but this is not mandatory.

Given the success of the Mathematics B-day in the participating countries, we believe time is ripe to scale up to an implementation across the whole EU (and beyond). The ETE-III conference is a perfect platform to initiate this and investigate how it could be further devolved. We discuss what issue are involved in setting up such a nation-wide activity and what solutions where chosen in the Netherlands. There is an important role for teacher education and PD, since teachers need to learn to value and assess open-ended inquiry tasks.

2. Workshop description

In the workshop we would like to share Mathematics B-day assignments and highlight the features of the materials that promote students' IBL. We take the perspective of the design team (consisting of mathematicians, mathematics educators and other mathematics professionals) to explain which are the ideas and principles underlying the design. Using sample student work, we illustrate what results from students can be expected.

From the perspective of the organizing countries we explain what it takes to implement the full day task nation-wide and how the competitive element, including the assessment, can be organized. Since the materials are to a large extent self-explanatory, they have a large potential for scaling-up. The materials have already been adapted effortlessly to the situation in various schools in different countries.

The goal is not just to implement the use in schools, but also in mathematics teacher education. In the workshop we present *good practice* examples of this implementation for PD in Slovakia (Bulková & Ceretkova, 2019) and the Netherlands.

3. Organization of the workshop

In the workshop we intertwine the following activities: Studying and working on mathematics B-day materials in small groups, whole-group discussions on the emerging issues, and presentations by workshop leaders on background, ideas and experiences, in particular in use of the mathematics B-day in PD in the Netherlands and Slovakia. The topics are: acquaintance with the mathematics B-day assignments, IBL-design principles and ideas underlying the assignments; and issues concerning the implementation in schools and in teacher education across the EU.

References

[4] https://www.uu.nl/en/education/mathematics-b-day

Bulková, Kristína & Ceretkova, Sona. (2019). Zig-Zag functions in mathematical open ended problems for functional thinking development. *To be published in conference proceedings for APLIMAT 2019*.

Doorman, L.M., Drijvers, P.H.M., Dekker, G.H., van den Heuvel-Panhuizen, M.H.A.M, de Lange, J. & Wijers, M.M. (2007). Problem solving as a challenge for mathematics education in The Netherlands. *Zentralblatt für Didaktik der Mathematik*, 39 (5-6), (pp. 405-418)

From PD to Classroom Instruction: The Journey of Innovative Curricular Materials – Material Dimension

Magner, Jodelle, State University of New York – Buffalo State, Buffalo, NY, United States
McMillen, Susan, State University of New York – Buffalo State, Buffalo, NY, United States
Monday, 7 October 2019, 17:15-18:15, KG5 104

1. Introduction

Our work with Mathematics Science Partnership [MSP] grants over the past 14 years strongly aligns with the theme of the conference, "Educating the Educators III: International Conference on approaches to scaling-up professional development in maths and science education." Working closely with over 500 mathematics teachers, coaches and administrators has afforded opportunities for individual educators to deepen their own mathematics content knowledge, develop their pedagogical skills and further develop their content knowledge for teaching mathematics.

Our MSP grant PD incorporated the following characteristics of effective professional development for teachers: content focused, incorporated active learning, supported collaboration, used models of effect practice, offered feedback and reflection, and was of sustained duration (Darling-Hammond, Hyler and Gardner, 2017). Most cycles of the MSP grants were of a three-year duration and had professional development sessions each month of the school year. Participants had the opportunities to engage with concepts multiple times and work with others to focus their own learning and then to work with their students with similar concepts and activities. Materials used not only addressed what content the teachers were to cover with their students, but also how the material was to be presented was highlighted. As innovative ways to teach for understanding are being incorporated into curriculum, sometimes teachers need support in understanding the subtle points of the materials. Many sessions were designed to immerse the teachers into activities they would use with their students.

2. Perspective

This session will target teacher educators, course leaders, educators of course leaders, teacher professional development centres, and maths and science education support centres. One theme throughout the cycles of professional development was using innovative models to teach mathematics. Some models were new to teachers, so we engaged them as learners to learn the content, make connections, and develop an appreciation for the usefulness of the models. Throughout this MSP project the focus was to implement a longitudinal approach to educate the educators and support them as they integrated new models and materials into their classrooms.

3. How it relates to one of the Conference Topics

This workshop aligns with Topic 2: The Material Dimension. The workshop will engage the participants in work with an innovative use of a mathematical model and demonstrate its usefulness in many content areas of mathematics. Workshop participants will experience the use of the model

in a variety of problem-solving contexts. Obstacles to teachers adopting these materials to use within their instruction and strategies used to overcome these challenges will be shared.

4. Which of the questions (exemplarily), raised in the topic descriptions will you address?

Some of the exemplar questions that will be addressed in the presentation include:

- What are the quality criteria for the design of materials for classrooms and/or PD? What are the features of materials for classrooms and/or PD that are suitable for promoting IBL
- Which factors promote or impede the implementation of innovative materials in practice?
- What has to be explained in particular in PD Materials and how do course leaders adapt materials?

Many of these questions will be discussed when both the planning for working with mathematics teachers is being described as well as, at the end of the workshop when the group will brainstorm how this would be useful for their work.

5. Description of the format to be used

We intend to make use of a 60-minute workshop. This will allow us to present a brief history of our project, those involved and some of the types of materials created. Next, participants of the session will be engaged in work with an innovative use of a mathematical model. Workshop participants will experience the use of this model in a variety of problem-solving contexts. Strategies for successful implementation of innovative mathematics models will be shared. The session will close with a discussion addressing benefits and obstacles to adopting these materials for use in classrooms. All participants will be encouraged to share their experiences of sharing innovative models to PD participants.

Acknowledgements

We would like to acknowledge the New York State Title II, Part B MSP: Mathematics and Science Partnership Grants. This funded the work that was done and supplied funds to purchase materials for the teachers to use with their students.

References

Darling-Hammond, L., M. Hyler and M. Gardner, 2017, *Effective Teacher Professional Development*. Available at: https://learningpolicyinstitute.org/sites/default/files/productfiles/Effective_Teacher_Professional_Development_REPORT.pdf (Accessed 3 March 2019).

Huinker, D. & V. Bill, (2017). *Taking action: Implementing effective mathematics teaching practices in K-grade 5*. Reston, VA: National Council of Teachers of Mathematics.

NCTM, National Council of Teachers of Mathematics, (2014). *Principles to actions: ensuring mathematical success for all.* Reston, VA.

Steele, M., M. Raith, & M. Smith, (2017). *Taking action: Implementing effective mathematics teaching practices in grades 6-8*. Reston, VA: National Council of Teachers of Mathematics.

The language of graphs and tables. Language-oriented mathematics teaching in professionally oriented contexts – Material Dimension

Wijers, Monica, Utrecht University, Utrecht, Netherlands
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Tuesday, 8 October 2019, 10:00-11:00, KA 102

1. The Lamavoc project

The aim of the Lamavoc[5] project (a EU funded project) is developing a teaching approach and respective teaching units for workplace-related and language-integrated mathematics learning on the mathematical topics fields of percentages, proportional reasoning and graphs/tables for vocational classes in the technical and agricultural sector. In this workshop we will focus on the topic 'graphs/tables in professionally oriented contexts'.

Students in (pre)vocational education have difficulties in learning and understanding mathematics. Especially in the lower levels of vocational education students are low achievers in the area of mathematics. This is a problem for both the school career and the skills needed for specific professions (Prediger and Wessel, 2013). One of the reasons why students have difficulties in understanding mathematics is the role of language. In vocational education the mathematics is used in an applied setting, and that means that the context is important, and that language plays an important role for understanding the situation.

Three countries are involved in this Lamavoc project (Germany, Sweden, the Netherlands), where teacher trainers, teachers and researchers from vocational education work together in a three-year project (2018-2020) to develop materials for (applied) mathematics with dedicated support for the role of language. In the workshop we will show and discuss first findings from this project.

2. The PD approach of Lamavoc

The unit 'language of graphs and tables' is one of the Lamavoc teaching units. In the workshop we will show the content of this unit. We start with the general Lamavoc professional development principles:

- Teachers work through the same material as the students
- Interacting with colleagues
- Teach as you preach
- Related to the teaching practice and the curriculum
- Concern based & Flexible
- Combine with learning-on-the-job at school

We will show how those principles have been used to develop the teaching unit and the according ideas for training. At the moment (school year 2018-2019) we are finalizing this teaching unit, and this unit is used in the three countries involved. Alongside we have developed a corresponding PD course of two meetings:

- Meeting 1 – Noticing and demanding language
    - Teachers exchange experiences
    - Examples of student work/behaviour
    - Relevance of academic language
    - Analyzing tasks / Predicting student difficulties
- Meeting 2 – Supporting language
    - Analyzing student work
    - Scaffolding

[5] **La**nguage for **Ma**themtics in **Vo**cational **C**ontexts

o Language goals -> in your own lessons.

In the workshop we will reflect on this professional development, by using the experiences from the three countries involved.

3. The role of language in vocational contexts

In vocational education we see lots of tables used in professionally oriented contexts. Reading tables and understanding what data is showed and understanding the relation between rows and columns is an important first step, where language plays an extremely important role. Let's have a look at an example from the teaching unit (Figure 1).

Look at the table below.

crop	germinating temperature (ºC)		
	minimum	optimum	maximum
cichory	5	25	30
root beans	10	14	30
beets	3	20	28
turnip cabbage	5	20-25	29
corn	8	30	40
peas	1	12-16	40

Discuss and answer the following questions together:

- Describe the meaning of the following words from the table:
  - Crop
  - Germinating temperature
  - Minimum
  - Optimum
  - Maximum
- What does this table give information about?
- In what kind of situation can you use this table?
- Come up with a fitting (short) title for this table.

In this example, taken from an agricultural context, a table is shown, and it is essential that students/workers understand the meaning of the words.

The questions below the table are used to activate the role of language. You can see the words 'discuss' and 'describe', those activities are sometimes not very common in a mathematics lesson but are essential for understanding the context.

Figure 1. An example from the Lamavoc teaching unit Graphs and Tables

4. Reflection and discussion

We will share first experiences and thoughts on this approach, talking about the European dimension of this work (differences in vocational systems, etc.).

Acknowledgements

We like to thank all Consortium Partners of Lamavoc project for their actual support and contribution to both PD and classroom materials, and the European Union (Erasmus+) to make it possible.

References

Prediger, S. and Wessel, L. (2013). Fostering German-language learners' constructions of meanings for fractions—design and effects of a language- and mathematics-integrated intervention. Mathematics Education Research Journal, 25, 435–456. doi:10.1007/s13394-013-0079-2.

SIA - student - engineer – academy – Personal Dimension

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Tuesday, 8 October 2019, 10:00-11:00, KA 106

1. Objectives of the SIA - student - engineer – academy

The objective of the Student Engineering Academy (SIA) is to promote the attractiveness of studying natural sciences, technology, electronics, information technology and similar fields of study.

The SIA supports the career choice process with regard to science and technology by giving students a practical test and intensive support of scientific abilities. The SIA promotes science-interested and gifted pupils. The project structure strengthens and develops the social skills and key qualifications. Due to the close cooperation of the universities, companies and schools, the SIA grants immediate insights into science and technology courses and the engineering profession, thereby optimizing the professional and study orientation of the participants. In practice-oriented project work, they get to know the tasks of engineers and get an insight into the various fields of working environments.

Within the framework of gender mainstreaming, the SIA wants to particularly interest female participants in the natural sciences and support them to take up engineering courses.

1.1 Target group and implementation into formal education

The SIA is a voluntary offer and is aimed at technically interested and curious students of the level 1 (11. Klassenstufe) of the upper secondary level, which are currently in the vocational orientation and career development phase. No special technical knowledge is required to participate, so the offer is open to all students.

The participation in the SIA is considered as a seminar course and thus flows into the Abitur grade. Each of the participants selects a topic from the SIA semester plan and compiles a seminar paper according to scientific criteria. The topic should be brought into a socio-scientific context. In a colloquium, the topic will be presented to a commission of teachers. The commission evaluates the presentation; the accompanying teacher grades the written work. From this an overall grade is formed.

1.2 Schedule

The SIA is designed for a duration of two semesters. The modules take place in the afternoons on a fixed date outside regular school hours (not during school holidays). By signing, the students assure a binding participation. You have the obligation to participate in all events offered, or to apologize if you cannot attend the event.

At the beginning of the SIA, each participating student receives a project folder that contains all the information about the project, such as the semester or project plan, contact details of contact persons, required worksheets, etc. The content of the project and its learning progress are documented by the participating students for each event in the dedicated documentation. During the duration of the project, the project manager checks the sample documents written by the students and teachers of the respective schools evaluate the written protocols.

The SIAs Freiburg I-IV is considered as a seminar course, so the grading is included in the high school diploma in the following school year. The final grade consists of the regular participation in the SIA, a written elaboration of a self-chosen topic and a final oral exam at the end of the SIA year. The evaluation is done by the supervising teachers.

Evaluation is done with a: Final survey of cooperation partners. b: Participants questionnaire & c: Final report.

2. Participants

The accompanying SIA teachers introduced the SIA in the relevant classes and were supported by the students of the previous "SIA Year" at the presentation. The project is also presented in the information sessions for the seminar course choice of the respective school.

Interested students undergo an application process, which is carried out by the secondary schools. Here, in particular, female pupils are motivated by a personal conversation and supported to participate.

3. In depth insight

The practice phase in the companies spanned three whole days in different companies like SICK AG, TDK Micronas, Northrop Grumman Litef and others.

The SIA Hochschwarzwald visited Furtwangen University on several afternoons and gained fundamental insights into project management and electrical engineering.

Examples of the project work in the company KNF Neuberger GmbH Freiburg, production and distribution of pumps. As a task, the student group was simulated a customer request. Based on this request, students should design, build and sell a pump. Under the guidance of mechanical engineers, the students were first taught the operation of a gas-based pump. With a small experimental setup, the students were able to experiment under which conditions the pump will perform better. Questions or tasks are for example: Should the vacuum in the pump be reduced yes or no? Or should the pressure be increased yes or no? After an introduction to programming with a CAD program, the students developed their own pump. Finally, the pump was evaluated according to business criteria, whether it meets the customer requirements and is economical.

Transforming Traditional Classroom into an Escape Room Classroom – Material Dimension

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Tuesday, 8 October 2019, 14:00-15:00, KA 102

1. Introduction. Game-based learning approach in chemistry teaching

Game-based learning (Burguillo 2010, Pivec and Dziabenko 2004) can be introduced among students as a method that helps them to make a connection between the previously acquired knowledge and the one learned from playing the game. Games will serve as a pedagogical tool in the school teaching practice only if they are well-designed and include relevant content. In this way they are aimed to develop higher-level thinking skills and inquiring and problem-solving skills, but also skills important in their further life such as team work and self-confidence. The escape room design is complex, but its popularity grows each day. Escape rooms are games that require a completion of several tasks or challenges to win. They are used in many areas, including education, and are considered as an innovative teaching method. Dietrich (2018) found out that this method develops team building (96% of students), increases motivation (93%) and communication (90%), but also students experience a flow of time (Peleg et. al. 2019).

Learning is active, not passive process. As the well-known saying states "Tell me – I will forget, show me – I will remember, including me – I will understand", students need to be engaged in the classroom activities and actively participate in the teaching and learning process. This method can be applied during the various types of lessons, from introduction of a new teaching unit to a formative assessment. Still, the greatest benefit is increasing the interest of students and developing a positive attitude towards the chemistry (or another subject).

The role of the teacher is crucial in designing the game-based activities and promoting discussion among students which will lead to clarification and correction of potential misunderstandings and

misconceptions. Therefore, it is of utmost importance to pay attention to educating pre-service and in-service teachers on the application of this method in teaching.

2. The escape room materials for hands-on classroom activities

2019 has been proclaimed the "International Year of the Periodic Table of Chemical Elements" by the United Nations General Assembly and UNESCO, thus games and puzzles in this workshop are related to the Periodic Table concepts. Some of the games are: Coded Message, Hidden Words, Chemistry Competition, Cool Chemistry Coffee Receipt, and Reversed Text. The suggested escape room classroom is one way to effectively master the curriculum, which also enables the active involvement of all students and the "revival" of the lessons. In the same time, the costs for these activities are minimal and materials can be reused. It is very important for teachers from developing countries since one of the biggest problems when it comes to chemistry teaching is the equipping of specialized cabinets and laboratories in schools. Learning chemistry without laboratory equipment and visual means for experimental work is like learning to ride a bicycle without a bicycle! As an educator, I can offer only a few examples of how to "revival" the lessons, and the teachers will adapt to the needs and conditions in their classroom using their creativity. In this way, the lack of conditions for laboratory work will be compensated at least, and at the same time this approach will have a positive effect on the students in terms of acquiring knowledge and skills.

In a typical escape room workshop, the participants are in one room and try to solve the puzzles to escape, or to open the award locked in the box. Specifically, these puzzles are designed to be used among primary and secondary school students. The initial idea was to introduce this escape room approach to chemistry teachers and get insight into their perceptions and opinions about the applicability of this method in their classrooms since it is not very familiar in North Macedonia. This was done during the seminars for chemistry teachers in 2019 and their response was very positive. In fact, they were fascinated what they can do with their students and were impressed by the fact that students will have fun and learn at the same time. Once the teachers accept the idea for creating an escape room in the classroom, they can use their own creativity to adapt the existent or create completely new puzzles that fits into the curriculum. They can use locks and boxes or ask students to send the correct code (the solution of the puzzle) via google form.

3. The relevance of the escape room scenarios on the professional development

The escape room offered for this workshop is based on an open path design, which means that puzzles can be solved without a particular order, still all puzzles have to be completed by the group to win. This is especially beneficial and addresses the diversity in class as it gives an opportunity every student to find a suitable puzzle to solve according to his/her interest and skills and, in that way, to contribute to the success of the group. Thus, designing an escape room in the classroom can be a great team experience and can be appropriate for any topic, any school subject and any age level. Therefore, it makes this approach suitable for professional development of teachers regardless of the teaching subject. To be successful in this approach, teachers must pay attention to the limited lesson time, preparation time and students' competitiveness. In North Macedonia there are 40-minutes lessons in primary and 45-minutes lessons in secondary schools and within this time teachers should carry out the escape room activity, followed by discussion, so the students can get an opportunity to share their experience and dilemmas about different aspects of the game. The preparation time for the puzzles could be longer, but once prepared they can be used in different school settings. Competitiveness among the groups can increase the excitement, but it must be taken into an account that cooperation is more important than competitiveness and that the winning the game is not the most important goal.

Teachers and the teaching profession have a key role in society. One of the key factors for quality student education is the teacher. Teachers need to know *what* to teach and *what* the students should know at the end of the lesson, but also *how* to transfer the teaching content to acquire

permanent conceptual knowledge. The quality of the lesson depends largely on the teacher and on his/her preparation, creativity, organizational skills and "pedagogical mastery". In order to achieve this, they need solid initial education and continuous professional development that begins on the first day and ends the last day of the teacher's working career. The ultimate goal of this lifelong learning process is acquiring, broaden and deepening the knowledge and skills that will help teachers in school and out-of-school activities, as well as easier facing the educational reforms. In addition, the development of science and technology, as well as the development of teaching methods, leads to the fact that today pre-service students are being taught in a different way from a few decades ago, so the self-education and improvement of the teaching practice is necessary.

Acknowledgements

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References

Burguillo J. C., 2010, "Using game-theory and competition-based learning to stimulate student motivation and performance", Comput Educ, Vol. 55, pp. 566−575.

Dietrich N., 2018, "Escape Classroom: The Leblanc Process – An Educational "Escape Game"". J. Chem. Educ., Vol. 95, pp. 996−999.

Peleg, R., M. Yayon, D. Katchevich, M. Moria-Shipony and R. Blonder, 2019, "A Lab-Based Chemical Escape Room: Educational, Mobile, and Fun!", J. Chem. Educ., in publication.

Pivec M., O. Dziabenko, 2004, "Game-based learning in universities and lifelong learning: "UniGame: social skills and knowledge training" game concept", J Univers Comput Sci, Vol. 10, pp. 14−26.

No escape: the basics and the possibilities for educators of the bottom-up phenomenon 'escape rooms' in education – Material Dimension

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Tuesday, 8 October 2019, 14:00-15:00, KA 101

1. Abstract

Commercial escape rooms have inspired teachers to adapt the popular entertainment activity for education, especially in STEM education. This global bottom-up phenomenon in education is implemented in various ways. Students use their knowledge and skills either to solve problems and "escape" the room, or built an escape room themselves. The implementation of escape rooms in educations has been scaled up by teachers, without institutes for teacher education or professional development. This workshop will start to bridge the knowledge gap for educators. The workshop gives educators an experience with an educational escape room. Subsequently, the participants experiences will be related to research on the experiences of students and teachers in secondary education and higher education with educational escape rooms. The workshops closes with a summary of possibilities and pitfalls of the use of educational escape rooms.

2. The rise of escape rooms in education

Globally, escape rooms have been finding their way into education, especially in STEM education. (Breakout EDU, 2018; De Groot, 2017). Escape rooms are live-action team-based games in which

players encounter challenges in order to complete a quest in a limited amount of time. The quests in the first rooms were ‘escapes’, nowadays the quest varies, for example to solve a murder mystery or break into a vault (Nicolson, 2015). The phenomenon has risen to immense global popularity in the entertainment industry. Implemented by enthusiastic teachers, escape rooms are gaining popularity as teaching and learning environments in higher, secondary and primary education (Breakout EDU, 2018; De Groot, 2017). For secondary education, teachers can share their materials on platforms such as Breakout EDU (Breakout EDU, 2018).

3. An escape room design

Within an escape room, all problems or activities are called puzzles. As escape rooms are inherently team-based games, the puzzles tend to ensure that every member of a team is active and can contribute (Nicholson, 2015). The puzzles, which can be categorized as: 1) cognitive puzzles that make use of the players’ thinking skills and logic, 2) physical puzzles that require the manipulation of artifacts to overcome a challenge, and 3) a meta-puzzle, the last puzzle in the game in which the final solution is derived from the results from the previous puzzles (Weimker,. Elumir & Clare 2015). Cognitive puzzles seem to predominate in escape rooms (Nicholson, 2015). To solve the puzzles, players require skills such as searching, observation, correlation, memorization, (logic) reasoning, math, reading and pattern recognition (Wiemker et al., 2015). After the gameplay, the gamemaster debriefs the players on the process and what they have achieved (Nicholson, 2015). Given the list of skills required and the reflection on the achievements, it is no surprise that escape rooms expand into new areas such as education.

4. Ways in which escape rooms can be used in education

Usually, escape rooms are implemented in two ways; teams of students use their knowledge and skills, either to solve the escape room or develop one while using their knowledge and skills. Dozens of articles with pilot studies in higher and secondary education suggest that teachers and students are satisfied with the educational goals reached. (e.g. Ma, Chuang, & Lin, 2018; Veldkamp, Knippels & Joolingen, 2019, *submitted*). In a project, we combined these two ways of implementing in order to interest bachelor students in STEM teacher education or educational developer. The students developed an escape room in the form of a puzzle box for kids on Science Day (see fig.2). In a follow up, students develop new escape rooms for whole classes in secondary education and will guide the games at school. In the workshop, one of the games can be played and results of this project shown.

Figure 1. One of the student developers of the puzzle box monitoring the pupils during the game on National Science Day 2018).

References

Breakout EDU. (2018, June 22). http://www.breakoutedu.com/

De Groot, A. (2017, January). Lerarenontwikkelfonds initiatieven; Escape the classroom 2.0. Retrieved from http://lerarenontwikkelfonds.onderwijscooperatie.nl/initiatief/escape-the-classroom-2-0/.

Ma, J. P., Chuang, M. H., & Lin, R. (2018). An Innovated Design of Escape Room Game Box Through Integrating STEAM Education and PBL Principle. In *International Conference on Cross-Cultural Design* (pp. 70-79). Springer, Cham.

Nicholson, S. (2015). Peeking behind the locked door: A survey of escape room facilities. Retrieved on 14 2, 2017, from http://scottnicholson.com/pubs/erfacwhite.pdf.

Veldkamp, A., Knippels, M.P.J. & van Joolingen, W.J. (2019). Escape rooms in secondary science education: teachers' and students' perceptions of the educational potential (submitted).

Wiemker, M., Elumir, E., & Clare, A. (2015). Escape room games: "Can you transform an unpleasant situation into a pleasant one?" In J. Haag, J, Weißenböck, M.W. Gruber, M. Christian, & F. Freisleben-Teutscher (Eds.), Game based learning, (pp. 55-68). St. Pölten: Austria: Fachhochschule st Pölten GmbH.

Discussion Group

Exploring Issues Related to Increasing CPD Leaders' Responsibility for Professional Learning – Personal Dimension

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Tuesday, 8 October 2019, 14:00-15:00, KA 106

1. Introduction

The Discussion Group (DG) aims to reflect on the question: *How do CPD leaders react to a training model that places greater responsibilities for professional learning on participants, and how effective is this model?* We plan to do this by engaging with theory, by offering participants the opportunity to analyse a 'case' in small groups, by presenting results from the 'Supporting Mathematics and Science Teachers in addressing Diversity and promoting fundamental Values' (MaSDiV) training programme for CPD leaders in Malta, and finally by offering space for whole group discussion intended to shed light on the above question.

2. The Theoretical Framework

A number of models can be used to design CPD programmes for educators. Kennedy (2014) refers to 9 models which she organises into 3 categories – transmission (i.e., learning based on transmission of knowledge by 'experts'), transitional (i.e., learning based on 'participants' working under the guidance of 'experts') and transformative (i.e., learning based on 'experts' and 'participants' co-creating learning). Moving from the transmission category through the transitional to the transformative category increases the level of autonomy and responsibility of participants. Moreover, while the relationship between 'experts' and 'participants' is top-down in the transmission category, some collegiality is introduced in the transitional category to make this relationship more equitable and less threatening. On the other hand, the relationship in the transformative category is collegial and non-threatening, with mutual support developing through ongoing negotiations of own practices informed by inquiry. The focus on inquiry in the transformative category renders the 'community of practice', which is normally associated with the transitional category, as a 'community of learners' in which members operate within cycles of learning, development and improvement. The emphasis here is on educators engaging in 'professional learning', as different from 'professional development', in order to create knowledge that leads to change (see Easton, 2008). While this notion of members of a community acting as inquirers is not emphasised in the transitional category, it is completely alien to the transmission category.

3. The MaSDiV Training Programme for CPD Leaders in Malta

As part of implementing the MaSDiV project in Malta, the first 3 authors organised a six-month CPD programme. This consisted of monthly face-to-face sessions, online and independent learning. Using MaSDiV teaching materials, the idea was to promote inquiry-based learning (IBL) in mathematics and science classrooms as a basis to position learning within real-life contexts and to support learning that is sensitive to cultural differences. This programme, spread over 3 modules, targeted mathematics and science educators that were willing to lead 'communities of learners' in schools for the duration of their training. This cascade CPD model (see Maaß, 2018) thus sought to train a number of CPD leaders while ensuring that this training was reaching in parallel a much larger number of mathematics and science teachers in schools. Drawing on social constructivist and socio-cultural theories of learning, the programme for CPD leaders was designed to encourage participants

to discuss pedagogical issues and engage reflectively about practice within a learning community led by three ‘facilitators’. Linked to this, the CPD programme drew on the transformative model of CPD rather than the transmission and transitional models. Being a credited university programme, the participants were asked to submit a portfolio with exemplars of project-related work and to participate in an online forum that was meant to offer opportunities for the sharing of practices and experiences as they worked with teachers in schools.

4. The Main Findings of the MaSDiV Training Programme for CPD Leaders in Malta

Through the online discussion forum, some CPD leaders (5 of the 27 taking this course) lamented about the transformative approach adopted by the university facilitators. In particular, they criticised the lack of classroom materials available and the co-learning approach adopted in which they had to assume responsibility for decision-making. These CPD leaders, and eventually a couple of others, also requested links to other online materials they could offer to their teachers. Rather than having sessions structured around discussion of materials and approaches to select and design the CPD materials to use with teachers, they preferred to be guided and told which activities to use and how to implement these with teachers. An emerging issue for CPD leaders, particularly at the beginning, was that the course was putting much effort on them and additionally expecting them to take a lead when they were still being ‘trained’. For these CPD leaders the sudden shift of responsibility, from a transmission format of CPD to a more transformative one (see Kennedy, 2014), offered challenges and they explicitly communicated their frustrations – particularly that of feeling uncomfortable facing teachers when they were still learning about IBL. Possibly because of their perceived limited knowledge of IBL and their prior transmission-oriented learning experiences, these CPD leaders expected to be provided with more guidance and tried-and-tested materials – tasks and lesson plans – that they could offer to teachers.

5. Proposed Structure of the Discussion Group Session

We are proposing to structure the one-hour discussion session as follows:

1. Presentation introduces ‘theory’ related to different forms of CPD and how participants react to increased responsibilities for their professional learning (10 min).
2. DG attendees are given a ‘task’ to be analysed in small groups. A member from each small group reports back to whole group (20 min).
3. Presentation on the ‘Malta MaSDiV results’ related to CPD leaders’ reaction to training that involves greater responsibilities for one’s professional learning (15 min).
4. Whole group discussion on the question identified in the ‘Introduction’ (15 min).

References

Easton, L.B. (2008) From professional development to professional learning. *Phi Delta Kappan*, *89*(10), 755–759.

Kennedy, A. (2014) Models of continuing professional development: A framework for analysis. *Professional Development in Education*, *40*(3), 336–351.

Maaß, K. (2018) Scaling up innovative teaching approaches in mathematics: Supporting teachers to take up a new role as professional development course leaders for inquiry-based learning. *Journal of Education and Training Studies*, *6*(7), 1–16.

Paper Presentations

Changes in educational science research competencies among teachers in further education – Personal Dimension

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Kittel, Daniel, University of Education Freiburg, Freiburg, Germany
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Monday, 7 October 2019, 16:15-16:40, KA 101

1. Theoretical Background

Teachers are increasingly required to back up their teaching activities with scientific evidence (Weber & Achtenhagen, 2009, p. 477).This means that they should be able to pose meaningful questions, search for relevant information, read and critically appraise evidence, evaluate and apply the resulting conclusions to their educational needs and environments (Davies, 1999). Shank and Brown (2007) describe corresponding competencies as Educational Research Literacy. A condition for Educational Research Literacy is the critical reflection of research literature in order to derive consequences for one's teaching practice. However, there is evidence that teachers seldom have a solid understanding of basic statistics (Peek, 2006, p. 1354), but need to consider underlying conceptual models in order to use data for lesson or school development (Groß Ophoff, 2013).

2. Research Question

Learning opportunities in further education seem to be a promising way to convey the required competencies to practicing teachers. Therefore, the aim of this paper is to investigate, whether and to what extent Educational Research Literacy of teachers can be improved by a part-time master's degree program.

3. Study Design and Method

The postgraduate master's course in Teaching and School Development at the University of Education Freiburg, Germany, was evaluated over the course of two years in a mixed-methods-design. The sample consists of 16 teachers (11 female, 5 males; mean age = 44; mean teacher work experience = 12 years) and covered the full cohort of students that run through the four-semester study program.

On the one hand, a standardized competence test (Groß Ophoff et al., 2017) was used in a pre-post-test design to assess changes in the Educational Research Literacy competence facets Information Literacy, Statistical Literacy and Evidence-Based Reasoning. On the other hand, nine of the teachers were interviewed extensively at the beginning, in the middle and at the end of their studies.

Based on the results of the standardization study (multi-dimensional Item-Response modelling, see Groß Ophoff et al., 2017), person measures (Plausible Values) were computed from anchored item difficulty estimates. Due to the small number of cases in the sample, the longitudinal development was analysed with Wilcoxon rank tests. The qualitative interviews were evaluated with the structured content analysis.

4. Results

Across the course of two years, the teachers' Information Literacy and Evidence Based Reasoning improved significantly from a rather low to an intermediate proficiency level. In both competence facets, the competence gain, can be classified as a major effect according to Cohen (1992). For Statistical Literacy, in contrast, no significant development could be determined.

Within the interviews the vast majority of the nine students stated that they had benefited in their research competencies from taking part in the study program. They described severe initial difficulties in developing an academic, research-led approach, when working on a problem and that it had been an obstacle for them to evaluate the meaning of empirical findings. At the end of the study program they reported competence gains, especially concerning their knowledge about research methods and statistics as well as their ability to work scientifically.

5. Discussion

The results show that even with a comparatively high-qualified group of teachers, a substantial increase in competencies can be achieved within a postgraduate program, especially in Information Literacy and Evidence-Based Reasoning. These findings are underpinned by the qualitative-methodological results, which show that the teachers perceived their deficits as well as their learning gains in Educational Research Literacy during their studies.

Overall, the results presented in this paper indicate, that the teachers were not or not sufficiently trained during their studies to adequately search for and understand research-based information. This is a clear call for putting a higher emphasis on Educational Research Literacy in study programs for becoming teachers as well as for in service trainings and advanced training opportunities for teachers. Across the course of two years, the teachers' Information Literacy and Evidence Based Reasoning improved significantly from a rather low to an intermediate proficiency level. In both competence facets, the competence gain, can be classified as a major effect according to Cohen (1992). For Statistical Literacy, in contrast, no significant development could be determined.

References

Cohen, J., 1992, "A power primer", Psychological Bulletin, 112(1), 155–159.

Davies, P., 1999, "What is Evidence-based Education?", British Journal of Educational Studies, 47(2), 108–121.

Groß Ophoff, J., 2013, „Lernstandserhebungen: Reflexion und Nutzung", Münster: Waxmann.

Groß Ophoff, J., Wolf, R., Schladitz, S., & Wirtz, M., 2017, "Assessment of Educational Research Literacy in higher education.", Journal for Educational Research Online, 35–66.

Peek, R., 2006, „Dateninduzierte Schulentwicklung", in H. Buchen (ed.), Professionswissen Schulleitung (S. 1343-1366). Weinheim: Beltz.

Shank, G. & Brown, L., 2007, "Exploring Educational Research Literacy", Routledge Taylor & Francis Group: London

Weber, S., & Achtenhagen, F., 2009, „Forschungs- und evidenzbasierte Lehrerbildung, in O. Zlatkin-Troitschanskaia (ed.), Lehrprofessionalität.: Bedingungen, Genese, Wirkungen und ihre Messung (pp. 477–487), Weinheim: Beltz.

Structures for the professional development of mathematics teachers in English vocational education – Structural Dimension

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Monday, 7 October 2019, 16:15-16:40, KA 209

The Centres for Excellence in Mathematics programme, an extensive new government initiative in England, has recently been introduced into an existing system of professional development which is localised and fragmented. This paper draws on findings from a current Nuffield-funded project, Mathematics in FE Colleges (MiFEC) to explore the context into which this new national programme is being introduced. This is country-specific but also addresses the wider issue of professional development for mathematics teaching in vocational learning which is relevant to other countries. The aim is to inform a discussion about the suitability and sustainability of this national framework in the current environment and the challenges that will need to be overcome.

1. General context

In the English education system, post-16 study pathways are clearly divided into vocational or academic streams, with Further Education (FE) colleges providing the majority of vocational qualifications, in the form of college-based rather than work-based learning. Since 1992, FE colleges in England have operated as independent providers of education under direct funding from the government. This means they are managed as independent businesses and, although there are recognised national providers of professional development, there is no national structure or entitlement to professional development currently in place.

Current policy in England requires students aged 16-18 years to continue studying mathematics if they have not achieved the minimum standard of a Grade 4 in mathematics in the General Certificate of Secondary Education (GCSE) examination taken at age 16 in school. The primary aim is for these students to retake the GCSE examination, although they may study for an alternative approved 'stepping stone' qualification first. The majority of these students are on study programmes in FE colleges and the achievement rate for retaking the GCSE examination is low. The reasons for this lack of success are wide-ranging but high-quality teaching is clearly required to help these students make the necessary improvement.

2. The Centres for Excellence programme

The Centres for Excellence in Mathematics programme aims to develop understanding and evidence of effective classroom practices, which will lead to improvements in mathematics teaching in FE colleges and student outcomes. A major focus will be on the large numbers of students retaking the GCSE examination. The first step of this initiative was the selection of 21 large colleges (of nearly 180 nationally) as Centres for Excellence in Mathematics on October 2018. Each college is tasked with developing its own network of colleges to work with and will lead on the trial and evaluation of designed interventions. Colleges will be supported by a consortium of organisations with relevant expertise in resource design, research and professional development.

3. Professional development in FE colleges

The MiFEC project provides evidence about the professional development needs of mathematics teachers in FE colleges and the ways in which they are currently being supported to improve their classroom practice. This study involves several interlinked research strands, including case studies of a balanced sample of over 30 FE colleges which suggest that three main approaches are currently used by FE colleges.

1. Collaborative approaches in which team members meet together regularly and provide the expertise to support others.
2. Formal training sessions from external professional development providers or awarding bodies.
3. The cascading of training received by individual team members or team managers at external events, or from network meetings with other colleges.

The first may involve a number of activities with a collaborative approach such as weekly formal meetings of the team for focussed discussion of teaching. Good practice or innovation may be identified by managers through informal classroom observations and then presented by individual teachers to other team members in these meetings. There is little evidence though of a spiral model of incremental improvement, or any systematic trial and evaluation. Neither does the collaborative activity form part of a planned purposeful strategy to develop a professional learning community, even though some of the accepted common characteristics are present (Stoll et al. 2006).

In the second and third approaches there is greater reliance on external sources and formal instruction. The effectiveness of such approaches in professional development has been questioned for some time (Matos et el. 2009) but the contributions of external experts are still valued by colleges, especially since colleges there is often limited engagement otherwise with evidence-based developments.

In the current situation, where colleges make their own decisions about professional development, the transition to a national system of college networks and a coordinated evidence-based approach has the potential to address current weaknesses. The independence of colleges and variability of practice presents challenges however to establishing a national framework. The foundations are already laid in many colleges for the development of effective college-based professional learning communities, but these would benefit from clearer aims and increased engagement in evaluative cycles of practitioner research (Dimmock 2016). Developing and nesting these within wider networks, with a focus on evidence-based teaching approaches, provides a structure with the potential to build on current strengths, bringing together practitioners and researchers in effective collaboration.

References

Dimmock, C., 2016. Conceptualising the research–practice–professional development nexus: mobilising schools as 'research-engaged'professional learning communities. Professional Development in Education, 42, 36-53.

Matos, J.F., Powell, A., Sztajn, P., Ejersbø, L., Hovermill, J. & Matos, J.F., 2009. Mathematics teachers' professional development: Processes of learning in and from practice. In R. Even & D.L. Ball (eds.) The professional education and development of teachers of mathematics. US: Springer, 167-183.

Stoll, L., Bolam, R., Mcmahon, A., Wallace, M. & Thomas, S., 2006. Professional learning communities: A review of the literature. Journal of educational change, 7, 221-258.

PHABLABS 4.0 - How to make science, and in particularly Photonics, understandable? – Material Dimension

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1. Photonics, a key enabling technology worthwhile to teach

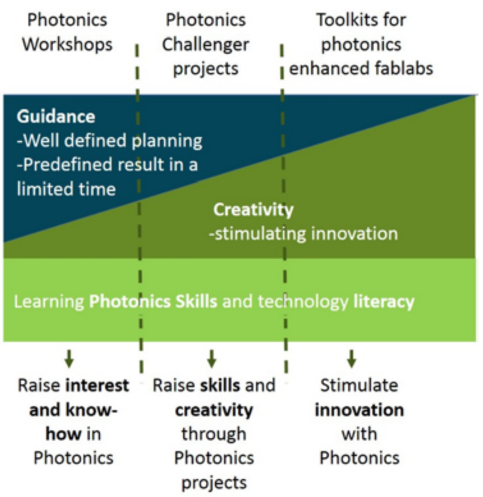
PHABLABS 4.0, a European project started since December 2016, combines two major trends into one powerful and ambitious innovation pathway for digitization of European industry: on the one hand the growing awareness of Photonics as an important innovation driver and a key enabling technology towards a better society, and on the other hand the exploding network of vibrant Fab Labs where next-generation practical skills-based learning using KETs is core but where photonics is currently lacking.

Photonics is the science and technology that exploits the unique properties of light to produce **innovative, durable, energy friendly products** that **improve the quality of our lives**. Today photonics, a key enabling technology (KET) for the European Commission, is an essential technology in areas such as energy, healthcare, communications, manufacturing and culture.

In parallel with the growing awareness of photonics in recent years, we have seen the emergence of the Fab Labs as a major ecosystem for harnessing education, social innovation and entrepreneurship, with a doubling of the number of Fab Labs worldwide every 18 months and over 300 facilities in Europe alone. A **Fab Lab**, or fabrication laboratory is a makerspace equipped with 3D printers, laser cutters, CNC milling machines, electronics and all kinds of consumables where you can make almost anything. A Fab Lab is a technical prototyping facility for innovation, experimentation and invention, providing stimulus for modern technology-based entrepreneurship at a local level. A Fab Lab is also a platform for learning and innovation: a place to play, to create, to learn, to mentor, and to invent.

2. Main objective of PHABLABS 4.0

The main objective of the PHABLABS 4.0 project is the **teaming up of photonics** organizations and research institutes with the growing network of **Fab Labs**. In this framework, different dedicated tools and activities are developed and tested during the PHABLABS 4.0 project with the aim to create a "**Pathway to Photonics Innovation**" which provides a highly effective bridge between the basic introductory level science taught in school, and the application of photonics at industrial level.



The three **complementary types of activities of Photonics Workshops, Challenger Projects and Toolkits within PHABLABS 4.0** have been specifically designed with the objective of bridging this "Valley of Death" where another whole generation of potential entrepreneurs and innovators can be lost because they didn't get sufficient progression in their knowledge and skills, particularly being hands-on with the right tools to grow their minds and "own" the knowledge. Each of the activities has an important task in the progression of learning and acquainting skills to be applied for the specific purpose of innovation. The activities have been deliberately designed to build deeper and deeper levels of knowledge and skills in the individuals so there is a lasting impact.

Figure 1. Complementarity of the PHABLABS 4.0 activities

3. **Which role can the PHABLABS 4.0 materials play in professional development for maths and science teachers?**

Learning starts with the "**Photonics Workshops"**. The "Photonics Workshops" are characterized by an acquisition of the basic photonics principles, while working towards a working system in a short period of time with excellent supervision and guidance. Many of the "Photonics Workshops" already include creativity aspects.

Participants then progress to the level of **"Photonics Challenger Projects"** which focus on longer term assignments where a practical challenge must be tackled with photonics tools and components, and where creativity is key. Here the role of the instructor is that of a coach. Participants will then be equipped to independently accelerate and deepen their competencies for innovation if they are given easy access to all of the right tools to put their ideas into practice.

In total 33 Photonics Workshops and 11 Photonics Challengers were developed to perform in Fab Labs. All instructions of these activities are made available on the PHABLABS 4.0 website: www.phablabs.eu and on the instructables website. The instructions include the photonics technology behind the project, the part list, indication of the duration and all steps needed to make the prototype.

The **"Toolkits for Photonics Workshops"**. PHABLABS 4.0 decided to provide complete toolkits (all components needed) for three different workshops which are covering physics topics from secondary schools. For all other workshops, only the photonics materials can be purchased online.

To enlarge and ensure the workforce of tomorrow it is imperative that we start **stimulating STEM from a young age**, that we continue to engage and inspire students with the enabling character of photonics, and that we properly equip and support our potential entrepreneurs to innovate successfully. Therefore the tools and activities of PHABLABS 4.0 are developed with 3 specific target groups in mind:

	Target groups	Focus
I	Young minds: (age 10–14)	To stimulate interest in STEM and in a technical profession, with a special attention on achieving strong female engagement
II	Students: (age 15–18)	To encourage experimentation with photonics and grasp the strong enabling character of this technology in combination with other KETs (Manufacturing, Electronics, Advanced Materials)
III	Young professionals and technicians (age 18+)	To introduce them to specific aspects of photonics and trigger innovation in their products, with focus on technological possibilities and entrepreneurial opportunities

Especially to foster **the interest of girls** in the domain of science and photonics, catching their interest and building their confidence before they become teenagers is really important. As girls are still underrepresented in science and engineering, there is a major opportunity to greatly expand and strengthen the workforce with greater female participation.

Within PHABLABS 4.0 appropriate attention is given to gender aspects. The instructions are written in a way not to push away girls and a Gender Booklet with gender guidelines useful for teachers and workshop instructors is currently available.

The presentation will focus on how teachers can handle the gender-balanced approach in their classrooms and how they can integrate the developed workshops during STEM-classes.

Characteristics and Impacts of Two Large-Scale PD Programs: Elaborating on Core Critical Features of Teacher PD – Structural Dimension

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1. Introduction

In recent years, several reports on critical features of high-quality professional development (PD) have emerged and supported the design of teacher PD programs (Borko et al., 2010; Desimone, 2009). We are currently involved in a research project studying characteristics and impacts of two large-scale PD programs for mathematics teachers in Sweden. The programs are similar if characterized according to established research frameworks (e.g., Desimone, 2009) of what constitutes high-quality PD and have been conducted within the same national context and during the same time frame. Despite this, our results suggest that they differ in their impact on student achievement, both between the programs and between grade levels (Lindvall et al., 2018). In this presentation, we will present results from ongoing studies aiming to explain possible reasons for these differences and which have the potential so support policy makers and PD developers in their design and implementation of future programs. In particular, we will address questions related to the Structural Dimension, such as: How can a design of an initiative or project aiming at a widespread implementation of innovative teaching and for scaling up professional development look like? Or which structures prove to be effective in which cultural context and which do not?

2. Core Critical Features of High-Quality Teacher Professional Development

Some years ago, agreement about five core critical features of high-quality teacher PD reached a level such that many in the field regarded it as consensus (e.g., Desimone, 2009; Penuel et al., 2007). These features include that the PD programs should emphasize both the subject matter and how to teach it (Content focus), align with policy standards and teachers' knowledge and beliefs (Coherence), and include multiple sessions spread over a longer period of time (Duration) where teachers, in cooperation with their colleagues (Collective participation), actively engage in activities involving planning, enacting, and revising their instructional practices (Active learning).

More recently, however, it has been questioned whether there really is a consensus (cf. Kennedy, 2016; Sztajn et al., 2017). For example, even though many programs have reached success in small-scale studies, studies of large-scale teacher PD programs incorporating all, or several, of the five critical features have shown mixed, or even no effects on student achievement. In the light of these arguments, scholars have lately concluded that though the five critical features of teacher PD are certainly important in explaining "what works", they are not sufficient on their own (Sztajn et al., 2017). Calls have therefore been made for studies not only studying "what works", but also for whom, when and how. However, conducting studies in which valid and reliable conclusions in relation to these questions can be answered is methodologically difficult. For example, in studies of only one PD program in one setting it is hard to define which feature of an intervention that was relevant. Therefore, studies *comparing* programs with slightly different features (Sztajn et al., 2017), as well as differential effects within the sample (Bryk et al., 2015), are needed. Within our research project, we aim to respond to these calls by studying and comparing characteristics and impacts of two large-scale teacher PD programs.

3. Two Teacher Professional Development programs

The first program, Boost for Mathematics (BfM), is a 649MSkr national state-coordinated project in which 80% of all mathematics teachers in Sweden have participated. The second program, Count on Västerås (CoV), has been conducted in cooperation between Mälardalen University and a larger Swedish municipality and engaged about 400 mathematics teachers in Grades 1-9. Both programs correspond well with the five core critical features of teacher PD. They are concentrated on specific subject matter and how students learn this content (Content focus). Special attention is directed towards teaching for the mathematical competencies set out in the national curriculum (Coherence), and teachers engage in cycles of activities where they plan for, enact and reflect on the outcome of mathematical lessons (Active Learning). Finally, teachers participate in PD sessions every one or two weeks during a whole year (Duration) together with their colleagues at the respective schools (Collective Participation).

Besides the core critical features, the programs also correspond well with additional recommendations in the research literature (e.g., Bryk et al., 2015). For example, they acknowledge the importance of support from school leadership, provide external support in the form of trained coaches who guide the collegial discussions, and are explicitly linked to classroom practices as teachers are asked to discuss lessons which they carry out in their respective classes.

4. Differential Impacts Between and Within the Professional Development Programs

Despite the programs' similarities, results from our research group have shown differential effects on student achievement, both between the programs and within different grade levels (Lindvall et al., 2018). The tests used for measuring student achievement emphasize students' number sense and were incorporated in the PD programs either as readings on number sense (BfM), or as tools for formative assessment (CoV). In sum, the results indicate that BfM have contributed to positive impacts on student achievement for the upper grades of elementary school and no impact in the lower grades. The results for CoV, on the other hand, point at the opposite direction. During the presentation, we will present results from ongoing studies in our research group which may provide explanatory value for the differences found and have possible implications for the design of large-scale teacher PD programs. In particular, our results suggest specifications of two of the core critical features: Content focus and Coherence. Moreover, depending on the programs' Content focus and Coherence, different methods for facilitating teachers' enactment of the promoted practices (cf. Kennedy, 2016) seem to be more or less effective.

References

Bryk, A. S., Gomez, L. M., Grunow, A., & LeMahieu, P. G. (2015). *Learning to improve: How America's schools can get better at getting better*. Cambridge, MA: Harvard Education Press.

Borko, H., Jacobs, J., & Koellner, K. (2010). Contemporary approaches to teacher professional development. In P. L. Peterson, E. Baker, & B. McGaw (Eds.), *Third international encyclopedia of education* (Vol. 7, pp. 548–556). Amsterdam, The Netherlands: Elsevier.

Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher, 38*(3), 181-199.

Kennedy, M. M. (2016). How does professional development improve teaching? *Review of Educational Research, 86*(4), 945-980.

Lindvall, J., Helenius, O., & Wiberg, M. (2018). Critical features of professional development programs: Comparing content focus and impact of two large-scale programs. *Teaching and Teacher Education*, *70*, 121-131.

Penuel, W. R., Fishman, B. J., Yamaguchi, R., & Gallagher, L. P. (2007). What makes professional development effective? Strategies that foster curriculum implementation. *American Educational Research Journal, 44*(4), 921-958.

Sztajn, P., Borko, H., & Smith, T. M. (2017). Research on mathematics professional development. In J. Cai. (Ed.), *Compendium for research in mathematics education* (pp. 793-823). Reston, VA: National Council of Teachers of Mathematics.

A model for educating educators in Suriname is adapted by making the education partly blended – Structural Dimension

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Monday, 7 October 2019, 16:15-16:40, KA 102

1. Introduction

In many developing countries, the teaching methods are still from the colonial era, since time and money for updating methods are scarce. It was difficult to reach all teachers to implement a curriculum innovation because the schools are scattered throughout the country and connections are poor. nowadays the internet, distance learning and international cooperation can help to overcome these problems. Here we report some lessons from our projects with educating educators in secondary physics in Suriname.

2. The first ETE-model

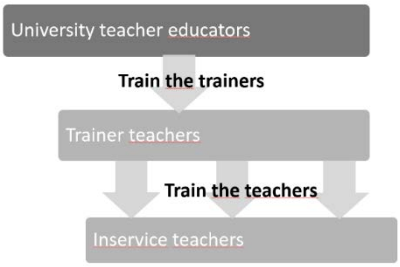

Figure 1. The first ETE-model

In 2015, we presented a model for educating inservice-teachers in a developing country (Van der Valk, Mooldijk & Duifhuis, 2016), implemented in Suriname. The education in Suriname is based upon the Dutch educational system dating from colonial times. The model works with two levels of implementation. On the first level, experienced teacher educators from the developing country and from a cooperating developed country train selected teachers how to teach innovations to their fellow teachers. We started this model in a project 'New Physics in Suriname' (NiNaS). The aim was to bring activating methods in physics education. The implementation of the model in the project was successful in preparing the teachers minds for the innovation and in that the teacher training was continued after the project. But already during the project we observed that the teacher trainers, experienced as they were in the traditional methods, lacked enough experiences in their own classes with the new methods they had to teach to their fellow teachers. That was the reason to ask for a follow-up project. The implementation model used in NiNaS was adapted: the training teachers increase their knowledge now also by distant learning. They also get the chance and the means to experience the innovations in their own classes (Bakkenes etal, 2010). The innovation aimed at is focused on doing physics experiments in the classroom.

3. The adapted model:

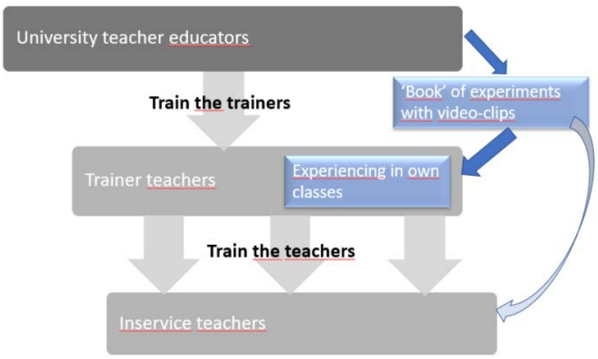

Figure 2. The adapted ETE-model

This model combines positive experiences of the previous project with new insights. Schools in Suriname are all over the country and teachers cannot see each other regularly. However, mobile internet is good. A small experiment with video-clips for teachers worked well, so we implement clips in the project. A chat app (WhatsApp) also works well for the small group of training teachers to keep in touch and exchange experiences. An accompanying website that follows the method gives room to explain didactic instructions and gives the video-clips a place. The website is easy to use via mobile phones.

The video-clips show how to do experiments in the classroom. Another video-clip gives practical suggestions for the experiment and educational hints. The idea is that teachers keep in control about their teaching but feel they are part of a community that wish to make changes to their teaching (Wallace &Loughran, 2012).

4. Does it work?

Whether the approach within this project is successful is the subject of (a bit of) research. Through questionnaires at conferences and with the help of students who are doing an internship in Suriname, we hope to gain insight into whether the approach is successful.

Acknowledgements

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References

Valk, T. van der, A. Mooldijk & P. Duifhuis (2016). Educating physics educators in Surinam: the NiNaS project. In: K. Maass, S. Prediger & D. Wernisch. *Conference Book Educating the Educators. 2nd conference on international approaches to scaling-up professional development in maths and science education, 7-8 Nov 2016 Freiburg, Germany.* Mascil, DZM, Pädagogische Hochschule Freiburg. pp. 85-87.

Wallace, J. &Loughran, J. (2012) Science teacher learning, in Fraser B et al. (ed*), Second international handbook of Science Education*, Springer London, pp 295 – 303.

Bakkenes, I., Vermunt, J. &Wubbels, T. (2010) *Teacher learning in the context of educational innovation; Learning activities and learning outcomes of experienced teachers*. Learning and Instruction, 20-6, pp 533-548.

Training prospective Primary teachers in Biology teaching through inquiry based: role of positive emotions anticipating learning – Personal Dimension

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Monday, 7 October 2019, 16:55-17:45, KG4 301

1. Introduction

Research in Science Education have shown that academic emotions and cognition (such as memory, attention, problem solving…) interact and are reciprocally conditioned (Pekrun, 2014). This highlight the relevance to simultaneously look into affective and cognitive aspects in teaching-learning processes. This is particularly important in pre-service teachers, since they can transfer their negative emotions towards science to their future students (Pekrun, 2014). In order to delve into the interplay between learning and academic emotions in pre-service science teachers, in this contribution we analyze the interactions between emotions and learning outcomes in a sample of 149 pre-service Primary teachers (University of Extremadura, 54.4 % females, 22 years old on average). Changes in emotions and learning were induced by implementing an active practical intervention of Microbiology that has been shown to be both effective and emotive (Marcos-Merino *et al*., 2019).

2. Methodology

2.1. Description of active intervention

To analyze the interactions between emotions and learning, we implement an active practice of Microbiology described in a previous research (Marcos-Merino *et al*., 2019). Briefly, groups of 20 students were arranged to develop a laboratory activity to learn basics of Microbiology. Students designed, under the guidance of teacher, different experiments to prove microorganisms´ ubiquity and diversity, as well as asepsis and sterilization. Then, they collected environmental samples that were plated on nutritive agar. After one or two weeks of incubation at room temperature, students observed and discussed results.

2.2. Instruments

We used two instruments, one for estimate emotions and another for determine Microbiology knowledge. For academic emotions, we use a simple and fast quantitative self-report test informing about ten academic emotions (joy, trust, satisfaction, enthusiasm, fun, worry, frustration, uncertainty, nervousness and boredom), which were rated on a Likert scale from 1 "not experienced" to 5 "intensely experienced". This test was previously validated through factor analysis (Marcos-Merino *et al*., 2019). Microbiology contents were assessed through questions about common misconceptions in Secondary School as well as questions extracted from TIMSS for Secondary Education. Students answered both tests before the intervention (to determine their previous Biology knowledge of Secondary Education and their expectation of emotions towards the practice) and 2 weeks after its implementation (to determine learning outcomes and the emotions they really feel during the intervention). Learning was calculated as the difference between posttest a pretest in a subset at or below 75th percentile of pretest.

2.3. Statistical analysis

SPSS was used for factor analysis (generalized least squares and Oblimin rotation) and extraction of positive and negative emotions (Marcos-Merino *et al*., 2019) and to calculate Spearman and Pearson correlations.

3. Results and discussion

Results reveal positive associations between positive emotions (joy, trust, satisfaction, enthusiasm and fun) and learning outcomes, as well as negative associations between them and the intensities of boredom and uncertainty (Spearman correlation, p-value<.05). In addition, Microbiology learning is associated positively with the enthusiasm, and negatively with the frustration, felt during the practice (Spearman correlation, p-value<.05). These observations agree with several previous researches that revealed that emotional information is better remembered than neutral information (Dunsmoor *et al*., 2015). Factorial model (Figure 2) reveal that positive emotions interact with learning outcomes and learning, highlighting their modulating role in learning and achievement (Pekrun, 2014). Noteworthy, positive emotions before and after the practice anticipate posttest and learning scores. These results suggest that those students who feel higher intensities of positive emotions during the practice, as well as those who have a higher previous expectation, are those who got better learning outcomes and learn more Microbiology. The predictive value of positive emotions regarding learning results has been displayed in previous researches (Pekrun, 2014); although these works also revealed predictive value of negative emotions.

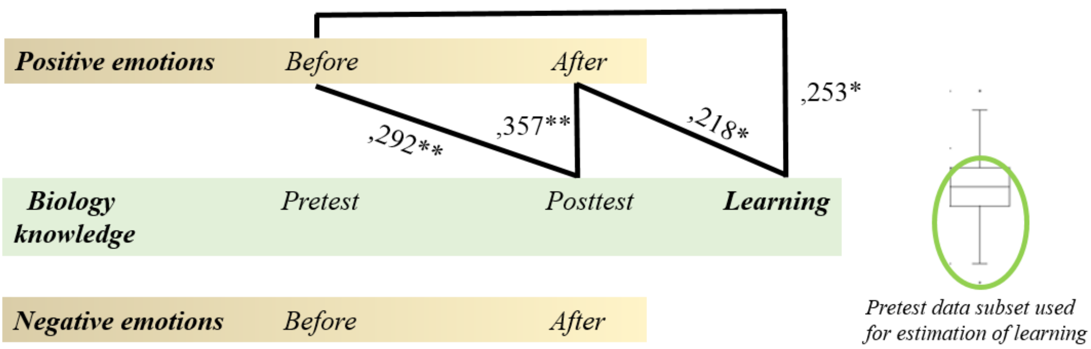

Figure 1. Pearson's correlation coefficients among knowledge assessment (middle), learning and factors of positive (top) and negative (bottom) emotions measured before (pretest) and after (posttest) the practice. The stars at lines indicate a p-value <.05 (*) and <.01 (**).

4. Conclusion

In agreement with previous research in academic emotions, our work provides evidences of interactions between emotions and active learning. Noteworthy, positive emotions before and after an active practice anticipate learning scores. Due to emotions felt by teachers influence learning processes, these interactions should be taken into account in initial training.

References

Dunsmoor J., V. Murty, L. Davachi and E. Phelps, 2015, "Emotional learning selectively and retroactively strengthens memories for related events", Nature, Vol. 520, pp. 345–348.

Pekrun R., 2014, "Emotions and learning", Educational practices series, Vol. 24, pp. 1-32.

Marcos-Merino J. M., R. Esteban and J. Gómez, 2019, "Formando a futuros maestros para abordar los microorganismos mediante actividades prácticas. Papel de las emociones y valoraciones de los estudiantes", Revista Eureka sobre Enseñanza y Divulgación de las Ciencias, Vol. 16(1), pp. 1602-1618.

Memory of Biology Secondary knowledge can condition current negative emotions of prospective Primary teachers towards Biology Education – Personal Dimension

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Monday, 7 October 2019, 16:55-17:45, KG4 301

1. Introduction

Classroom is an emotional place: there is virtually no major human emotion not experienced in academic settings. Cognition (such as memory, attention, language, problem solving and learning strategies) and emotions are integrated in the brain in critical areas for regulating the flow of information between regions, being reciprocally conditioned (Eldar and Niv, 2015). This circumstance highlights the relevance to simultaneously look into affective and cognitive aspects in teaching-learning processes. This is particularly important in the future Primary teachers´ training, since the interplay between their emotions and their learning can determine their future professional performance (Mellado *et al*., 2014). To deepen these interactions, in this research we analyse, in a sample of future Primary teachers (students of the Degree in Primary Education at the University of Extremadura), the interactions between the memory of core Biology contents of Secondary School and their expectation of emotions towards a Biology lesson, included in their training program. The objective is to determine if the past level of Biology knowledge is linked to current emotions in future Primary teachers.

2. Methodology

2.1. Sample

The sample consists of 575 pre-service Primary teachers (60.1 % females; 22 years old on average), all being students enrolled in a Science Education subject of the sixth semester of the Degree in Primary Education (University of Extremadura). Students were informed about the goals of the research, procedure, duration and anonymity of their data.

2.2. Instruments

We apply two tests, one for estimate the expectation of emotions and another for determine the memory of Biology contents of Secondary School. Firstly, to determine the expectation of academic emotions towards a present Biology lesson, we use a simple and fast quantitative self-report test informing about ten academic emotions (joy, trust, satisfaction, enthusiasm, fun, worry, frustration, uncertainty, nervousness and boredom). These emotions were rated on a Likert scale from 1 “not experienced” to 5 “intensely experienced”. This test was previously validated through factor analysis (Marcos-Merino *et al*., 2019). Secondly, Secondary Biology core concepts were assessed through questions about common misconceptions as well as questions extracted from TIMSS for Secondary Education.

2.3. Statistical analysis

Due to data do not follow a normal distribution, Spearman correlation analysis are performed (SPSS program, IBM software). Coefficient differences between genders are explored through bootstrapping method.

3. Results and discussion

Results reveal a negative correlation between the memory of Secondary Biology contents and the present expectation of some negative emotions. Namely, we find negative associations with the expectations of worry and boredom (Table 1). There are no differences between these correlation coefficients between males and females. This result suggest that low levels of previous Biology knowledge of Secondary Education can be predictors of high intensities of boredom and worry. The predictive value of previous knowledge regarding present negative emotions has been displayed in several previous studies (Pekrun *et al.* 2009), although these researches also revealed predictive value regarding present positive emotions. Considering these results, it is necessary to reflect upon the influence of the Secondary level of previous scientific knowledge in the negative emotions, towards Science and its teaching, of prospective Primary teachers (Mellado *et al*., 2014).

Table 1. Coefficients of correlation between the intensity of emotions prior to a Biology lesson included in the initial teacher training and the previous Biology knowledge of Secondary Education. Stars highlight significant correlations (Spearman, ***p-value<.001, **p-value<.01, *p-value<.05)

Expectation of emotions towards a current Biology lesson	**Correlation with the memory of Secondary Biology knowledge**
Joyful	.060
Trust	.035
Satisfaction	.026
Enthusiasm	.083
Fun	.055
Nervousness	.033
Boredom	-.166***
Frustration	-.036
Worry	-.245***
Uncertainty	.064

4. Conclusion

Results show interactions between the Secondary Biology knowledge of a sample of future Primary teachers and their expectation of emotions towards Biology Education. Due to emotions felt by teachers influence teaching-learning processes, these interactions should be taken into account in initial Primary teachers training.

References

Eldar E. and Y. Niv, 2015, "Interaction between emotional state and learning underlies mood instability", Nature communications, Vol. 6, pp. 6149-6159.

Marcos-Merino J. M., R. Esteban and J. Gómez, 2019, "Formando a futuros maestros para abordar los microorganismos mediante actividades prácticas. Papel de las emociones y valoraciones de los estudiantes", Revista Eureka sobre Enseñanza y Divulgación de las Ciencias, Vol. 16(1), pp. 1602-1618.

Mellado V., A. Borrachero, M. Dávila, L. Melo and M. Brígido, 2014, "Las emociones en la enseñanza de las ciencias", Enseñanza de las ciencias, Vol. 32, pp. 11-36.

Pekrun R., A. Elliot and M. Maier, 2009, "Achievement goals and achievement emotions: Testing a model of their joint relations with academic performance", Journal of Educational Psychology, Vol. 101(1), pp. 115–135.

Professional development – a program for mathematics teachers – Structural Dimension

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Monday, 7 October 2019, 16:55-17:45, KA 209

1. Introduction

This paper reports on findings from a study of a yearlong program for in-service mathematics teachers, in compulsory schools with the purpose of responding to teachers' needs for professional development in mathematics teaching. It was based on theories of teachers' professional development and mathematics teaching and learning as well as teachers expressed needs. Our goal with studying the program was to be able to develop further opportunities for in-service teachers to attend university courses with the aim of improving their practice as mathematics teachers.

Our research question is: How do teachers who participated in a yearlong mathematics education program interpret that their competence has developed?

2. Theoretical background

Learning communities, where teachers share their understanding of the nature of good teaching and work together on improving their practice was at the core of the program. According to Desimone, (2009) they seem to create fruitful conditions for teachers' professional development. Loucks-Horsley, et al. (2010) emphasize that the competencies of its members can develop in several regards such as professional communication and collaboration particularly in in-service programs.

In 2014, Gunnarsdóttir, studied the professional development opportunities for in-service mathematics teachers in Iceland. Her analysis was based on five main features put forth by Desimone (2009) about effective professional development; focus on content, active learning, coherence, duration and collective participation. She found that most of the courses have strong content focus,

active learning and collective participation. There is a lack of coherence and time. We planned the program and the courses on Gunnarsdóttir's findings and core principles for effective professional development (Desimone, 2009). Our focus was on building learning communities, coherence, duration (year-long program), connection to practice, i.e. students learning and teaching specific content.

3. Methods

The model for mathematics competency (Niss & Højgaard, 2011) was adopted for analysing the data and the findings organised according to them (i) curriculum competency; (ii)teaching competency; (iii) of revealing learning; (iv) assessment competency; (v) cooperation competency; (vi) professional development competency. The goal of this study was to collect information on 48 teachers experience of participating in the program. Six 5 ECTS courses were successively taught throughout the year. The structure of the courses differed concerning content and approaches to mathematics teaching and learning but professional development was always at the core. Data consisted of teachers' answers to a few open questions in the beginning and at the end of the program, recordings from discussions, assignments and teacher educators' notes. While reading through the data, initial categories emerged that were generated through coding (Saldana, 2009).

4. Findings and discussions

We chose to present one example of how the teacher competences emerged in the data. This program seems to have resulted in improved professional development competency of the teachers as reported by three teachers:

Actually, I learned most from the classes on Thursdays. At least I have got new and deeper insight into much in relation to mathematics teaching.

The best part of this program was to meet and discuss what we read and the projects we worked on each time.

We learned a lot from following the lesson study process in mathematics. It was demanding and interesting to work with a certain framework and have to anticipate students' responses.

These teachers report that they valued meeting colleagues and participating in professional discussions about mathematics education. The possibilities for active learning and collective participation were important. They experienced that their participation gave them opportunity to develop their mathematics teaching competences. We observed that a fruitful learning community was created that can be characterized by eager discussions and positive learning environment. The distance learners were active attendants at the courses and their participation in real-time allowed them to take part in building a learning community and sustain it.

The analysis based on the competency model (Niss & Højgaard, 2011) show that the teachers feel that they have developed as mathematics teachers. The focus of the study program was on improving teaching competence and professional development through collaboration and active learning. The teachers were eager to try out new things and didn't feel they were restricted by curriculum or school authorities. They did not hesitate to choose topics and approaches they were studying at the courses.

In the program there was a strong focus on building learning communities (Desimone 2009). The teachers reported that they built strong relationships with other participants and found ways to communicate with each other on collegial basis both on campus and via the internet as found in

Loucks-Horsley, et al. (2010). The teachers gave positive feedback of their participation and felt that they had gained knowledge and tools for improving their teaching.

The experience gained from carrying out this year-long university program for in-service mathematics teachers was rich and rewarding. We gained knowledge about how teachers work and how they approach their studies. In future courses we will emphasize active participation and find ways to improve on-line communication.

References

Desimone, L.M. (2009). Improving Impact Studies of Teachers' Professional Development: Toward Better Conceptualizations and Measures. *Educational Researcher,* 38(3), 181–199.

Gunnarsdóttir, G.H. (2014). Professional Development: Possibilities and restrictions for mathematics teachers in lower secondary school in Iceland. *The Mathematicians Enthusiast,* 11(1), Article 10. Available at: https://scholarworks.umt.edu/tme/vol11/iss1/10

Loucks-Horsley, S., Stiles, K. E., Mundry, S., Hewson, P.W. & Love, N. (2010). *Designing Professonal Development for Teachers of Science and Mathematics* (3rd edition.). Thousand Oaks, CA: Corwin.

Niss, M., & Højgaard, T. (eds.). (2011). *Competencies and mathematical learning: Ideas and inspiration for the development of mathematics teaching and learning in Denmark*. IMFUFA, 485/2011. Roskilde: Roskilde University.

Saladana, J. (2009). *The coding manual for qualitative researchers.* London: Sage.

Use of Lesson Study in Mathematics Teacher Education as a means to encourage professional development – Material Dimension

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Monday, 7 October 2019, 16:55-17:45, KA 209

1. Introduction

Lesson Study, a spiral model for learning from student-thinking by implementing thoughtful and thorough lessons, seems a promising method to motivate teachers to enhance their lessons, based on observing student-thinking – not only in in-service teacher training, but also in pre-service teacher training.

In this presentation, we will focus on the use of Lesson Study in pre-service mathematics teacher education, and discuss some indications from our practice that show that Lesson Study as PD is embraced by novice teachers who worked using this method during their pre-service education. One of the conditions for Lesson Study to be successful is that it is clear to the students what the quality criteria are for the design of the materials for the classroom.

In this presentation, we will present materials from students and from their reflections on the process, and discuss this with the audience.

2. Background on Lesson Study

Lesson study is an inquiry cycle conducted by a team of teachers that is centered around a "research lesson"— an actual classroom lesson designed to investigate and improve the teaching of a particular topic (Lewis et al., 2012). During the research lesson, which will be taught by one of the team members, the other team members gather data on student thinking and learning. They study

selected students to see how their thinking evolves (or fails to), and what aspects of the lesson design enhance or pose barriers to learning. Team members present and discuss these data during a postlesson discussion, drawing out implications for teaching and learning the specific topic and for teaching and learning more broadly. Based on their findings, they redesign the lesson. Lesson Study, therefore, is comparable with the *spiral model* that has been used in PD in several projects and studies: teachers collaboratively design a lesson, predict student out-comes of their lesson, implement and observe, and reflect on the outcomes.

3. Theoretical framework

In pre-service teacher education, pre-service teachers can find it challenging to offer grounds for their teaching actions and to explore how their beliefs about teaching relate to theory (Lunenberg & Korthagen, 2009). This 'lack of transfer' was recognized in a study that was done at the Hogeschool van Amsterdam (Amagir, A. et al., 2014): pre-service teachers find it hard to connect theory to practice; they just follow the textbook.
Following the textbook not only prevents pre-service and novice teachers from using theory they learn during their education, but it also results in "task propensity", together with a lack of attention for more advanced conceptual mathematical goals, as findings from three PhD-studies show (Gravemeijer , K. et al., 2016). Findings showed that students had mastered some basic solution methods but had not learned to reason on a more general, higher, level of mathematical understanding.
Today's society asks for citizens who have developed competences in attaining new knowledge, knowledge, creative problem solving and critical thinking (Maaß & Doorman, 2013). This asks for teachers who ask high-level questions.

To stimulate pre-service teachers to step away from the textbook, to foresee children's thinking and to prepare for asking high-level questions to promote problem solving and a higher level of mathematical understanding, we decided to introduce Lesson Study in mathematics teacher education as a methodology, using theory on inquiry-based learning, on what is known about student thinking, on what is known about stimulating mathematical thinking, to design their lesson(s).

4. Lesson Study in Mathematics Teacher Education

Pre-service teachers were asked to collaborate in groups of 4, or 5, as part of a semester-course, during their last year of study. At least one of them should be teaching during that semester – as part of an internship, or as part of a job (since part-time pre-service students in mathematics most of the time already have a job as a mathematics teacher due to the shortage in teachers, although they don't have their teaching license yet).

In schoolyear 2016-2017, there were 16 groups of students (total number of students: 55); in schoolyear 2017-2018 there were 17 groups (total number: 66) and schoolyear 2018-2019 there were 13 groups (total number: 54). They all managed to

1) Choose a topic to teach that, one way or another, needed improvement in teaching and learning and find literature on this topic, also on misconceptions;
2) Design a series of lessons on this topic, and decide which one would be the "research lesson";
3) Design the research lesson including predictions of student thinking, including examples by and questions of the teachers, including use of methods to make student-thinking visible;
4) Teach/observe the research-lesson;
5) Discuss the findings and redesign the research lesson.

6) Reflect on the process.

Since the two teacher educators who were involved in this course had to facilitate all groups, it was hard to keep track of the progression that took place in each group. In the first year (2016-2017), this resulted in a "research-lesson" by one of the groups that was completely procedural, without any student-thinking taking place – but the students were very happy with the result, since everything they predicted, actually happened, so to them it was a 'perfect lesson'.
That's why, in the next year, we included a check on the content of the research-lesson by the teacher educator, to make sure there would be "student-thinking" to anticipate on.
This way of working resulted in research-lessons and processes that motivate most students in such a way that they are enthusiastic about Lesson Study as a method for professional development, also during the continuation of their work after finishing their studies. We can conclude this from their reflections and from following former student-teachers who are still/again involved in Lesson Study, as an in-service trajectory within their school.

References

Amagir, A., Van den Berg, G., Van Veldhuizen, B., & Wilschut, A. (2014). "Transfer in de tweedegraads lerarenopleidingen: rapportage van een intern onderzoek". Amsterdam: Hogeschool van Amsterdam, Kenniscentrum Onderwijs en Opvoeding.

Gravemeijer, K., Bruin-Muurling, G., Kraemer, J.-M. & Van Stiphout, I. (2016). "Shortcomings of Mathematics Education Reform in The Netherlands: A Paradigm Case?" Mathematical Thinking and Learning, 18(1), 25-44.

Lewis, C. C., Perry, R. R., Friedkin, S., & Roth, J. R. (2012). "Improving Teaching Does Improve Teachers: Evidence from Lesson Study", Journal of Teacher Education, 63(5), pp. 368–375. doi: 10.1177/0022487112446633.

Lunenberg, M., & Korthagen, F. (2009). "Experience, Theory, and Practical Wisdom in Teaching and Teacher Education". Teachers and Teaching 15(2), pp. 225-240.

Maaß, K., & Doorman, M. (2013). "A model for a widespread implementation of inquiry-based learning". ZDM—The International Journal of Mathematical Education, 45(6), pp. 887-899. doi: 10.1007/s11858-013-0505-7

Algorithms without a computer – Material Dimension

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Monday, 7 October 2019, 16:55-17:45, KA 106

1. Introduction

The success of helping students to discover their passion for computer science can depend on the way it is taught, as can happen with any other subject. This means that having well-prepared teachers with a good understanding of the purpose of the curriculum is key to its success. In reality, recently most countries are adopting curricula that cover issues of computer science (CS or informatics) in connection to computational thinking such as the performance of algorithms, data representation and data structures, software engineering, networks, security, and more.

Various ideas on deepening knowledge and strengthen skills have been developed. The well-known Computer Science without computer (CS Unplugged: www.csunplugged.com) has incorporated ten "big ideas" in CS that were collated by seeking input from a range of CS education researchers and professionals from around the world (Bell et al., 2018). The central big idea identified was that

“digital systems are designed by humans to serve human needs”; other ideas covered topics such as data representation, algorithms, complexity, computability, virtual representations, time dependent operations, and communication protocols. Many of the activities are mathematically based, e.g. exploring binary numbers, mapping and graphs, patterns and sorting problems, and cryptography.
This workshop addresses all teachers and education scientists who are interested how school students can deepening knowledge in mathematics and computational thinking.

2. Computer science without computer in the class

CS Unplugged is a collection of free learning activities that teach informatics through engaging games and puzzles that use cards, string, crayons and lots of running around. We originally developed this so that young students could dive head-first into informatics, experiencing the kinds of questions and challenges that computer scientists experience, but without having to learn programming first.
The students are actively involved in solving problems on graphs and cryptography, communication, creativity, and thinking skills in a meaningful context. The activities also provide a very engaging way to explore “computational thinking”, which is gaining traction in school curricula (Bell, 2018).

The collection was originally intended as a resource for outreach and extension, but with the adoption of computing and computational thinking into many classrooms around the world, it is now widely used for teaching.

3. Samples of unplugged activities of informatics and connected to mathematics

Activity 1. The Muddy City

Description. Our society is linked by many networks: telephone networks, utility supply networks, computer networks, and road networks. For a particular network there is usually some choice about where the roads, cables, or radio links can be placed. We need to find ways of efficiently linking objects in a network. This activity will show you how computers are used to find the best solutions for real-life problems such as how to link power lines between houses. Related subjects: mathematics (geometry – exploring shape and space, discrete mathematics, graph theory – exploring structures), technology (the shortest path algorithms).

Students get worksheets with an example of the city. They have to investigate strategies how to link power lines between houses.

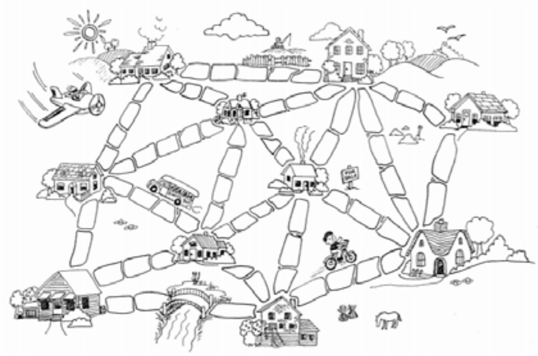

Figure 1. Picture of the city

Extensions of activity. How many roads or connections are needed if there are n houses in the city? It turns out that an optimal solution will always have exactly n–1 connections in it, as this is always sufficient to link up the n houses, and adding one more would create unnecessary alternative routes between houses.

Activity 2. Card Flip Magic—Error Detection & Correction

Description. When data is stored on a disk or transmitted from one computer to another, we usually assume that it doesn't get changed in the process. But sometimes things go wrong, and the data is changed accidentally. This activity uses a magic trick to show how to detect when data has been corrupted, and to correct it. Related subjects: mathematics (number – exploring computation and estimation, algebra – exploring patterns and relationships, solving for a missing value, rows and columns, coordinates), technology (validating data)

Two-sided cards are used in this activity. For the demonstration it is easiest to use flat magnetic cards that have a different colour on each side—fridge magnets are ideal, but make sure they are magnetic on both sides.

1. Choose a student to lay out the cards in a 5 × 5 square, with a random mixture of sides showing. Casually add another row and column, "just to make it a bit harder".
2. Get a student to flip over one card only while you cover your eyes. Can the students guess how the trick is done? It's magic!

Extensions of activity. It can be used with other objects. Anything that has two 'states' is suitable. For example, you could use playing cards, coins (heads or tails) or cards with 0 or 1 printed on them (to relate to the binary system).
It can be tried this with a much larger layout e.g. 9 × 9 cards, with the extra row and column expanding it to 10 × 10.

In this card exercise an even parity were used — using an even number of coloured cards. Can it be done with odd parity? (This is possible, but the lower right-hand card only works out the same for its row and column if the numbers of rows and columns are both even or both odd; for example, a 5 × 9 layout will work fine, or a 4 × 6, but a 3 × 4 layout won't.)

References

Bell, T., 2018, "Computer Science in K-12 education: the big picture", Olympiads in Informatics, Vol. 12, pp. 3-12.

Bell, T., Tymann, P., & Yehudai, A., 2018, "The Big Ideas in Computer Science for K-12 Curricula", Bulletin of EATCS, Vol.1, N. 124, pp.
http://bulletin.eatcs.org/index.php/beatcs/article/view/521

PD for Language-Responsive Mathematics – What teachers need to learn to implement a language-responsive learning trajectory on proportionality – Material Dimension

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Monday, 7 October 2019, 16:55-17:45, KA 106

1. Background and relation to conference aim

The presented research and material development (on the classroom level and Professional Development (PD) level) is embedded in the project "*Language for Mathematics in Vocational contexts*" which is an Erasmus+ funded design research cooperation between Germany, the Netherlands, and Sweden (2017-2020). In three cycles of teaching material and PD material development, teaching and PD experiments, and exchanging modified materials between the project partners, topic-specific language-responsive teaching designs for young adults (mostly aged 16-22)

are developed (for three topics percentages, proportionality, and language of diagrams and graphs) and intertwined with the developed country-specific Professional Development programs for teachers at vocational schools.

Due to the relevance of language proficiency for achieving mathematical conceptual understanding, mathematics teachers are requested to arrange their classrooms in language-responsive ways. This requires teaching approaches which not only attend to language demands but also support language learners to develop language proficiency that is relevant to the subject matter being learned. As a consequence, the improvement of teachers' expertise in language-responsive teaching is an important goal in pre-service and in-service teacher education throughout all subjects, and especially in mathematics. In Germany, there is a huge interest in empirically investigating effects and conditions of success of language-responsive mathematics teaching approaches and designs (e.g. Wessel and Prediger 2013). On the PD level, learning pathways of teachers implementing language-responsive teaching approaches are investigated in design research studies on the facilitator level relying on a job-analysis approach (Prediger 2019). Understanding how teachers fulfill or are challenged by the relevant jobs for language-responsive mathematics teaching is important for designing, enriching and connecting PD activities in PD programs as well as scaling-up processes.

For the PD developmental work in this project, a double focus is put on understanding how classroom material must be designed to demand and support language in vocational mathematics classrooms and which corresponding PD activities have to be implemented in the accompanying PD program so that the material can unfold its potentials.

2. International research and practice perspective

The presentation is addressed from an international research and practice perspective: In the project, we follow a joint teaching approach for developing the language-responsive teaching units captured in core Design Principles. These design principles are realized in the developed teaching units, with the teaching materials developed collaboratively in several cycles of design experiments together with the involved teachers who experiment with the material. But since the teaching quality in the (mathematics) classroom is reached by teachers, not the teaching learning arrangements alone, high emphasis is put on the development of an accompanying PD program for professionalizing teachers how to implement the developed teaching unit.

The research relies on a conceptual framework for teacher expertise in language-responsive mathematics teaching, starting from typical situational demands that teachers face in language-responsive mathematics teaching and the orientations, categories, and pedagogical tools they need to cope with these situational demands, especially the demand to identify mathematically relevant language demands (Prediger 2019).

3. Material Dimension: Teaching designs for understanding proportionality and fulfilling demanding discourse practices

The core of the project are iteratively developed language-responsive teaching units and PD activities. In this presentation, we concentrate on the teaching unit proportional reasoning and what teachers have to know and learn in order to achieve the core content goals while also accounting for demanding, supporting and developing language. Proportionality belongs to the multiplicative conceptual field and is one important concept to be developed in middle school mathematics. "Proportional reasoning refers to detecting, expressing, analyzing, explaining, and providing evidence in support of assertions about proportional relationships. (Lamon 2007, p. 647). Lamon further unfolds the notion of understanding proportionality, which - amongst others - also entails "the development and use of the language of proportionality" (ibid., p. 639). In our research on the classroom level we developed a conceptual learning trajectory and related this to the necessary

language learning. Based on this, corresponding PD activities have been developed and will be in the fore of the presentation while pursuing the following questions:

- How do teachers adapt language-responsive teaching designs and material for teaching proportionality in vocational contexts?
- What do teachers need to know in order to demand and support language in classroom discourse on understanding proportionality?

4. Description of the format

We present the overall teaching approach with core design principles. By drawing on empirical insights into the classroom video data, we show how different teachers adapt the teaching designs and which challenges they face in classroom interaction to draw conclusions on the PD level. The presentation should be followed by a workshop of our project partners (Vincent Jonker, Freudenthal Institute).

Acknowledgements

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References

Lamon, S. J., 2007, Rational numbers and proportional reasoning: Toward a theoretical framework. In F. Lester (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 629-668). Charlotte, NC: Information Age Publishing.

Prediger, S., in print for 2019, Investigating and promoting teachers' expertise for language responsive mathematics teaching. To appear in Mathematics Education Research Journal.

Prediger, S., Wessel, L., 2013, „Fostering German language learners' constructions of meanings for fractions – Design and effects of a language- and mathematics- integrated intervention". Mathematics Education Research Journal*,* *25*(3), pp. 435-456.

Influence of the implementation of STEM workshops on the learning and emotions of primary school pupils – Structural Dimension

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1. Introduction

STEM (Science, Technology, Engineering and Mathematics) education has been a focus of attention in recent years (Bybee, 2010; Kennedy and Odell, 2014). As some studies indicate, it is necessary to integrate STEM areas in order to promote interdisciplinary teaching of these subjects and to foster a scientific-technological culture in students at all educational levels (Slavit, Nelson and Lesseig, 2016). This need to rethink scientific-technological education becomes more relevant from the first school years, since at this stage the first emotions towards these areas begin to be constructed, and as some authors point out, the affective domain influences the cognitive domain and vice versa (Osborne, Simon and Collins, 2003). Along these lines, it would be interesting to implement practical activities in classrooms to stimulate the understanding of scientific concepts, maximizing the effectiveness of learning and fostering student attitudes to these contents through recreational science practices (Martínez, Naranjo, Mateos and Sánchez, 2018). Based on this, in this research STEM workshops

were designed and implemented in the primary classroom with the purpose of validating their didactic use in terms of learning and emotions.

2. Methods

The research followed a quasi-experimental, quantitative design, with control group, experimental group, pre-test and post-test. The main objective of the research was to analyse how the implementation of STEM workshops in the science classroom in formal contexts influences the learning and emotions of primary school students. The randomly selected sample consisted of 148 primary school students between the ages of 9 and 12. These subjects were divided into two groups, a control group (CG) formed by 74 students and an experimental group (EG) formed by 74 students. The purpose was to compare both the learning and the emotions experienced by the subjects during the process of teaching STEM contents by means of two different didactic methodologies. In the control group a traditional didactic intervention was used and in the experimental group a practical didactic intervention based on the development of STEM workshops. Two measuring instruments were designed. One was used as a pre-test to evaluate the initial level of knowledge of the participating sample and the other as a post-test to check the influence of the different didactic interventions on the learning and emotions of the students.

3. Results

Curriculum contents that the students had not studied before were chosen, revealing in the pre-test of both groups a low level of initial knowledge, with no statistically significant differences between the two. This guaranteed us a homogeneous starting point between both groups. However, the grades obtained in the post-test after the didactic interventions improved both in the control group and in the experimental group, reaching scores higher than 5 points out of 10 in both groups. Specifically, the CG scores 5.55 points out of 10 with a standard deviation of 1.57 and the EG scores 7.22 points out of 10 with a standard deviation of 1.52. To establish the significance between the average scores of both groups, an inferential analysis was carried out with a Student's t-test. The results revealed the existence of a difference between groups of 1.67 points out of 10, being statistically significant (Sig. < 0.001) and in favor of the experimental group that worked with the STEM workshops developed.

In addition, with regard to the emotional variable, it should be noted that after the didactic intervention, the students in the experimental group showed a higher frequency of positive emotions and a lower frequency of negative emotions, as opposed to the students in the control group. Specifically, primary students are more predisposed to manifest positive emotions after the development of STEM workshops, significantly increasing (Sig. < 0.05) emotions such as *fun*, *interest*, *joy* or *confidence* and decreasing negative emotions such as *stress*, *worry*, *anxiety* or *sadness*.

3. Conclusion

The results reveal that didactic interventions, both traditional and experimental, improve the level of knowledge of students. However, there are statistically significant differences in favour of the experimental group, both in the cognitive and affective variables. It is concluded that developing hands-on STEM experiences can promote significant learning and avoid vocational decline in these areas, since this type of didactic innovation allows learning STEM content in a playful and recreational way, as some authors point out (Martínez, Naranjo, Mateos and Sánchez, 2018). Learning can be strengthened by including practical activities that integrate in an interdisciplinary way contents of science, technology, engineering and mathematics, from the first school stages (Becker and Park, 2011).

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References

Becker, K. & Park, K., 2011, "Effects of integrative approaches among science, technology, engineering, and mathematics (STEM) subjects on students' learning: A preliminary meta-analysis", Journal of STEM Education, Vol. 12, pp. 23-37.

Bybee, R. W., 2010, "Advancing STEM Education: A 2020 Vision", Technology and Engineering Teacher, Vol. 70, pp. 30-35.

Kennedy, T. J., & Odell, M. R. L., 2014, "Engaging students in STEM education", Science Education International, Vol. 25, pp. 246-258.

Martínez, G., Naranjo, F. L., Mateos, M. and Sánchez, J., 2018, "Recreational Experiences for Teaching Basic Scientific Concepts in Primary Education: The Case of Density and Pressure", EURASIA Journal of Mathematics, Science and Technology Education, Vol. 14, pp. 1-16.

Osborne, J., Simon, S. & Collins, S., 2003, "Attitudes towards science: a review of the literature and its implications", International Journal of Science Education, Vol. 25, pp. 1049- 1079.

Slavit, D., Nelson, T. H., & Lesseig, K., 2016, "The teachers' role in developing, opening, and nurturing an inclusive STEM-focused school", International Journal of STEM Education, Vol. 3, 1-17.

Cognitive, affective, competential and didactic analysis of the development of STEM projects in the primary education teacher training stage – Structural Dimension

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Monday, 7 October 2019, 16:55-17:45, KA 101

1. Introduction

Several studies (Van Aalderen, Walma, and Asma, 2012) warn that a considerable percentage of students in the initial training stage as primary school teachers have low levels of knowledge and training in STEM subjects (Science, Technology, Engineering and Mathematics). Some studies indicate that this group had negative experiences in their school stage towards learning these areas, which has led them to negative attitudes and emotions (Mellado et al., 2014). Likewise, they do not feel competent to teach scientific-technological contents to their future students, showing low levels of teaching self-efficacy (Kazempour, 2014). Therefore, during teacher training, active methodologies should be integrated that promote the acquisition of STEM competencies and improve teacher self-efficacy beliefs and abilities to teach these contents in an interdisciplinary way (Adams, Miller, Saul and Pegg, 2014). In the research carried out, didactic projects were developed and implemented with a sample of teachers in training in order to contribute to an improvement in STEM education from the first school stages. This group will be responsible for promoting the acquisition of these skills in future students, being able to promote STEM vocations, which are essential as many studies warn (Bybee, 2010).

2. Methods

A quasi-experimental, mixed design was followed, with pre-test and post-test. The general objective was to analyze the evolution of the cognitive, affective, competential and didactic domain during the development of STEM projects. The sample, selected by means of non-probability sampling due to the ease of access to it, was made up of 142 future primary school teachers who were in the last year

of their formative stage. 80% come from a high school degree in social sciences or humanities and over 75% are women. The study variables were related to cognitive, competence, affective and didactic factors in order to analyze the influence of the development and implementation of STEM projects in this group. The participating subjects were divided into subgroups of 3-4 components and had to design and implement a STEM didactic project that would be applicable to the primary classroom (9-12 years old). The purpose of each project is to promote the acquisition of the scientific, technological and mathematical components of the students, in order to help promote STEM vocations among these groups. As measuring instruments, questionnaires were designed and implemented as pre-tests and post-tests to measure the evolution of the variables under study after the implementation of the projects. In the pre-test it was intended that the teacher in training carry out an initial analysis on the teaching and learning of STEM areas (emotional factors, teacher competence and a diagnosis of knowledge). In addition, a post-test was designed and implemented at the end of the didactic interventions to reflect on cognitive, affective and teacher self-efficacy factors.

3. Results and conclusions

The development of the experience led to the elaboration of 45 STEM projects that can be implemented in the primary classroom. From the data extracted in the measuring instruments, it was possible to analyze the evolution of the different variables (cognitive, competential, affective and didactic) in the participating subjects. The initial diagnosis of the teaching-learning of STEM areas revealed very low levels of knowledge and skills. It was also found that this group had very low levels of teacher self-efficacy, which in turn were positively and significantly correlated with the low levels of knowledge shown. With respect to affective domain, negative emotions such as *Insecurity*, *Boredom*, *Stress*, *Anxiety* or *Concern* about teaching and learning STEM areas initially manifested in the pre-test. However, the results obtained in the post-test after the STEM projects revealed a statistically significant increase (Sig. < 0.05) in the frequency with which they experienced positive emotions (*Interest*, *Curiosity*, *Joy*, *Enthusiasm*, *Intrigue*, *Tranquility*, *Satisfaction*, *Surprise* or *Fun*). Likewise, negative emotions manifested previously such as *Worry*, *Stress*, *Nervousness*, *Sadness* or *Anxiety* significantly decreased (Sig. < 0.05). On the other hand, with respect to the evaluation made by the participating subjects of the usefulness of STEM projects to improve their levels of teacher competence or self-efficacy, the data show that a high percentage consider it very useful (57.7%) or totally useful (30.3%). Likewise, they consider it very useful to improve their learning as teachers (60.9%) and to improve the STEM learning of their future students (71.4%).

The results obtained reveal an improvement in the initial development of the teacher in training from three perspectives: attitudinal-emotional, competence-cognitive and didactic. It is concluded that STEM projects in an integrated teaching-learning format can lead teachers in training towards positive attitudes towards STEM learning and teaching. It is concluded that it is necessary to develop STEM projects that allow these competencies to be worked on at all levels of the education system, including the training of future teachers, in order to improve cognitive and emotional domain. This group will be responsible for promoting the acquisition of scientific-technological skills in the students of future generations, which may lead to promote future scientific vocations, as necessary as many European reports warn.

Acknowledgements

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References

Adams, A. E., Miller, B. G., Saul, M. & Pegg, J., 2014, “Supporting elementary pre-service teachers to teach STEM through place-based teaching and learning experiences”, Electronic Journal of Science Education, vol. 18, pp. 1-22.
Bybee, R. W., 2010. “Advancing STEM Education: A 2020 Vision”, Technology and Engineering Teacher, Vol. 70, pp. 30-35.
Kazempour, M., 2014, “I Can’t Teach Science! A Case Study of an Elementary Pre-Service Teacher’s Intersection of Science Experiences, Beliefs, Attitude, and Self-Efficacy”, International Journal of Environmental and Science Education, Vol. 9, pp. 77-96.
Mellado, V. et al., 2014, “Emotions in Science teaching”, Enseñanza de las ciencias, Vol. 32, pp. 11-36.
Van Aalderen, S. I., Walma, J. H. & Asma, L. J., 2012, “Primary teachers' attitudes toward science: A new theoretical framework”, Science education, Vol. 96, pp. 158-182.

Study about self-efficacy of teachers in training in their performance as science teachers – Personal Dimension

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1. Introduction

Currently, we live in a constantly changing world. That is why is required to train the citizens to be able to adapt to new environments and to find the solution to the possible problems that may arise. A solid background in science will make it easier for them to make good decisions and form critical thinking. Science and technology are present in almost every aspect of our lives and the existence of qualified people is quite necessary for society (Vazquez_A and Manassero_MA 2008).
In this context, the role of the teachers is key. Nevertheless, if teachers don’t feel able to doing their job because of their science background is not good, the correct transmission of these contents will not be possible (Mellado_V et al. 2014).

The University of Extremadura has been working for years in the initial formation of Primary teachers. At the third international conference “Educating the educators” we want to contribute with the initial stage of a doctoral thesis. We think that the self-efficacy of teachers is a very important piece of the teaching and learning process and educating science educator become a fundamental part of their future teaching work.
In this study, we would like to know about the self-efficacy of teachers training when they teach sciences, that’s why we choose the first topic to explain our work, self-efficacy is a personal dimension of educating course leaders.
The first objective of investigation was to know if men and women have the same self-efficacy when they teach sciences. The second objective was to differentiate contents in Physics, Chemistry, Mathematics, Biology and Geology and to see if there is a relationship with them previous academic education (sci-tech or humanities).

2. Methodology

This is an exploratory descriptive study, in which a type of survey research has been carried out. The sample has been chosen by means of a non-probability convenience sample. The reasons that support this decision are based on the availability of time and cases. The sample is composed of 47 teachers in training (55% female), they are in the second year of the Degree in Primary Education (4 years). SPSS has been used to analyse the data.

3. Results and discussion

A student T test has been applied to check if there were differences in self-efficacy by gender and any significant differences were found (Table 1). However, in all cases men feel more capable than women when it comes to imparting scientific content, although is only significant for the case of chemical content associated with "chemical reactions: combustion, oxidation and fermentation" with a p-value <0.05. Vázquez and Manassero (2008) don't find gender differences in their studies either.

	Previous studies	Mean	Std. Error Difference	Sig.
Mean of ability	Humanities	5.904	0.6284645	0.210
	Sciences	6.690	1.3425659	0.175

Table 1. Independent sample test by gender

In order to know whether there were differences according to the background science studies, student T test was carried out and we obtained p-value=0,210 (Table 2) so no significant differences were found between self-efficacy and the previous studies.

	Sig. (2-tailed)	Mean difference in gender	Std. Error Difference	95% Confidence Interval of de Diffence	
				Lower	Upper
Mean of ability	0.178	0.630	0.461	-0.298	1.558

Table 2. Independent sample test by previous studies

Teachers in training have beliefs, attitudes and emotions towards the teaching-learning of the different subjects because of their previous education (Mellado et al., 2014).

4. Conclusions

Results of the study of Brígido and Borrachero (2011) show the importance of studying students' own beliefs for teachers about their self-concept and self-efficacy as science teachers. The self-efficacy of a group of teachers in training has been studied to know if there exist some differences by gender or by their previous education. We find that self-efficacy is the same for students with a background in sciences and in humanities and we don't find significant differences by gender, we only found differences in self-efficacy in one topic of chemistry.

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References

Brígido_M M., Borrachero_ B C, 2011, "Relación entre autoconcepto, autoeficacia y autorregulación en ciencias de futuros maestros de primaria", Psicología emocional. Psicología positiva, Vol. 01 (02), pp 107-113.

Mellado_V., Borrachero_B C, Brígido_M., Melo_L V., Dávila_M A., Cañada_F., Conde_C., Costillo_E., Cubero_J., Esteban_R., Martínez_G., Ruíz_C., and Sánchez_J., 2014, "Las emociones en la enseñanza de las ciencias", Enseñanza de las Ciencias, Vol. 32 (3), pp 11-36.
Vazquez_A., Manassero_M A, 2008, "El declive de las actitudes hacia la ciencia de los estudiantes: un indicador inquietante para la educación científica", Eureka, Vol. 5 (3), pp 274-292.

Preparing to lead a learning community: A study of mathematics and science CPD leaders in Malta – Personal Dimension

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1. Introduction

This oral paper reports a study related to the personal dimension of educating the educators and focuses on the needs and experiences of a group of continuing professional development (CPD) leaders. These CPD leaders facilitated teacher learning communities during a six-month programme as part of the MaSDiV (Supporting Mathematics and Science teachers in addressing Diversity and promoting fundamental Values) project focusing on the use of inquiry-based learning (IBL) for addressing cultural and achievement-related diversity, using real-life contexts. In preparation for this role, CPD leaders participated in a specially designed course.

2. Background

Helping teachers with the implementation of IBL, dealing with diverse achievement levels and the teaching of fundamental values is no easy feat. Teachers often have to deal with challenges such as lack of resources, demands of curricula and other systemic factors (Anderson, 2002). But perhaps the most significant factors are teachers' own beliefs and attitudes (Anderson, 2002) and their experience of implementation (Guskey, 2002). A course aimed at encouraging teachers to implement IBL needs to address these beliefs and attitudes.

The situation is more complex in the context of the course described in this study. Not only was it necessary to prepare CPD leaders to guide teachers, but CPD leaders needed to acquire knowledge and skills and to examine their own beliefs too before they were able to guide the teachers they were leading. CPD leaders' influence and effectiveness has been attributed to the leaders' own personality, management, motivation, support, evidence and professionalism (Linder, 2011) as well as to specific skills such as good understanding of IBL and experience of using IBL, very good knowledge of subject content and pedagogy and familiarity with the school context (Farrugia, 2015).

Several sources report on features that influence effectiveness of CPD programmes (Capps et al., 2012) such as duration of the programme (Garet et al., 2001), type and extent of support provided and opportunities for reflection (Darling-Hammond and Mc Laughlin, 1995) and use of a constructivist sociocultural approach (Brand and Moore, 2011).

For these reasons the course for CPD leaders attempted to introduce leaders to IBL, to the main concepts behind the programme and also to help them develop skills needed to lead teachers. The course allowed participants to discuss pedagogical issues and engage reflectively about their role within a learning community.

3. The study

The CPD course design was evaluated from the CPD leaders' perspective. The study reported in this paper investigated whether the course design was effective in facilitating the acquisition of the intended knowledge and skills and in providing adequate learning support to participating teachers, according to the CPD leaders.

Pre- and post- CPD questionnaires were administered to all participating CPD leaders. The questionnaires sought information about the leaders' prior experiences, personal expectations, perceived benefits and challenges faced. The responses were analysed in order to identify key themes in the data.

4. Findings

Thirteen Mathematics and 13 Science CPD leaders with a range of teaching experience participated in the study. Most had prior experience in leading a group (73.1%) and teaching in a multicultural classroom (61.5%). However, half the group had no prior experience in IBL.

CPD leaders regarded the online component, together with the face-to-face sessions as key aspects of the course design. The range of resources provided, the awareness about diversity and multicultural issues in the classroom, together with the development of practice-based knowledge were in turn considered as important main aspects of the course content.

With respect to the learning support provided to teachers in the CPD course, leaders considered collaborative planning and subsequently the organisation of professional learning communities as crucial aspect of the CPD course design. Furthermore, the course materials offered an excellent opportunity for reflection and classroom implementation. A number of systemic and school constraints affected their work in schools. These, together with other challenges encountered will be discussed in the presentation.

5. Conclusion

Overall, the design of the course was considered as an effective model for creating and cultivating communities of learners. It provided opportunities to reflect, share, discuss and collaborate with colleagues as well as exposure to novel pedagogical approaches. Some CPD leaders felt the need for further collaborative professional learning opportunities.

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References

Anderson, R.D., 2002. Reforming science teaching: What research says about inquiry. Journal of science teacher education, 13(1), pp.1-12.

Brand, B.R. and Moore, S.J., 2011. Enhancing teachers' application of inquiry-based strategies using a constructivist sociocultural professional development model. International Journal of Science Education, 33(7), pp.889-913.

Capps, D.K., Crawford, B.A. and Constas, M.A., 2012. A review of empirical literature on inquiry professional development: Alignment with best practices and a critique of the findings. Journal of science teacher education, 23(3), pp.291-318.

Darling-Hammond, L. and McLaughlin, M.W., 1995. Policies that support professional development in an era of reform. Phi delta kappan, 76(8), pp.597-604.
Farrugia, J. (2015) Long-term Teacher Professional Development: Lessons learnt from PRIMAS. In Maaß, K., Barzel, B., Törner, G., Wernisch, D., Schäfer, E., & Reitz-Koncebovski, K. Educating the educators: international approaches to scaling-up professional development in mathematics and science education.
Garet, M.S., Porter, A.C., Desimone, L., Birman, B.F. and Yoon, K.S., 2001. What makes professional development effective? Results from a national sample of teachers. American educational research journal, 38(4), pp.915-945.
Guskey, T.R., 2002. Professional development and teacher change. Teachers and teaching, 8(3), pp.381-391.
Linder, S.M., 2011. The Facilitator's Role in Elementary Mathematics Professional Development. Mathematics teacher education and development, 13(2), pp.44-66.

Scientix portal: An educational community of learning and practice – Material Dimension

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Monday, 7 October 2019, 17:50-18:15, KA 209

Scientix aims at creating and supporting a European community for Science Education and STEM subjects. The project which is now ten years old, already from the start tried to exploit new technologies and by creating an internet based portal managed to help in the creation of a digital community of educators, offering chances of searching and downloading educational materials, of communication, of exchanging good practices and training, using methodologies of distance education or in-person training.

Having all these features, the scope of this paper is to claim that Scientix project through the above portal, has fostered the creation of a community of practice of educators, offering opportunities for training and professional development.

Teachers' knowledge for teaching mathematics to braille readers – Personal Dimension

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1. Introduction and theory

Students whose primary medium for reading is braille (hereafter braille readers) use a braille display and Text–To–Speech (TTS) synthesizer for reading and processing mathematical text. Mathematical teachers need to have technological (TK), pedagogical (PK) and content (CK) knowledge and skills

(TPACK) to utilize the potential of these devices in mathematics education (Koehler, Mishra and Cain, 2013). Moreover, they need to have insight into the interaction between these components. To support mathematics teachers to improve their TPACK, a professional development (PD) course was designed. The following research questions were asked:

1. How does teachers' TPACK in mathematic for braille readers develop during a four-session professional development course?
2. Which characteristics of the professional development course were beneficial in helping teachers to develop TPACK knowledge and skills?

2. Methods

To answer the research questions a PD course was developed focusing on topics that arise from the TPACK model for mathematics teachers of braille readers. To answer the first research question, the results from pre- and post-course interviews and evaluation questionnaires were used. To answer the second question, two case studies were elaborated.

Five mathematics teachers, from two different secondary schools for visually impaired students, participated in this study. All were qualified teachers but only one was qualified in mathematics. They did not receive any training in teaching mathematics to braille readers prior to the PD course described in this study. About 30% of their students were braille readers; the other students were partially sighted. The classrooms were very small, consisting of six to eight students. Braille readers and partially sighted students were in the same class.

The course consisted of four sessions spread over three months. In the first two sessions, the focus was on reading and processing mathematical expressions with the braille display or TTS synthesizer. The topic of the third session was "Working with heterogeneous groups" and the importance of cooperative learning and learning to inquire (Maass and Doorman, 2013). The teaching and learning activities were presentations, discussions, modelling of one - to – one or classroom situations, providing student experiences (e.g. braille reading) and small-group work.

To address the first research question, the interviews and evaluation questionnaires were coded. For this study, the codes of the TPACK model were adapted (Koehler, Mishra & Cain, 2013). For example, PCK (pedagogical content knowledge) was defined as knowledge about how mathematics needs to be transformed for the learning and teaching of braille readers. For each question, the assigned codes from the pre- and post-course interviews were compared on frequency. To address the second research question, the case reports were used. For these reports, different sources of data were collected. We checked consistency by triangulating data from interviews, evaluation questionnaires and observations during the course. Finally, we analysed whether the intended learning goals of the course were achieved and which activities helped to achieve these goals.

3. Results

The first research question addresses the teachers' development with respect to their technological, pedagogical and mathematical knowledge and skills. Figure 1 summarizes the results of the application of the TPACK codes to the responses in the interviews. The first interview question was about the extra time needed to read and comprehend mathematical expressions. The second question was about the mathematical notation for braille readers. The last question was about the teacher's perception of confidence in the different domains of TPACK.

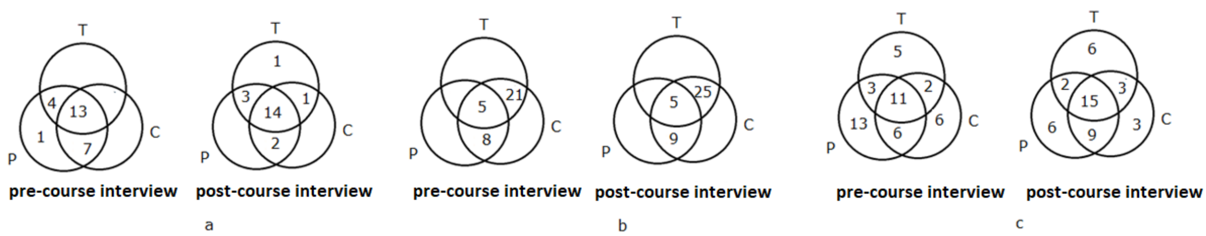

Figure 1. Teachers' total TPACK scores in the pre- and post-course interviews. Figure 1a, 1b and 1c show the assigned codes to the responses in the first, second, and third question respectively (T is technology, P is pedagogy and C is content).

The second research question addresses the characteristics of the PD course that were beneficial in helping teachers to develop TPACK knowledge and skills. The reports of the case studies show that the learning goals with respect to the braille display, the mathematical braille notation and mathematical vocabulary were achieved. Intended learning goals and underlying activities with respect to the TTS synthesizer and working with heterogeneous groups, however, did not emerge.

4. Conclusions and Discussion

The results show a small positive effect of the course. Understanding what teaching mathematics to braille readers embraces is expected to improve their learning. The teachers' knowledge of assistive technology and mathematics was less than expected. It was not possible to brush up the mathematics required for their teaching during such a short course. We conclude that content-related activities within PD courses need a subtle balance between building upon teachers' knowledge and providing applications.

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References

Koehler, M. J., Mishra, P., and Cain, W. (2013). "What is technological pedagogical content knowledge (TPACK)?", Journal of Education, 193(3), 13–19.

Maass, K., and Doorman, M. (2013). "A model for a widespread implementation of inquiry-based learning", ZDM Mathematics Education, 45(6), 887–899.

Multi-professional - description of professionalization processes of facilitators in mathematical education – Personal Dimension

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Monday, 7 October 2019, 17:50-18:15, KA 101

1. Theoretical Framework

The different roles of facilitators are substantiated in differentiated competence lists (e.g. Zaslasvsky 2008). Typical for a facilitator's work is the integration into different levels of professionalization in a school system. A model that reflects this level structure is the "threetetrahedron model of professionalization research", developed by the DZLM (Prediger et al. 2017). Facilitators are themselves "learners" at the facilitator PD level; involved in qualification courses. Knowledge of their competences is necessary at this level for adequate qualification.

For example, Borko et al. (2014) use their competence framework to describe the knowledge for facilitators as "Mathematical knowledge for Professional Development (MKPD)". They propose the

following three areas of competence of facilitators: specialized content knowledge, pedagogical content knowledge and learning community knowledge. This extended knowledge does not only refer to the new knowledge of mathematical content and the relevant didactic aspects, but also the didactic knowledge of general adult education. These include, e.g., knowledge about mentoring, existing practices of teachers (Even 2005) or current views on teacher education (Borko et al. 2014). It should be emphasized that there are also knowledge elements that are relevant for teachers but not for facilitators (Beswick & Chapman 2015), e.g. background knowledge about individual students.

Due to the heterogeneous frameworks that we were able to filter from our literature research, we also focused our perspective on general adult education within the framework of the DZLM. As part of the BMBF project “Basics for the Development of a Cross-Provider Recognition Procedure for the Competences of Teachers in Adult and Continuing Education“ a competence model GRETA (abbreviation in German) (Fig. 1) was developed based on a Delphi-survey by the German Institute for Adult Education (DIE) in a process of exchange with adult education experts (Lencer et al. 2016). It provides to be a framework for the education of adults in all fields of work. Adapting aspects from other frameworks with a focus on mathematics should lead to a suitable new one of facilitators, which essentially follows the structuring of the GRETA model.

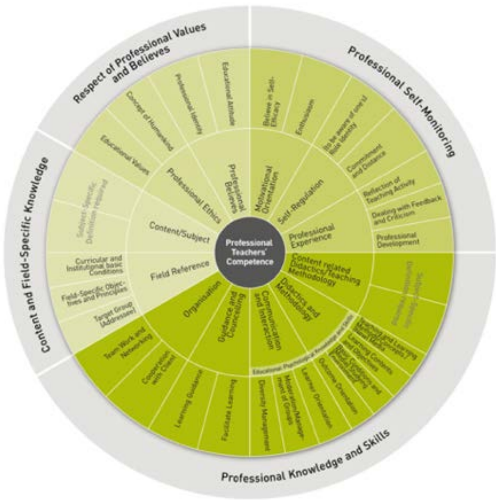

Figure 1. GRETA model (Lencer et al. 2016, p.7)

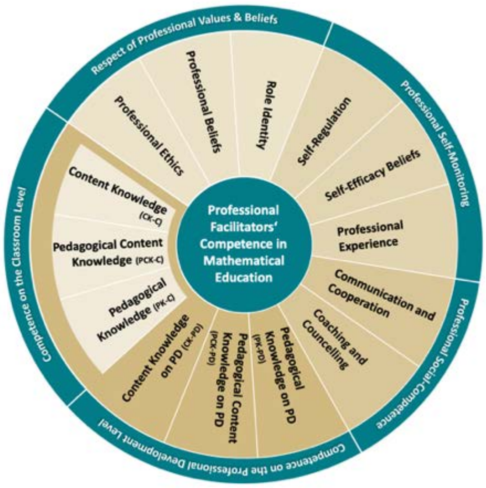

Figure 2. The new profile

In order to achieve a systematic further development with both perspectives, we developed a competence framework in an exchange process after a review of the relevant literature, in which researchers in mathematics education and important key stakeholders in mathematics education were involved. The new framework is intended to ensure that, in addition to mathematical competences, the special competences required for adult education are also taken into account. The framework offers orientation in development and research (Fig. 2).

2. Project *multi-professional*

2.1. Research Questions

Q1: Development of a test instrument – Which modifications and operationalizations must be carried out for a mathematics-specific test instrument?

Q2: Detection of the current status – Which competences of facilitators can be captured by the developed test instrument?

Q3: Describing the professionalisation processes – Which professionalization processes can be cover using the test instrument before and after qualification courses?

2.2. Research Design & Current Status

The aim of the project is to develop a test instrument, which captures the competences of the new framework for facilitators in mathematical education. Thus, the PortfolioPlus developed by DIE is concretized. In order to clarify which modifications and operationalisations need to be carried out (Q1), a first version of the test instrument was prepared during internal expert discussions. The test instrument provides a rough structure to capture all competences in closed and open items. Nevertheless, due to the development of a mathematics specific competence framework, significant changes have to be made here as well. The structure was adopted from PortfolioPlus and the items were selected to fit in the field. The new and modified items now have a mathematics-specific concretization with a partial focus on digital technology in mathematical education. To answer the research question 2 and 3 the test instrument is to be used before and after a qualification course with a focus on digitalization. A compressed online version of the test instrument has been used for a first preliminary study. This serves as the basis for the current revision phase. For example, formulations regarding the interpretation of participants need to be reviewed. In further interviews, the "think-aloud technique" and demand techniques are to be used for this purpose (Fowler 1995). The modifications of the test instrument will be presented at the conference as well as first results of the actual status of the competences of the participants before the qualification course.

References

Beswick K., & Chapman, O. (2015). “Mathematics Teacher Educators' Knowledge for Teaching”. In S. Cho (Eds.), *The Proceedings of the 12th International Congress on Mathematical Education*, Cham: Springer, 629-632.

Borko, H., Koellner, K., & Jacobs, J. (2014). “Examining novice teacher leaders’ facilitation of mathematics professional development”, *Journal of Mathematical Behavior*, 33, 149-167.

Even, R. (2005). “Integrating knowledge and practice MANOR in the development of providers of professional development for teachers”, *Journal of Mathematics Teacher Education*, 8(4), 343-357.

Fowler F. J. (1995). “Improving survey questions: design and evaluation.”, *Thousand Oaks*, California: Sage Publications, Inc.

Lencer S., & Strauch, A. (2016). „Das GRETA-Kompetenzmodell für Lehrende in der Erwachsenen- und Weiterbildung“, www.die-bonn.de/id/34407, online access 29.03.2019.

Prediger S., Leuders, T., & Rösken-Winter, B. (2017). „Drei-Tetraeder-Modell der gegenstands-bezogenen Professionalisierungsforschung: Fachspezifische Verknüpfung von Design und Forschung.“, *Jahrbuch für Allgemeine Didaktik*, 2017, 159-177.

Zaslavsky, O. (2008). “Meeting the challenges of mathematics teacher education through design and use of tasks that facilitate teacher learning”. In B. Jaworski, & T. Woods (Eds.), *The Mathematics Teacher Educator as a Developing Professional*, 4, 93-114.

Prospective mathematics teachers’ pedagogical approaches in dealing with diverse classrooms – Material Dimension

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Monday, 7 October 2019, 17:50-18:15, KG4 301

The present study aims to investigate how Prospective Teachers (PTs), who had been involved in a module on “Pedagogical approaches to mathematics and science teaching in multicultural classrooms” developed in the context of European Project (Inclusme-project.eu), tried to deal with

diverse classroom activities. 19 PTs' assignments were analysed using grounded theory techniques. The assignments were based on a task asking the PTs to identify one main challenge that mathematics teachers may face while teaching in multicultural classrooms and propose ways to deal with it in their lesson designs. The main challenges identified by the PTs concerned students' difficulties to cope with language demands, teachers' difficulty to evaluate students' understanding and contributions as well as to cope with the students' diverse cultural and mathematical backgrounds. Moreover, teachers' and students' stereotypic beliefs were brought up. In order to deal with these challenges, the PTs proposed many pedagogical practices concerning: the language of teaching and learning in the classroom; the integration of students' culture in the classroom; the creation of an inclusive classroom culture and the alignment of assessment practices to students' individual needs. Finally, all the PTs showed an awareness of the complexity of the culturally responsive teaching.

Math for All: Scaling-Up and Evaluating A Teacher Professional Development Program for Personalizing Mathematics Instruction in Grades K–5 – Structural Dimension

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Monday, 7 October 2019, 17:50-18:15, KA 106

1. Overview and Connection to Conference Theme

Math for All (MFA) is an intensive professional development (PD) program designed to help general and special education teachers in Grades K–5 to personalize rigorous mathematics instruction for a wide range of learners, including students who are low performing, and students with disabilities. A large-scale randomized controlled trial conducted in collaboration with Chicago Public Schools has established the efficacy of MFA for positively affecting teacher beliefs and practices and students' mathematics achievement (Duncan et al., 2018). With funding from the Education Innovation and Research (EIR) program of the U.S. Department of Education, we are currently working on a five-year effort to regionally scale up this program across a variety of settings and with diverse populations in the state of Illinois. The goal of this presentation is to share our strategies for scaling-up MFA, to describe our approach for researching these efforts, and to report preliminary findings. This presentation is well aligned with the conference theme as it focuses on mathematics teaching and learning, an innovative teaching approach (personalizing mathematics instruction for diverse learners), and the sharing of scale-up strategies such as building capacity among local staff developers and school leaders to implement a published teacher professional development program.

2. Perspective

The presentation will focus on scale-up and research practices and will be relevant to PD developers and providers, teacher educators, education administrators, researchers, policy makers. The design of the Math for All regional scale-up efforts builds on Coburn's (2003) framework for scale. Rather than simply defining scale up as an expansion the number of schools reached by an innovation, this

framework identifies four interrelated dimensions that are relevant for scale: depth, sustainability, spread, and shift to local ownership of an intervention.

3. Outline of Content and Subject Matter of Planned Presentation and Relation to Structural Dimension's Topics

Our main goal for this presentation is to share the strategies we are using in our large-scale effort to ensure the depth of implementation, sustainability, spread to a large number of teachers and students, and shift to local ownership of Math for All. After a brief description of the MFA program (goals, content and format, and evidence base), we will discuss challenges for scale-up, and the strategies we are using to address these challenges, including providing PD to local staff developers to enable them to implement MFA in their schools or districts, involving school leaders in the PD for local facilitators and teachers, require school-wide participation, embedding the PD for teachers into teachers' regular workday, work with regional PD providers to build local capacity, and provide access to a published, multi-media PD curriculum. We will also describe approaches for impact evaluation and implementation research and present preliminary findings about how our scaling strategies play out in different settings (rural and urban) and school contexts. We will conclude with a discussion of remaining challenges such as how to ensure fidelity of implementation and determining the generalizability of findings.

4. Structural Dimension Questions Addressed

We plan to address the following four key questions to address the structural dimension:

1. What does a design of an initiative aiming at a widespread regional implementation of innovative teaching of mathematics and for scaling up professional development look like?
2. What adaptations need to be made in scale-up approaches when implementing them in different settings and with different populations?
3. What challenges remain to be overcome even if such initiatives gain traction?
4. How can the impact and implementation of a scale-up effort be empirically investigated?

5. Format

This paper will be delivered as an oral presentation. Our focus will be on reporting practices. We will describe the scale-up strategies we are employing and the impact and implementation research that is accompanying our work. We will use the first 20 minutes of this session to presenting information about our project. During the last 10 minutes we plan to engage the audience in discussion using several questions prepared in advance.

Acknowledgements

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References

Coburn, C.E., 2003, "Rethinking scale: Moving beyond numbers to deep and lasting change.", Educational Researcher, Vol. 32(6), pp. 3-12.

Duncan, T. G., Moeller, B., Schoeneberger, J., & Hitchcock, J. (2018), "Assessing the impact of the Math for All professional development program on elementary school teachers and their students." Fredricksburg, VA: Deacon Hill Research Associates. Available from: http://go.edc.org/mfastudy

How do the 5E-model and the Nysgjerrigper method support or not support the implementation of inquiry-based learning at lower primary? – Material Dimension

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Tuesday, 8 October 2019, 10:00-10:45, KA 209

1. Introduction

This presentation relates to Topic 2 (Material dimension) and addresses to the question: "What are the features of materials for classrooms and/or PD that are suitable for promoting inquiry-based learning (IBL)?" As teacher educators, we design course materials for our pre-service teachers in initial teacher education (ITE), among others materials on IBL. Our aim is twofold: Firstly, to equip future primary science teacher with knowledge about IBL and competencies in teaching using the IBL approach. Secondly, by working with prospective teachers, we hope they will continue implementing IBL in their day-to-day science teaching once they finish their education, we aim thus at spreading the classroom IBL implementation at national level. In the design of our course, we used the 5E-model and the Nysgjerrigper method (explained below), to guide our pre-service teachers. This presentation deals with our investigation of the pre-service teachers' perspective on the use of the 5E-model and the Nysgjerrigper method. The material is meant to be used by teacher educators, hence the relevance to the overall conference theme (Educating the Educators) and to Topic 2; our presentation is addressed from target group-specific perspective, i.e. pre-service teachers' experience. We intend to use the oral presentation format.

2. Theoretical framework

Despite the good systemic support (KD, 2016), the implementation of IBL in classroom teaching the Norwegian primary schools have not been as broadly as intended. The Norwegian Center for Science Education has promoted the 5E-model (Bybee et al., 2006) as guide for planning and implementing IBL, clarifying the teachers' role and the students' role (Svendsen, 2015). The Norwegian Research Council has developed a teachers' guide to scientific methods, called The Nysgjerrigper Method (Norwegian Research Council, 2016) meant to assist teachers in developing teaching practices that promote inquiry. These guides are available for teachers' use, and in our study we used them in our courses designed for the pre-service teachers (PST).

In the Norwegian initial teacher education, practicum (i.e. PST are sent to placement schools to practice teaching) plays an equally important role as the theoretical study. The prospective teachers need to learn how to enact inquiry not purely based on theoretical ideas, but also through experiencing in the reality of the classroom (Crawford, 2014). PST practicum intend to bridge the gap between theory and practice (Allen et al, 2014), but the relevance of coursework in preparation for practicum has shown to be low during the first two years of ITE (Choy et al. 2014). In our study, we introduced PSTs to the 5E-model and the Nysgjerrigper method, and we asked the PST to plan a lesson using IBL approach, implement it at 1st or 2nd grade of primary school where they had their practicum (Allen et al. 2014), and reflected on the experience. Our research question was: *How do the 5E-model or the Nysgjerrigper method support, or not support the IBL implementation at lower primary?*

3. Method

We followed the design-based research principle involving cycles of design, enactment, analysis and redesign (Cobb et al., 2003). We have done three cycles within three consecutive school years, one

cycle per year. This paper gives an overview of the results of the data accumulated during these years.

3.1. Participants and Setting

The main participants of this study were primary school PST at the second year of their ITE. We worked with a new batch of PST each year. During the practicum, the PST worked in groups, and each group was supervised by a mentor teacher (MT) from the placement school. After the practicum ended, the PST came back to the university and we asked them to reflect on what went well or not and why (Nilsson, 2008; Mellado, et al.1998). In total, we have worked with 60-70 PST in 18 groups, having two-three week practicum in 12 different primary schools, and taught more than 250 6-8 year old students. The chosen topics consisted of: "senses", like sight, hearing, taste, smell and touch (6 groups), "digestive system" (3 groups), "floating and sinking" (3 groups), "autumn" (2 groups), and the topics "sound", "day and night", "windmill" and "oil in water" with 1 group each.

3.2 Data Collection and Analysis

We collected the lesson plans and the reflections from all 18 groups after the PST came back to university from the practicum. In addition, we distributed open-ended questionnaires to PST and MT and conducted semi-structured interviews. The PST interviews were done in-group, and the MT interviews were individual. Only those who were available and gave consent were interviewed. 8 questionnaires or group interviews of PST and 9 questionnaires or MT interviews were collected. All reflections and interviews were audio-recorded. We also conducted at least two classroom observations per cycle to see directly the implementation of the planned lessons. Together with the MT interviews, the classroom observation served as validation of the data from the PST, enhancing reliability beyond self-reporting. The collected data were analyzed qualitatively using thematic analysis (Braun and Clarke, 2016).

4. Results and discussion

Our preliminary analysis shows the 5E-model and the Nysgjerrigper method were good support in general in planning and implementing the IBL lesson. However, some pre-service teachers could conduct "cook-book-recipe-like activities", hence not inquiry-based, even though they used 5E-model, similarly for the Nysgjerrigper method. These teacher guides could either support or not support the IBL implementation, depending on how much the pre-service teachers managed to balance between the scaffold and the degree of freedom (Febri and Staberg, 2019). More results and discussion will be given at the oral presentation.

Acknowledgements

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References

Allen, J. M., and S. W. E. Wright, 2014, "Integrating theory and practice in the pre-service teacher education practicum", *Teachers and Teaching*, Vol. *20*(2), pp. 136-151.

Braun, V., & V. Clarke, 2006, "Using thematic analysis in psychology", *Qualitative Research in Psychology,* Vol.**3**, pp. 77-10.

Bybee, R. W., J. A.Taylor, A. Gardner, P. Van Scotter, J. C. Powell, A. Westbrook, and N. Landes, 2006, "The BSCE 5E instructional model: origins and effectiveness", Colorado Springs: BSCS.

Choy, D., A.F.L. Wong, K.C. Goh, and E.L. Low, 2014, "Practicum experience: Pre-service teachers' self-perception of their professional growth", *Innovations in Education and Teaching International*, Vol.*51*(5), pp. 472-482.

Cobb, P., J.Confrey, A. diSessa, R. Lehrer, and L. Schauble, 2003, "Design experiments in educational research", *Educational Researcher,* Vol.31(1), pp. 9-13.
Crawford, B. A., 2014, "From Inquiry to Scientific Practices in the Science Classroom", In: N. G. Lederman and S. K. Abell (Eds.), *Handbook of Research on Science Education, II* (Vol. New York, pp. 515-541): Routledge.
Febri, M.IM., and R.L. Staberg, 2019, "Pre-service teachers' challenges and affordances in implementing inquiry-based science teaching at lower primary", *Proceeding NPSE conference*, March 2019, Florence, Italy, available at https://conference.pixel-online.net/NPSE/ conferenceproceedings.php
Nilsson, P., 2008, "Teaching for understanding: The complex nature of pedagogical content knowledge in pre-service education", *International Journal of Science Education*, Vol. *30*(10), pp. 1281-1299.
Mellado, V., L. J. Blanco, and C. Ruiz, 1998, "A framework for learning to teach science in initial primary teacher education", *Journal of Science Teacher Education*, Vol. *9*(3), pp. 195-219.
Nysgjerrigper/Norwegian Research Council, 2016, *Nysgjerrigpermetoden* (The Nysgerrigper method). Teacher guide. Oslo: 07 Gruppen AS. https://nysgjerrigper.no/Artikler_Engelske/the_nysgjerrigper_method
Svendsen, B., 2015, "Mediating Artifact in Teacher Professional Development", *International Journal of Science Education*, Vol. 37(11), pp.1834-1854.

What should facilitators know about teachers' use of differentiating tasks for teaching mathematics?

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Tuesday, 8 October 2019, 10:00-10:45, KA 209

One of the key challenges for teachers is how to deal constructively with the increasing heterogeneity in the classroom. An important competence of teachers is thus the ability to adapt teaching to heterogeneous learning groups (adaptivity). In the following, "differentiation" is understood as any teacher strategy that aims to improve adaptivity. Differentation can be achieved by grouping learners according to their abilities or needs (Lou et al., 1996, critical discussion at PME 39: Forgasz, 2015). Another possibility is to remain in the whole-class setting and select and/or construct suitable tasks. However, the quality of the tasks plays a decisive role in the establishment of a differentiated instruction (Brändström, 2005). But which tasks are suitable for use in heterogeneous learning groups?

Studies show that tasks in mathematics education are not used effectively enough and that part of the potential of the tasks often remains unused (e.g. Hiebert et al., 2003). On the other hand, tasks often have only a low cognitive activation potential (e.g., Jordan et al., 2008). To judge the quality of tasks, one can refer to a number of features. We focus on features of tasks that are suitable to address learners with different skills / prior knowledge. We call this focus "differentiation potential" (Leuders, 2015).

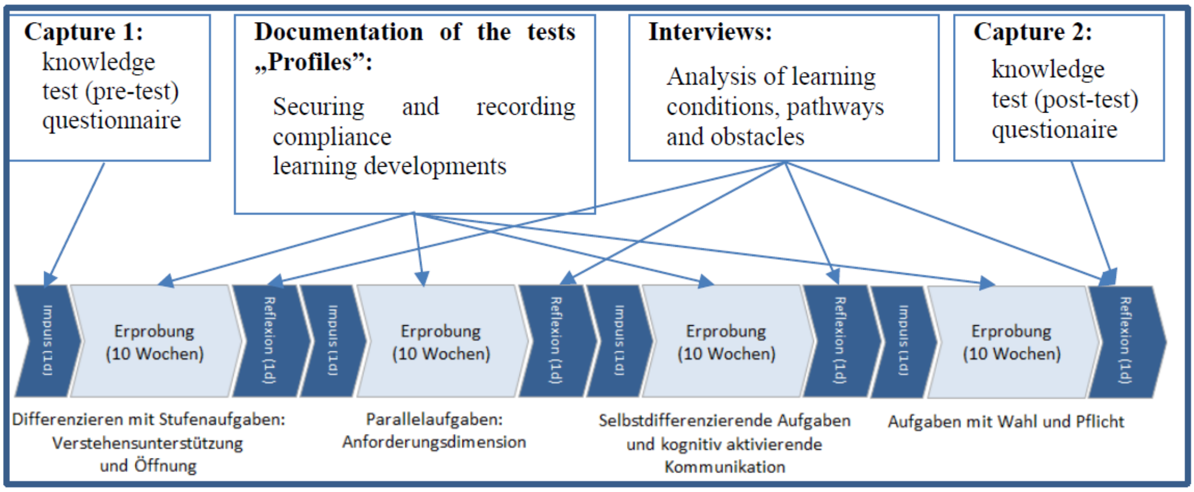

Figure 1. Structure of the training series and research instruments

The training was designed according to the DZLM criteria for training quality (DZLM framework). It is divided into four phases (see Fig. 1). Teachers should deal with the differentiation potential of tasks. They were trained in various aspects of tasks that point to a high potential for differentiation. Teachers should develop their view of tasks (especially textbooks) and develop the ability to change unsuitable tasks with regard to a differentiated use in the classroom in such a way that differentiation potential is increased.

First results answer the question as to what justifications teachers make when (not) selecting tasks in relation to the differentiated assignment before starting the training (Bardy et al., 2018, Holzäpfel et al., 2019). The presentation gives a detailed overview of the conception of the training series. In particular, it will be shown how teachers assess mathematical textbook tasks with regard to their potential for differentiation at the outset of the training. We ask: (A) What are the features of successful programs for educating course leaders? Which pitfalls have to be avoided? How can essential contents be identified and which activities are suitable to learn the contents? And (B) How can courses for course leaders look like that address cultural or achievement related diversity in class?
The training concept and the study will be presented in the form of a talk with the possibility of a discussion.

References

Bardy, T., Holzäpfel, L., & Leuders, T. (2018). Was wissen Mathematik-Lehrkräfte über das Differenzierungspotenzial von Aufgaben. *Beiträge zum Mathematikunterricht 2018*, 181-184. Münster: WTM-Verlag.

Brändström, A. (2005). *Differentiated tasks in mathematics textbooks: An analysis of the levels of difficulty* (Doctoral dissertation, Luleå tekniska universitet).

Forgasz, H. J. (2015). „Grouping Students by Attainment is essential for their Learning of Mathematics": A Debate. In K. Beswick, T. Muir & J. Wells (Eds.), *Proceedings of the 39th Psychology of Mathematics Education conference, Vol. 1,* 69-87.

Hiebert, J., et al. (2003). *Teaching mathematics in seven countries: Results from the TIMSS 1999 Video Study* (NCES 2003–013). Washington, DC: National Center for Education Statistics.

Holzäpfel, L., Leuders, T., & Bardy, T. (2019). Preparing in-service teachers for the differentiated classroom. *Proceedings of the 43rd Conference of the International Group for the Psychology of Mathematics Education*. Pretoria, South Africa: PME.

Jordan, A., Krauss, S., Löwen, K., Blum, W., Neubrand, M., & Brunner, M. (2008). Aufgaben im COACTIV-Projekt: Zeugnisse des kognitiven Aktivierungspotentials im deutschen Mathematikunterricht. *Journal für Mathematik-Didaktik, 29* (2), 83-107.

Leuders, T. (2015). Aufgaben in Forschung und Praxis. In R. Bruder, L. Hefendehl-Hebeker, B. Schmidt-Thieme, H.-G. Weigand (Hrsg.), *Handbuch der Mathematikdidaktik*, 435-460. Berlin, Heidelberg: Springer.

Leuders, T., & Prediger, S. (2016). *Flexibel differenzieren und fokussiert fördern im Mathematikunterricht*. Berlin: Cornelsen.

Lou, Y., Abrami, P. C., Spence, J. C., Poulsen, C., Chambers, B., & d'Apollonia, S. (1996). Within-class grouping: A meta-analysis. *Review of Educational Research, 66* (4), 423-458.

Policy shifts in primary mathematics professional development in England: hybrid roles and system leadership – Personal Dimension

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Tuesday, 8 October 2019, 11:30-11:55, KG4 301

Our contribution focuses on national change initiatives in school mathematics and specifically in the primary (4-11 years old) phase in England. We address the topic of the personal dimension of educating professional development leaders' roles and activities. We focus on three time periods and roles promoted through national policy during these times.

The first period we examine is the introduction of the National Numeracy Strategy from 1997 to around 2006. The National Numeracy Strategy was a research informed programme of improvement (Brown et al., 2003). A cascade model of training began with the training of a cadre of full-time numeracy consultants who subsequently led courses for school-based numeracy coordinators, who in turn led school based training using provided training materials (Corbin, McNamara & Williams, 2003). Although leading formal training was an important aspect of numeracy consultants' role, it extended beyond this to an ongoing advisory role in schools.

The second period we consider is 2007-2012, during which the National Centre for Excellence in Teaching Mathematics (NCETM) supported and promoted a variety of teacher led teacher enquiry groups and mathematics teacher networks. During this period, teacher leaders in hybrid roles (Margolis, 2012) would instigate or inter-school networks for practitioner-based research or to implement research informed change. Thus, the role is one of facilitator of professional learning. Their activity and role has been analysed through teacher and system leadership perspectives and social movement theory as adaptive leaders. To succeed these teacher leaders needed to innovate, to be responsive and purposeful, networkers and system workers (Boylan, 2018). System working points to the 'micro-politics' that may be involved in promoting mathematics education. In such roles in addition to knowledge and skills for teaching; facilitation skills and knowledge; and knowledge about professional development (Perry and Boylan, 2018), adaptive leaders also need knowledge about how to promote and develop professional development opportunities. In the English context, this is a performative and neo-liberal education system (Boylan, Adams, Coldwell and Willis, 2018), however, contextual issues we argue that contextual issues will be important elsewhere.

The third period is 2014 to the present and our focus is the role of the primary mathematics mastery specialists in England. In the English context, 'mastery' is the name used to refer to East-Asian informed teaching practices (Boylan and Townsend, 2018) which is currently central to government education policy in mathematics education (Boylan et al., 2019). The mastery programme is a research informed at scale reform programme - styled as expert-developed Shanghai informed mastery pedagogy. Whether the attempt to 'policy borrow' is advisable, or will lead to improvements

in outcomes, is questionable. Evidence from initial evaluation suggests that policy makers hopes may not be realised (Boylan et al. 2019), and there is evidence that East Asian success in comparative tests is in largely due to cultural issues. Nevertheless, the mastery programme is focusing attention on specific classroom practices for which there is evidence of efficacy - for example, greater and more varied use of models and representations (Boylan et al., 2018). However, the focus in our contribution is not whether the policy is a good one but rather on policy implementation.

The 'teaching for mastery' programme consists of interconnected activities, including the Primary Mathematics Specialist Teachers programme (PMSTP); 140 teachers join the two year programme annually. The programme includes online training/courses and six days of face to face training over three residential events. Half of the PMSTP teachers take part in a teacher exchange, spending one week in Shanghai and hosting a Shanghai teacher for two weeks. A mastery specialist is tasked with leading change in their own school and working with other schools through the creation of small collaborative professional development networks - styled as Teacher Research Groups (TRG) or work groups - and one to one mentoring or individual support to other teacher leaders. A TRG is informed by collaborative forms of development found in Shanghai, and provides a forum through which teachers share learning and experiences. The representatives from other schools taking part in TRGs are designated as 'mastery advocates'. We contend that the new role of the mastery specialist represents a hybrid between previous subject leadership roles in mathematics education in England with reform or improvement aims. As a hybrid role, mastery specialists are positioned at the boundary between the national and local; they are tasked with promotion and implementation of a nationally advocated pedagogy and at the same time with fostering teacher networks focused on developing local practices and ongoing collaborative professional development. This merges previous roles involving cascade of national system change with the more ad hoc and fluid 'system leadership from below' (Boylan, 2018).

Considering these three periods and roles we address topic questions related to:

- what are the tensions between local enactment and national policy in different leadership professional development leadership roles?
- how is enactment of these roles is influenced by other policy and systemic forces?
- what diverse forms of knowledge and skills, beyond those of subject knowledge, pedagogical subject knowledge, and professional development knowledge, are needed by professional development leaders?
- what are the forms of and constraints on the agency of professional development leaders in different roles and how does this relate to the types of professional learning they support?

References

Boylan, M. (2018). 'Enabling adaptive system leadership: Teachers leading professional development.' Educational management administration & leadership, 46(1), 86-106.

Boylan, M., Adams, G., Coldwell, M., Willis, B., & Demack, S. (2018). 'Theorising variation in engagement in professional and curriculum development: performativity, capital, systems and purpose.' Review of Education, 6(3), 360-407.

Boylan, M., Maxwell, B., Wolstenholme, C., Jay, T., & Demack, S. (2018). 'The Mathematics Teacher Exchange and 'Mastery' in England: The Evidence for the Efficacy of Component Practices' Educational Sciences. 2018, 8(4), 202; https://doi.org/10.3390/educsci8040202

Boylan, M. et al. (2019) 'Longitudinal evaluation of the Mathematics Teacher Exchange: China-England: Final report'. https://www.gov.uk/government/publications/evaluation-of-the-maths-teacher-exchange-china-and-england

Brown, M., Askew, M., Millett, A., & Rhodes, V. (2003). 'The key role of educational research in the development and evaluation of the National Numeracy Strategy'. British Educational Research Journal, 29(5), 655-667.

Corbin, B., McNamara, O., & Williams, J. (2003). 'Numeracy coordinators: 'Brokering' change within and between communities of practice?.' British Journal of Educational Studies, 51(4), 344-368.

Margolis, J. (2012). 'Hybrid teacher leaders and the new professional development ecology.' Professional development in education, 38(2), 291-315.

Perry, E., & Boylan, M. (2018). 'Developing the developers: supporting and researching the learning of professional development facilitators.' Professional development in education, 44(2), 254-271.

Outdoor science learning in a multicultural classroom: Students' perspectives – Material Dimension

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1. Introduction

This presentation relates to Topic 2 (Material dimension) and the following question: "How can materials look like that address cultural or achievement related diversity in class?" Within the Erasmus+ project IncluSMe (https://inclusme-project.eu/), we developed teaching modules linking science education and intercultural learning for initial teacher education. Our module highlights the potentials of arenas outside of school for science learning in intercultural context. We used targeted outdoor activities within the scope of education for sustainable development, visiting a park in a large city as the outdoor arena. Two partner countries piloted the material, and we implemented it in a multicultural classroom in an international science summer school organized as part of the project. This presentation deals with our investigation of the students' reflections after being taught using the material. The results of this study will inform us on how to further improve the material. The material is meant to be used by teacher educators, hence the relevance to the overall conference theme (Educating the Educators) and to Topic 2; our presentation is addressed from target group-specific perspective, i.e. pre-service teachers' experience. We intend to use the oral presentation format.

2. Theoretical Framework

Research literature suggests that science teachers feel unprepared to work with culturally and linguistically diverse students (e.g. Lee and Buxton, 2010) and pre-service teachers need more effective strategies to teach multicultural classes (Colón-Muñiz et al. 2010). Further, it is a cultural challenge in traditional science education to be able to take into account the students' social and language background (Meyer & Crawford, 2011).

Learning outside the classroom or outdoor schooling are concepts that are interpreted and used in different ways. Rennie (2007, pp. 140-142) tries to systematize the different ways of using the concept learning outside the classroom: *according to where you go*, e.g. field trips in rural areas, excursions in urban parks, museums, science centres, etc., *according to who is responsible for the out-of-classroom work*, e.g. schools, science centres, parents, or voluntarily organisations. In this study, we use a pragmatic approach where we include all sort of teaching outside the classroom as long as it is organized by the teacher.

Barker, Slingsby, and Tilling (2002) address the importance of doing science outside of school. Dillon (2006) and Nundy (2001) summarize the benefits of outdoor science: Positive effect on long-term memory, personal and social growth, mutual strengthening of the emotional (inclusive attitudes) and the cognitive, with the potential for higher order knowledge. Doing science outside the classroom also gives the students possibilities to develop their own potential for learning (McNeil, 2000). Although these studies on outdoor learning did not specifically address multicultural context, others (e.g. Lee and Luykx, 2007; Tolbert and Knox, 2016) suggest that teaching in situated and meaningful contexts could promote better science learning, better participation and positive attitudes in multicultural science teaching.

We investigated how a multicultural pre-service teacher group (from now on called "students") participating in a summer school responded to science lessons outside the classroom. Our research question is: *Which arguments do students after an international science summer school use to promote outdoor schooling in a multicultural classroom?*

3. Context and method

26 students from seven countries participated in the IncluSMe summer school "Intercultural learning in science education". The data consisted of written feedback from 24 students collected after lessons on intercultural science learning outside-of-school using the material described in the introduction. We collected feedback through: a) *open-ended reflection notes* answering to the following tasks: Reflect on how concretes from outdoor can help you to develop scientific language/knowledge of scientific concepts, and how they can have impact of cultural difference between students? Reflect on how all senses can be utilized, if language barriers appear. Reflect on what could be learnt from the fieldwork activity, regarding being a future teacher; b) *"post-it notes"* answering to the task: "Write two good reasons for using science outside school in a diverse classroom". We inductively categorized the feedback and counted how many statements related to each category were mentioned.

4. Results and discussion

Below we present the results of our analysis, Table 1.

Table 1. Categories of feedback and the number of statements related to each category

Categories	Mentioned in reflection notes	Mentioned on "post-it notes"
Language related (verbal, gests, senses/tactile)	20	9
Concretizing	9	3
Situated: Realistic /experience real life / relevant	10	17
Pre-during-after field work	2	
Sharing experiences	2	3
Science subject matter knowledge/concepts	6	
Activate / Motivate	2	4
Social aspects (relations)	6	12

Our findings show that a majority of the students appreciated the outdoor schooling because it broke down language barriers, was concrete and situated, and promoted social aspects. These findings are important aspects of teaching diverse student groups, with different cultural and language background. In the oral presentation we will discuss the students' statements in light of the literature (Dillon, 2006; Lee and Buxton, 2010; Nundy, 2001).

One limitation of the study is the formulation of the reflection note tasks, which invited the reflection on language and use of concretes. This might explain fewer answers in other categories, e.g.

motivation. We will discuss this in the oral presentation. We need to investigate further how outdoor schooling in a multicultural classroom could enhance science learning and how the students' experience can contribute in improving the teaching module (material).

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References

Barker, S., D., Slingsby and S. Tilling, 2002, "Teaching biology outside the classroom. Is it heading for extinction? A report on biology fieldwork in the 14-19 curriculum", Yorkshire: Field Studies Council/British Ecological Society.

Dillon, J., 2006, "The value of fieldwork", retrieved 26th March 2019 from: https://www.rgs.org/in-the-field/fieldwork-in-schools/the-value-of-fieldwork/

Colón-Muñiz, A., S. SooHoo and E. "Gigi." Brignoni, 2010, "Language, culture and dissonance: a study course for globally minded teachers with possibilities for catalytic transformation", Teaching Education, Vol. 21(1), pp.61–74.

Lee, O. and C.A. Buxton, 2010, "Diversity and equity in science education : research, policy, and practice". New York: Teachers College Press.

Lee, O. and A. Luykx, 2007, "Science Education and Student Diversity: Race/ Ethnicity, Language, Culture, and Socioeconomic Status", In: "Handbook of Research on Science Education", S.K. Abell and N.G. Lederman (Red.), pp. 171-197. New Jersey: Lawrence Erlbaum Associates.

Meyer, X. and B.A. Crawford, 2011, "Teaching science as a cultural way of knowing: merging authentic inquiry, nature of science, and multicultural strategies", Cultural Studies of Science Education, Vol. 6(3), pp. 525–547.

McNeil, L.M., 2000, "Contradictions of School Reform. Educational Costs of Standardized Testing", New York: Routledge.

Nundy, S., 2001, "Raising Achievement through the Environment: the Case for Fieldwork and Field Centres", Peterborough: National Association of Field Studies Officers.

Rennie, L.J., 2007, "Learning Science Outside of School", In: "Handbook of Research on Science Education", S.K. Abell and N.G. Lederman (Red.), pp. 125-167. New Jersey: Lawrence Erlbaum Associates.

Tolbert, S. and C. Knox, 2016, "They might know a lot of things that I don't know': investigating differences in preservice teachers' ideas about contextualizing science instruction in multilingual classrooms", Int. J. Sci. Ed., Vol. 38(7), pp. 1133–1149.

Investigating STEM Teachers' Initial Beliefs Entering a Professional Development Programme Addressing Diversity – Structural Dimension

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Tuesday, 8 October 2019, 11:30-11:55, KA 106

1. Introduction

Addressing achievement-related diversity in classrooms is a major challenge to teachers across the world (OECD 2014). Inquiry-based learning (IBL) provides an opportunity for teachers to address

achievement-related diversity through an active and independent engagement with science content for their students (Alfieri et al. 2011). To implement IBL successfully, it is essential that teachers have appropriate knowledge, as well as adequate beliefs about the benefits and strong self-efficacy beliefs (SEB) on the use of IBL for addressing achievement-related diversity (Kunter et al. 2013). In order to enable teachers to meet the challenges of implementing IBL purposefully, scaled-up professional development (PD) addressing teachers' knowledge, beliefs and SEB are needed. However, to support teachers accordingly, PD courses need to align the structural dimension of PD with teachers' prerequisites (e.g. prior experiences or initial beliefs). These prerequisites are influenced by the teachers' perception of the self as well as the environment shaped by culturally and socially shared norms and values (Talbot & Campbell 2014). Culturally shared norms and values are prominently classified into a more collectivistic or a more individualistic orientation of society (Hofstede 2001). In addition to cultural circumstances, institutional aspects (e.g. school and class context) and individual factors shape the actual learning experience of the individual and should therefore also influence the development of beliefs. Considering predictors on the individual, the institutional and the cultural level is a key aspect in developing appropriate PD programmes. Our research-based presentation therefore focuses on the impact of different influencing factors on teachers' beliefs and SEB entering a scaled-up PD addressing achievement-related diversity through the use of IBL.

2. Method

To investigate the impact of influencing factors on beliefs about the benefits and SEB on the use of IBL for addressing achievement-related diversity, we utilized data from teachers from six European countries participating in a scaled-up PD course on diversity. A total of N=385 teachers for lower secondary STEM subjects participated in the study (see Table 1), with an average age of 40 years (SD=11 years) and 64% female participants. In order to account for cultural differences, the countries were divided into a group with more individualistic views and a group with a more collectivistic value system, according to their Hofstede-Index Individualism versus Collectivism (IDV) (Hofstede 2001). Institutional and individual factors were assessed with adapted established items (e.g. Skaalvik & Skaalvik 2010).

Table 1. Sample composition and IDV of the country.

	Cyprus	Turkey	Spain	Malta	Germany	Netherlands
N	60	57	52	104	38	74
IDV	35	37	51	59	67	80

Teachers' beliefs about the benefits of IBL and SEB on the use of IBL for addressing achievement-related diversity were assessed with a newly developed instrument consisting of 4 items each. Both scales show adequate reliabilities ($\alpha_{Beliefs}$=.71, α_{SEB} =.70).

3. Results

For the beliefs, a significant difference was found between countries from different cultural backgrounds ($t(368)=2.23$, $p<.05$). Teachers in countries with a more collectivistic view report higher beliefs about the benefits of IBL for addressing achievement-related diversity (M_{ind}=3.28, M_{coll}=3.38, d=.23). Differences in SEB between the country groups were not significant. Additional regression analyses reveal influencing factors on individual, institutional and cultural level. For example, the cultural variable "PD need for teaching diversity" and the "perceived achievement-related diversity" as an institutional constituent show significant influences on both constructs. While teachers reporting a higher perceived achievement-related diversity declare higher beliefs and SEB, reported PD need for teaching for diversity has a different impact on beliefs than on SEB. The positive influence of a reported need for PD on teachers' beliefs indicates an awareness of the importance of the topic for the teacher, whereas a high need on PD suggests a certain insecurity with the topic that

could account for lower SEB on the use of IBL to address achievement-related diversity. Our results show that influencing factors for teachers' beliefs and SEB exist on all three levels.

4. Discussion and conclusion

Following our presumption of influencing factors' relation to teachers' beliefs about the benefit and SEB on the use of IBL for addressing achievement-related diversity, the presented study shows that beliefs and SEB are impacted by individual, institutional and cultural factors. This indicates the need for consideration of contextual characteristics in PD programmes designed to change or strengthen these constructs as a means to enhance teachers' professional behaviour in the classroom and ultimately promote more meaningful science and mathematics learning.

Acknowledgements

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References

Alfieri, L, Brooks, PJ, Aldrich, NJ & Tenenbaum, HR 2011, 'Does discovery-based instruction enhance learning?', Journal of Educational Psychology, vol. 103, no. 1, pp. 1–18.

Hofstede, G 2001, Culture's consequences. Comparing values, behaviors, institutions, and organizations across nations, Sage, Thousand Oaks.

Kunter, M, Kleickmann, T, Klusmann, U & Richter, D 2013, 'The Development of Teachers' Professional Competence' in Cognitive Activation in the Mathematics Classroom and Professional Competence of Teachers, eds M Kunter, J Baumert, W Blum, U Klusmann, S Krauss & M Neubrand, Springer US, Boston, MA, pp. 63–78.

Skaalvik, EM & Skaalvik, S 2010, 'Teacher self-efficacy and teacher burnout. A study of relations', Teaching and Teacher Education, vol. 26, no. 4, pp. 1059–1069.

OECD 2014, TALIS 2013 Results, OECD Publishing.

Talbot, J & Campbell, T 2014, 'Examining a teacher's negotiation through change. Understanding the influence of beliefs on behavior', Teacher Development, vol. 18, no. 3, pp. 418–434.

Utilizing Data from International Achievement Studies in Teacher Professional Development in Science – Personal Dimension

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Tuesday, 8 October 2019, 11:30-11:55, KA 102

1. Introduction

The growing importance of science and science education worldwide is clearly evident in the emphasis placed in these subjects in developed countries across the world (Duschl, Schweingruber & Shouse, 2007), as well through their links with a country's human capital. A country's human capital is often determined by the quality of schooling and quality according to Woessmann (2006) is measured by performance on cognitive achievement tests. These cognitive achievement tests have shown to exert an impact on the level of economic development (Hanushek & Kimko, 2000) and for Cyprus these measures, especially in science and mathematics have been consistently low during the last decades (World Bank Report, 2014). Despite various curriculum reform efforts in Cyprus during

the last decades, assessment scores in science remain low. Given the importance of teacher professional development and the opportunity to use data from international studies, the purpose of this paper is to show how data from the Trends in International Mathematics and Science Study (TIMSS) were used for a professional development workshop focused on helping teachers identify reasons that could explain the low achievement of Cypriot students in science, and propose ways to support them in science.

2. The workshop

As a way to support teachers' understanding of the underlying reasons for the low scores of Cyprus in TIMSS science, a professional development workshop was developed for elementary school teachers in Cyprus in 2017. According to Gess-Newsome, Taylor, Carlson, Gardner, Wilson and Stuhlsatz (2017), students' outcomes in science should be used as part of teacher professional development programs as a way to empirically help teachers reflect on their teaching practices and improve them. The workshop was collaboratively developed by academics in science education and measurement. The workshop was structured around three main components: a) Introduction to TIMSS; b) Reflecting on students' responses; and c) Strategies to support students. The workshop took place in January and February 2018 and was compulsory for all teachers who act as coordinators for science lessons in elementary schools. Of the 346 teachers that participated in the workshop, some had experience with TIMSS as their students had participated in the study in the past. The workshop took place during school time and had a total duration of five hours. A detailed description of the workshop will be provided during the conference.

3. Results

In the first part of the workshop, a poll took place among the workshop participants in order to gather their pre-existing views on the reasons due to which the performance of the Cypriot elementary school students in TIMSS science was inadequate. According to the results of the poll, the reason that was selected by the majority of the teachers (35%) was the student's difficulty in reading the instructions for the test items. The second most frequently selected reason (25%) was that these students did not have a lot of skills in answering such tests. Twenty-two percent of the participants indicated that the terminology that was used in the science items was the reason due to which the Cypriot students did not perform adequately. Finally, 11% indicated that the students did not have enough motivation to do well on the test, while 6% indicated that the low results were due to the lack of science content knowledge. At a later stage of the workshop, the qualitative descriptions of the discussions that took place were summarized, while emphasizing the variety of reasons that were used to explain the performance of the Cypriot students on each item. Based on this summary, a number of distinct patterns emerged. First of all, the wording of specific items was a significant factor that could explain part of the performance of students. In some items for example, the terminology that was used was more scientific and differed from the everyday terminology that is typically used by the students in their everyday life. As a result, this more unfamiliar terminology might have been one factor that could potentially explain the unsatisfactory results on some test items. In addition to problems with terminology, the students also tended to have difficulties in the reading and comprehension of text-intensive items that were quite lengthy. So, students from Cyprus were either not able to properly comprehend these items or were less likely to make an effort to read and answer them correctly.

A second and very important finding from the workshop verified the fact that Cypriot students tended to do better on the items that included scenarios that were closer to their everyday experiences. For example, due to the climate of Cyprus, the students appeared to be very knowledgeable of how to protect themselves and their skin from the sun and performed quite well on items related to this issue. The positive results on the items related to their experiences were found even with items whose content was not included in the science curriculum up to the fourth

grade and thus were never taught in the classroom. Moreover, as expected, the Cypriot students did less well on items with content that was not related to their experiences or the local context.

4. Conclusions

Overall, this professional development workshop could be considered as an effective way of using empirical data from international studies for professional development. The presentation of the restricted-use items along with the percentage of correct responses drew the teacher's attention to the main building block of these assessments (the items) and away from discussions on the usefulness of league tables and a country's rank. This also gave them the opportunity to reflect on possible reasons due to which our students did not do well on certain items, while allowing them to make connections between their teaching practice and student content knowledge misconceptions. Specifically, the teachers highlighted difficulties with language skills and lack of experiences as important reasons for students' low achievement. Researchers in science education have repeatedly highlighted these reasons, but according to the teachers, the local science curricula does not place an emphasis on the aspect of language and terminology. Since TIMSS also has a mathematics component, this model could be replicated in other subjects as well.

References

Duschl, R., Schweingruber, H. & Shouse, A. (2007) Taking Science to School. (National Research Council, Ed.). National Academies Press. Retrieved from European Commision (2004). Europe Needs more Scientists (pp. 1–24).

Gess-Newsome, J., Taylor, J., Carlson, J., Gardner, A. Wilson, Ch. & Stuhlsatz, M. (2017) Teacher pedagogical content knowledge, practice, and student achievement, International Journal of Science Education, DOI: 10.1080/09500693.2016.1265158

Hanushek, E. & Dennis D. (2000) Schooling, Labor-Force Quality and the Growth of Nations. *American Economic Review,* Vol. *90,* No. 5, pp.1184–1208.

Word Bank Report (2014) *Analysis of the Function and Structure of the Ministry of Education and Culture of the Republic of Cyprus*. The World Bank.

Woessmann, L. (2006) Growth, Human Capital and the Quality of Schools: Lessons from International Empirical Research, *Strategies for Employment and Growth in Austria*, Vol. 10, pp. 74-98.

Mathematics & Inclusion – a Professional Development Program on Inclusive Maths Classes in Rhineland-Palatinate (Germany) – Structural Dimension

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Tuesday, 8 October 2019, 12:15-12:40, KG4 301

1. The project “Mathematics & Inclusion”

About 25 teachers from different types of schools in Rhineland-Palatinate participate in the professional development (PD) program “Mathematics & Inclusion” on inclusive maths classes. Eight schools take part in the program for two years (September 2017 to September 2019) in order to refine their inclusive maths lessons on the secondary level. Central goals of the project include: school and lesson development (especially via support in team building), development of concepts and teaching materials for inclusive maths classes, educating participants for being a multiplier within their own schools, professionalization and cross-linking of different facilitators in Rhineland-Palatinate on the topic “inclusive maths classes” and the development of sustainable concepts for PD programs. For this conference we like to concentrate on the scaling-up idea within the project.

The structure of the statewide project provides different opportunities for supporting the teachers in developing their own expertise. Therefore, the project consists of various training modules and practical attempts in classroom. Thus, the participants are going to be experts for this topic and can contribute to the development of their schools. The participating teachers are prepared in the way that they can use their newly gained expertise in their own schools, throughout the whole project. This means that scaling-up in our context is based on a bottom-up idea (see for example Kaur 2015) so that teachers can spread the new gained expertise from the PD program in their schools right from the start.

In the project “Mathematics & Inclusion”, teachers are educated to become a kind of multiplier for promoting the topic “inclusive maths classes” in their own school and in surrounding areas. We use the word “multiplier” for the participating teachers in the program, as they are educated to become “experts in practice” and to differentiate them from the facilitators of the PD program, who are responsible for the implementation of the project. Concerning this point, the scaling-up idea in our context differs slightly from the Cascade Model, which can be seen as one common scaling-up idea. In the Cascade Model, “experienced teacher educators provide PD for future teacher educators […], who in turn provide PD for teachers, and so on” (Krainer 2015: 144), whereas the participating teachers in this project are not obligated to provide PD programs for teachers. Normally, facilitators in Rhineland-Palatinate get a certificate after having completed an educational training for about two years and have a commitment to advise schools, so there is a difference here as well. Concludingly, multipliers are experts in their own schools.

Furthermore, the project reacts on the needs for teacher professionalization derived from inclusion as being one of the current challenges in the education system. All in all, the PD program follows the DZLM (German Centre for Mathematics Teacher Education) design principles for in-service teacher education (Barzel & Selter 2015). Some of the principles are addressed explicitly like the following three: fostering (self-)reflection, participant-orientation and stimulating cooperation. The other principles are also included: competence-orientation, case-relatedness and diverse instruction formats. The project takes into account that the cooperation in multiprofessional teams gains importance in inclusive lessons. For this reason, the project focuses on a specific target group and follows a specific structure which is going to be explained in the next paragraph.

2. Practical realisation of the project with its (specific) structure and content

In accordance with the characteristics for effective PD programs (see for example Lipowsky & Rzejak 2012), the PD program consists of five modules with intermediate periods, in which the teachers can put the newly gained ideas into practice. One special feature of the PD program is the close supervision between facilitators and teachers during the modules as well as in the practical periods in class. Therefore, the PD program is planned and conducted by six facilitators with expertise in inclusion and six facilitators with expertise in the development of mathematics lessons. These facilitators serve the school teams, consisting of usually one special needs teacher and two mathematics teachers from each participating school. The school teams are seen as a professional learning community and work together with one *facilitator for inclusion* and one *facilitator for maths* each. The facilitators support the teachers, particularly within the periods in which the teachers put the newly gained ideas into practice. For example, they meet members of the school management or meet with other teachers from the same school and are invited to support the implementation in the schools.

The content of the five modules includes the following topics: 1) inclusion in school and lesson development, 2) teaching design and learning, 3) diagnosis of learning difficulties and individual support, 4) training and ensuring (learning from mistakes, also with different media) and 5) implementation and transfer at the schools. Furthermore, the PD program works on teachers’

attitudes (concerning inclusive maths classes), team cooperation, classroom management and other aspects of inclusive maths lessons as a whole.

Different stakeholders cooperate in the project. On the one hand, the facilitators with different expertise work together and on the other hand, the Pedagogical Institute cooperates with the DZLM as the project is academically accompanied by a team of researchers from Ruhr University Bochum. The accompanying research investigates the learning processes of the participating teachers throughout the whole project. In the practice-based presentation we use some impressions from our research to illustrate the scaling-up idea from a teacher's point of view. Especially, we are going to focus on the specific structure of the project in connection with our scaling-up idea.

3. Discussion and Outlook

The daily school life and routine is an essential every day challenge for teachers. Some conditions at their schools inhibit the progress of those teachers that take part in the program. Nonetheless, the different modules motivate teachers to carry on. Finally, problems concerning the implementation and limitations as well as possible improvements of the project, which we have gained from the experiences in the project, are going to be presented.

References

Barzel, B., & Selter, C. (2015). Die DZLM-Gestaltungsprinzipien für Fortbildungen. *Journal für Mathematik-Didaktik, 36*(2), 259-284.

Kaur, B. (2015). What matters? From a small scale to a school-wide intervention. *ZDM Mathematics Education 47*(1), 105-116.

Krainer, K. (2015). Reflections on the increasing relevance of large-scale professional development. *ZDM Mathematics Education 47*(1), 143-151.

Lipowsky, F., & Rzejak, D. (2012). Lehrerinnen und Lehrer als Lerner – Wann gelingt der Rollentausch? Merkmale und Wirkungen wirksamer Lehrerfortbildungen. *Schulpädagogik heute 3*(5), 1-17.

Developing a Module on Copyright for Applied Science Students in Canada – Material Dimension

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Tuesday, 8 October 2019, 12:15-12:40, KA 209

1. Introduction and Context

In the globally-networked economy, knowledge is produced in the interdisciplinary marketplace of ideas, characterized by multimodality, breath-taking speed and scale. Indeed, "creating, owning, using, sharing, citing, and ultimately building upon intellectual works to create new knowledge is the lifeblood of the academic community of practice" (Horava 2011). Teachers and students pursue research projects that involve data mining and primary analysis of sources; they extensively use both copyrighted material and material from the public domain.

The copyright discourse in Canada developed at the crossroads of several key dimensions in the educational setting: values, policies and technology. Attempts to reform copyright laws in Canada resulted in polarized media coverage, raised the public awareness of copyright issues, and led to an emotionally-charged public discourse. Such a polarized context makes copyright education extremely important for academic and professional communities of practice. Educators need to inform students about the responsibilities involved in using copyrighted material not only because students are the

knowledge-makers of tomorrow, but due to their collaborative and highly personal approach to learning. Students already consume and generate content from a broad range of online sources and view remixing and mashing-up as a standard process for problem solving and for developing their own multimodal texts and objects. Questions of copyright ownership and permissions are often overlooked.

Many Canadian universities recently updated their policy frameworks to articulate the obligation to respect copyright laws and established a web presence of copyright issues for the purposes of education, communication, due diligence and compliance. The University of British Columbia (UBC) became the first Canadian university to independently license teaching materials. This oral presentation is prepared from a country-specific perspective and will discuss the development of a module on copyright in a technical communication course for applied science students at UBC.

2. Research Questions

This research is guided by the following questions:

- How is the discourse of legal, institutional and educational communities of practice shaped by their systems of activities?
- How does knowledge of recent copyright issues travel from one domain to another?
- How can we design a module to address contemporary copyright issues in a technical communication course for applied science students?

3. Theory and Methodology

Within the theoretical framework of transformative learning theory (Mezirow 2009) and activity theory (Russell 1997), knowledge-production is seen as a complex process shaped by the activities of scholars, students and staff that work in specific contexts within various power hierarchies. The classroom becomes a place in which “power is circulated, managed, exploited, resisted, and often directly impacted by institutional policies and changes” (Huckin 2012). We create, distribute and receive knowledge via various technologies and establish an archive of thought, action and events for further social use. This complexity invites multi-disciplinary theoretical approaches that allow the researcher to integrate various perspectives in a single inquiry. It also invites new forms of conceptualization that bring together the disciplinary insights in a common vision. My methodology involves action research based on observation, interviewing, pedagogical reflection, and critical discourse analysis of available texts and contexts. Action research contributes to the transformation of professional practice and generates new knowledge and can be undertaken by a teacher, a group of instructors working at the same university, researchers within the same department, students and advisers (Cebrian et al. 2012; Cohen et al. 2000).

4. Results

The oral presentation will demonstrate how the module on copyright lays a solid basis for students’ exploration of social and ethical aspects of their profession. Students learn to appreciate the complexity of various modes of knowledge production in formal communication (e.g., articles, books, journals, and reports) and informal communication (e.g., podcasts, blogs, websites, videos, and media mash-ups). They develop an awareness of laws and institutional policies that shape the context through legal directions and guidelines. By identifying themselves as knowledge workers, students are better prepared to engage in the public discourse on copyright and respect the viewpoints of various stakeholders. They understand that wider distribution and market potential for intellectual work is inevitably associated with a greater opportunity for infringement of copyright. This new awareness of the complexity of rights and uses in knowledge-based organizations (including schools and universities) helps students realize that professional values are indispensable as the ethical foundation for knowledge-making.

References

Cebrian G. et al., 2012, “Developing people and transforming the curriculum: Action research as a method to foster professional and curriculum development in education for sustainable development in higher education,” In: Sustainable Development at Universities: New Horizons, W. Filho, Ed. Frankfurt, Peter Lang, pp. 273-284.
Cohen L. et al., 2000, Research Methods in Education. Abingdon: Routledge and Falmer.
Horava T., 2011, “Copyright discourse in the academy: values, policies, and technology,” Academic Matters, [online]. Available: http://www.academicmattersca/2011/10.
Huckin T. et al., 2012, “Critical discourse analysis and rhetoric and composition,” College Composition and Communication, Vol. 64, no.1, pp.107-128.
Mezirow J., 2009, Transformative learning theory. In Mezirow, J., Taylor, E.W. and Associates (Eds.), In Transformative Learning in Practice: Insights from Community, Workplace and Higher Education, pp. 18-32. Jossey-Bass, San Francisco, CA.
Russell D., 1997, “Rethinking genre in school and society: An activity theory analysis,” Written Communication, Vol. 14, no. 4, pp. 504-544.

Coping with teachers' contributions in discussions – A case study on facilitators’ practices in PD courses on language-responsive mathematics teaching – Personal Dimension

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Tuesday, 8 October 2019, 12:15-12:40, KA 106

1. Investigating facilitators’ practices as important background for the design of facilitator preparation courses

For scaling up successful professional development (PD) programs, it is important to take into account the crucial role of facilitators (e. g. in leading productive discussions) for the success of the PD courses. Thus, PD facilitators have recently attracted an increasing research interest (e. g. Borko et al., 2014), and still more research is required for conceptualizing their expertise, especially with regard to specific PD contents (Prediger, Rösken-Winter & Leuders, submitted).

The proposed presentation contributes to research aiming at describing and explaining facilitators’ practices in a video-based PD program on the content of language-responsive mathematics teaching. For explaining the facilitators’ content-specific practices, the qualitative case study identifies underlying situative goals, orientations and categories.

2. Methodological background for investigating facilitators’ practices in PD courses on language-responsive mathematics teaching

The PD courses on language-responsive mathematics teaching (four modules of three hours each) belongs to the large research program of the DZLM (German National Center for Mathematics Teacher Education), which aims at developing carefully designed PD programs and scaling them up in a research-based way. The video data corpus of the case study currently consists of ten videotaped PD sessions conducted by n = 5 facilitators in pairs and video-based post-PD reflection session between the researchers and the facilitators (in total about 40 hours of video material). The qualitative data analysis identifies typical practices based on a model of content-related facilitator expertise (Pöhler & Prediger 2019).

3. Inductive development of a model of content-related expertise for facilitators

The inductive development of a model of content-related facilitator expertise starts from lifting a situated model of teacher expertise (Prediger, 2019 based on Bromme, 2001). In the model professional expertise of facilitators' is conceptualized starting from typical, often complex situational demands during the PD course (jobs) and the facilitators' recurrent patterns of facilitation behaviour for meeting these demands during PD courses (practices). In this presentation the job of coping with teachers' contributions in discussions within PD courses on language-responsive mathematics teaching is focused. The practices for coping with the job are constituted by concretely applied pedagogical tools (e. g. facilitation moves, van Es et al., 2014), and explained by underlying content-related categories (stem e.g. from knowledge on the PD content or on typical professionalization processes on the PD content, Borko et al., 2014), content-related orientations (e. g. beliefs about the PD content or teachers' learning processes) and situative goals (Schoenfeld, 2010) of different nature (atmospheric goals, process goals and learning goals).

Whereas the pedagogical tools (How does the facilitator cope with the job?) are visible, the content-related categories, orientations and situative goals have to be carefully identified empirically (Why does the facilitator cope with the job in this way?).

4. First results and contributions of the research

As a first result, the qualitative analysis strengthens the assumption that the use of certain pedagogical tools alone is probably not decisive for the success of a PD course. This indicates that explaining how facilitator cope with a job probably requires the investigation of the underlying aspects of facilitators' decision making.

More specifically, this reconstruction shows that for adequately meeting the job of "coping with teachers' contributions in discussions" in PD courses on language-responsive mathematics teaching, it is highly relevant for facilitators

- to focus on teachers' learning pathways towards the PD content,
- to take the noticed teachers' learning into account when conducting discussions and
- to bridge the noticed aspects of teachers' learning towards the PD goals.

In order to be able to achieve this, the facilitators themselves require a detailed pedagogical content knowledge on the PD level, especially adequate content-related categories (e. g. on teachers' orientations about the relevance of language-responsive mathematics teaching). These findings have already influenced the design of the facilitator preparation courses: Such courses need to be content-specific and provide learning opportunities on teachers' content-specific learning pathways.

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References

Borko, H., K. Koellner and J. Jacobs, 2014, "Examining novice teacher leaders' facilitation of mathematics PD", Journal of Mathematical Behavior, 33, pp. 149-167.

Bromme, R., 2001, "Teacher expertise", In: International encyclopedia of the social and behavioral sciences, N. J. Smelser and P. B. Baltes (Eds.), Amsterdam: Elsevier, pp. 15459–15465.

Pöhler, B. and S. Prediger, 2019, in press, “Facilitators’ practices and situative goals in conducting PD courses on language-responsive mathematics teaching”, Beiträge zum Mathematikunterricht 2019.
Prediger, S., 2019, online first, “Promoting Teachers’ Pathways towards Expertise for Language-Responsive Mathematics Teaching”, Submitted manuscript.
Prediger, S., B. Roesken-Winter and T. Leuders, submitted, “Which research can support PD facilitators? Research strategies in the Three-Tetrahedron Model.”
Schoenfeld, A. H., 2010, “How we think: A theory of goal-oriented decision making and its educational applications”, New York: Routledge.
Van Es, E. A., J. Tunney, L. T. Goldsmith and N. Seago, 2014, “A Framework for the Facilitation of Teachers’ Analysis of Video”, Journal of Teacher Education, 65(4), pp. 340-356.

Can Grounded Math and Education and Research Become Relevant to Learners – Structural Dimension

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Tuesday, 8 October 2019, 12:15-12:40, KA 102

1. Abstract

This presentation relates to the topic 3 question 3 about challenges to be overcome even if innovative teaching has been designed and initiated. The main question about mathematics education and its research is: ‘If 50 years of research fails to solve the problems of math education, then what can?’ The presentation allows the audience to give comments to the five section questions that are inspired by the Chomsky-Foucault debate on Human Nature.

Humans communicate in languages, a word-language and a number-language. We learn to speak the word-language in the family, and we are taught to read and write in institutionalized education, also mediating the number-language under the name mathematics, thus emphasizing the three r’s: Reading, Writing and Arithmetic. Despite intensive research, international tests show that the learning of the number-language is deteriorating in many countries.

This raises two questions: May a change in mathematics, education and research make more learners reach the goal of math education? Is the goal of mathematics education to echo an inside university truth regime labelled mathematics, or to master the outside fact Many?

2. Education in general

On our planet, life takes the form of single black cells, or green or grey cells combined as plants or animals. Humans only need a few children in their lifetime, since transforming the forelegs to hands and fingers allows humans to grasp the food, and to share information through communication and education by developing a language when associating sounds to what they grasp. Where food must be split in portions, information can be shared through education.

Education takes place in the family and in the workplace; and in institutions with primary, secondary and tertiary education for children, for teenagers and for adults. English language does not have continental Europe’s words for education using Plato’s cave to picture learners as unformed and living below: Bildung, Unterricht, Erziehung, didactics, etc. Likewise, Europe still holds on to the multi-year line-organized office preparing education that was created by the German autocracy shortly after 1800 to mobilize the population against the French democracy, whereas the North American republics use self-chosen half-year block-organized talent developing education from secondary school. So, how well-defined is ‘education’?

3. Mathematics and its education

The Pythagoreans used the word ‘mathematics’ as a common label for their knowledge about Many by itself and in space and time, arithmetic and geometry and music and astronomy. Without the two latter, mathematics later became a common label for arithmetic, algebra and geometry, which may be called pre-setcentric math, challenged by the present setcentric ‘New Math’ appearing in the 1960s, again challenged by a post-setcentric math seeing math as a natural science about its outside roots, Many, since setcentric mathematics never solved its self-reference problem that became visible when Russell showed that the self-referential liar paradox ‘this sentence is false’, being false if true and true if false, reappears in the set of sets not belonging to itself, where a set belongs only if it does not, and vice versa.

In any case, mathematics is a core subject in schools together with reading and writing. However, there is a difference. If we master the outside world by proper actions, it has meaning to learn how to read and how to write since these are action-words. But, we cannot math, we can reckon. Continental Europe taught reckoning, called ‘Rechnung’ in German, until the arrival of the New Math. When opened up, mathematics still contains reckoning in the form of fraction-reckoning, triangle-reckoning, differential-reckoning, probability-reckoning, etc.

Today, Europe only offers classes in mathematics, whereas the North American republics offer classes in algebra and geometry, both being action words meaning to reunite numbers and to measure earth in Arabic and Greek. So, how well-defined is mathematics and its education?

4. The teacher and the learner

It seems natural to say that the job of a teacher is to teach learners so that learning takes place, checked by written tests. However, continental Europe calls a teacher a ‘Lehrer’ thus using the same word as for learning. In addition, a Lehrer is supposed to facilitate Bildung, Unterricht and Erziehung and to foster competences. In teacher education, the subject didactics, meant to determine the content of Bildung, is unknown outside the continent. In the American high school, teachers have their own classroom to teach one subject; outside teachers must teach several subjects to students forced to stay in the same class for several years.

As to learners, the tradition sees learning taking place when learners follow external instructions from the teacher in class and from the textbook at home. Then constructivism came along suggesting that instead learning mostly takes place through internal construction when working with peers or with manipulatives. So how well-defined is a ‘teacher’ and a ‘learner’?

5. Research and conflicting theories

Typically, research is seen as a search for laws predicating essence to an existent subject. But, is the subject the root or an example of its predication? Holding that existence precedes essence, Existentialism has no doubt, but what about other philosophical observations?

Using the word sophy for knowledge, the ancient Greek sophists warned against choice masked as nature whereas the philosophers saw choice as an illusion since the physical is but examples of metaphysical forms only visible to them when educated at the Plato academy as scholastic ‘late opponents’ defending their comments to an already defended comment against three opponents. Newton’s natural science installed validation by unfalsified predictions instead, which inspired the 18th century Enlightenment period, which again created counter-enlightenment, so today research still uses Plato scholasticism outside the natural sciences.

Using classrooms to gather data, math education research could be a grounded natural science, but seems to prefer scholastics by researching, not math education itself, but theories on math education instead. But this raises questions about what to do with conflicting theories:

Within philosophy the Greek controversy between sophists and philosophers is revived today between structuralism on one side and French post-structuralism and American pragmatism on the other side. Within Psychology, Vygotsky sees education as building ladders from the present theory regime to the learner's learning zone, where Piaget replaces this top-down view with a bottom-up view inspired by American Grounded Theory allowing inside categories to grow from concrete outside experiences and observations. And Sociology fiercely discusses who constructs who in the relation between individual agency and social structure.

References

Chomsky, N, and Foucault, M, 2006, "The Chomsky-Foucault debate on human nature", New York, The New Press. And on YouTube, https://goo.gl/d3pQKj.

Ernest, P, and Tarp, A, 2012, "A postmodern math education", YouTube, https://goo.gl/etL5ye.

Tarp, A, 2018, "Mastering Many", Journal of Mathematics Education, vol 11(1), pp. 103-117.

Propagating stochastics expertise for teaching: From input to agency – Personal Dimension

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Tuesday, 8 October 2019, 14:00-14:50, KA 209

1. Introduction and context of the professional development project on stochastics

Stochastics (statistics and probability) has long been neglected in German classrooms although its relevance in modern life is undisputed. Curriculum innovations have recently placed special emphasis on the handling of data, particularly on what inferences can (or cannot) be drawn from samples. Consequently, the demand for teacher professional development (PD) courses has risen. The DZLM (German Centre for Mathematics Teacher Education), among others, offers such courses – with the quality criterion that DZLM courses are designed by qualified mathematics education researchers and practitioners and follow six design principles (Barzel & Selter, 2015) that aim at real and sustainable PD.

In the case of the PD course that is the focus of this paper, the DZLM cooperated with regional educational administrations which enabled different teacher and facilitator PD approaches. Our oral presentation will elaborate on how three strategies were combined, with regard to moving from input towards agency. Therefore, we give details on a teacher PD course focused on input, a facilitator professional learning community (PLC) with the aim of adapting and conducting the PD course, and teacher PLCs centered on individual school practice.

This must be viewed with the background that the German educational system is somewhat complicated in that educational policies are the responsibility of the regional governments (*Länder*), with a common committee for general coordination (*Kultusministerkonferenz*, Standing Conference of the Ministers of Education and Cultural Affairs of the *Länder* in the Federal Republic of Germany). On the one hand, this presents a challenge to any kind of scaling up, as the regional officials have to be addressed through their various local institutions. On the other hand, this also constitutes the necessity to meet representatives from different levels when dealing with teacher PD, including teachers themselves.

2. Content and design of the PD course on upper secondary stochastics

The PD course covers the complete content for upper secondary level, e.g. conditional probability, binomial and normal distribution, the law of large numbers, and hypothesis testing, while also addressing the use of digital tools for simulating and visualizing (Oesterhaus & Biehler, 2014), always consistently with a focus on student understanding. The course usually takes place on five full days over a stretch of several months. It was first conducted in 2013 and has been constantly developed, re-modelled, and improved. Among its participants there were teachers, teacher trainers, heads of departments, facilitators, and task designers.

The central design principle of the course is the perspective to choose the classroom level as a starting point, casting the light on the concrete learning progression that is to be aspired for students, and lift this to the PD level, and in some cases to the facilitator qualification level (cf. the three levels of the Three-Tetrahedron Model in Prediger, Roesken-Winter & Leuders, submitted). This means that PD course participants experience carefully designed and selected tasks and problems first from a learner's perspective, then reflect on them from an instructor's view – and some of them eventually take a facilitator's stance. One attraction here is that teachers can use the teaching sequences directly for their own classes.

3. Scaling up of the PD course

Conducting the five-day PD course was regarded as a necessary first step on the road to implementing the innovative instruction ideas. To really achieve change, preferably on a large scale, further initiatives are required. These should comprise smaller groups and a more pronounced focus on discussion and exchange than was possible during the five-day course crammed with input. PLCs have recently gained in relevance as they are considered an efficient tool for teacher PD (Stoll, Bolam, McMahon, Wallace, & Thomas, 2006). A group of teachers can be classified as a successful PLC, if they possess five characteristics, according to Newmann et al. (1996, p. 181f.): (1) shared norms and values, (2) a focus on student learning, (3) reflective dialogue, (4) de-privatizing of lessons, and (5) teacher collaboration.

Consequent to the PD course described above, two kinds of PLCs were established, both working on the basis of the input and material from the PD course: The first kind of PLCs consists of groups of teachers from one school, where one had participated in the PD course, and the others had volunteered to work together to incorporate the PD course content into their school curricula. The second kind of PLC entailed groups of (aspiring) facilitators who intended to conduct an analogous PD course themselves.

As a result, aspects of evaluation of the PLC work will be presented in our oral presentation. The teachers partaking in a PLC show indications of professional growth, e.g. in reference to their repertoire of tasks, explanations, and examples. The facilitators' PLC yields encouraging data on its effectiveness and on the acceptance by its participants. Moreover, our presentation will elaborate on the specificities of these PLCs, how they contributed to scaling up the ideas of the PD project, what challenges occurred and how these were dealt with. Our perspective is specific of Germany, with particular regard to the stochastic content. In this context, the personal dimension is crucial, i.e. what roles the parties involved take, what attitude they display towards the content, and how they view the tasks and activities. This enables insights into the links between the levels of PD: from teacher PD level to classroom level and to facilitator PD level. Thus, we address questions on how to combine approaches on different levels, what factors are relevant when doing so, and what support is needed in different scenarios.

Acknowledgements

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References

Barzel, B., & Selter, C. (2015). Die DZLM-Gestaltungsprinzipien für Fortbildungen. Journal für Mathematik-Didaktik, 36(2), 259–284.

Newmann, F. M. et al. (1996). *Authentic achievement: Restructuring schools for intellectual quality*. San Francisco: Jossey-Bass Publishers.

Oesterhaus, J., & Biehler, R. (2014). Designing and implementing an alternative teaching concept within a continuous professional development course for German secondary teachers. In K. Makar, B. de Sousa, & R. Gould (Eds.), *Sustainability in statistics education. Proceedings of the Ninth International Conference on Teaching Statistics, ICOTS9, Flagstaff, Arizona.* Voorburg, Netherlands: International Statistical Institute.

Prediger, S., Roesken-Winter, B., & Leuders, T. (submitted). Which research can support PD facilitators? Strategies for content-related PD research in the Three-Tetrahedron Model. *Journal for Mathematics Teacher Education*.

Stoll, L., Bolam, R., McMahon, A., Wallace, M., & Thomas, S. (2006). Professional Learning Communities: A Review of the Literature. *Journal of Educational Change*, *7*(4), 221–258.

Quality criteria of inquiry-based learning resources in primary school science education: A systematic literature review – Material Dimension

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Tuesday, 8 October 2019, 14:00-14:50, KA 209

1. Introduction

There are many resources for inquiry-based learning in primary school science education available, but only a few have been empirically evaluated. Therefore, it is a vital skill for teachers to be able to assess the quality of the resources. Well-designed resources increase inquiry-based learning considerably (Lazonder & Harmsen 2016, Möller 2010, Möller Kleickmann and Tröbst 2009). Likewise, knowledge about quality criteria is central to developers of learning resources, policy makers and school authorities responsible for issuing recommendations and regulations for instructional materials. Despite the importance of evidence-based quality criteria, a systematic literature review (SLR) that compiles quality criteria is lacking. To fill this gap, we conducted a SLR that identifies quality criteria of inquiry-based learning resources for primary school science education.

Teachers often emphasize the importance of active learning sequences. Many hold the belief that the students' engagement in doing experiments automatically leads to enhanced science understanding. The effectiveness of doing hands-on experiments is, however, often only marginal (e.g. Meyer 2004). One of the reasons for this ineffectiveness is the students' focus on doing the experiment "right". Rather than understanding the underlying principles and connections involved in an experiment, students are merely focused on following recipe-like instructions accurately. Well-designed experiments including comprehensive guidance can foster conceptual learning by helping teachers to arrange effective learning settings. The presented SLR gives an overview of research-based quality criteria for inquiry-based learning resources and compares them to criteria mentioned in current guide lines, recommendations and regulations relevant for the teachers' practice.

2. Method

We defined several keywords that we combined to strings to systematically search educational literature databases (ERIC, Fachportal Pädagogik). The strings narrow down the search space to the teacher's perspectives on learning resources, primary school level, science classes and hands-on activities (i.e. experiments). We also included grey literature such as guide lines of school authorities and open access databases (e.g. peDOCS) because we expected that documents describing recommendations and regulations of practical relevance in education might not be captured by the literature databases.

The identified literature was screened considering titles and abstracts. We discarded those documents, which did not explicitly discuss quality criteria of inquiry-based learning resources, hands-on activities or experiments in primary school science education. The remaining relevant documents were read thoroughly and judged for eligibility using our inclusion criteria. Afterwards, we categorized the quality criteria. All of these steps were done by two independent raters to increase objectivity. Disagreements were resolved by discussion.

3. Results

We identified 38 documents that meet the inclusion criteria. As expected, there was a considerable amount of relevant grey literature (22 documents) describing guide lines and recommendation for the use of educational resources at school.

The comparison between research-based quality criteria (12 documents) and criteria from a teacher's perspective revealed systematic differences. Research-based criteria emphasize the importance of authenticity, clear educational objectives, the relation to the students' everyday experience, the building on students' prior knowledge and conceptions, the possibility for individual learning paths, the development and reflection of students' own ideas, the formulation and testing of hypotheses, the possibility for collaboration, comprehensive guidance for both students and teachers supporting deep learning and thinking processes as well as extended field tests and iterative optimisation of the developed learning resources. Although the teachers' perspective includes several of the above criteria, the teachers' focus seems to be more student-centred. For example, teachers emphasize that experiments are supposed to spark the students' interest, that the learning resources must fit with the students' skills and abilities and that the students can work on their own. Also, the clarity of instructions and ease of use of the materials are frequently mentioned criteria.

We found two main differences. First, research-based criteria are much more differentiated with respect to what makes learning resources effective. The teachers' perspective recognises that it is important that students learn "something". However, typically no details are provided on what "to learn" exactly means and what aspects of the resources contribute to the students' learning success. Second, the teachers' perspective appears to focus more on the students' physical activity rather than on cognitive activation.

4. Conclusions

The differences between quality criteria from a research and a teachers' perspective found in this SLR suggest that two aspects need more attention in teacher education and professional development. First, it is of high importance to help teachers understand how inquiry-based learning resources need to be designed to develop a conceptual understanding in science. Second, it seems necessary to explicitly tackle the belief that physical hands-on activation do automatically also imply cognitive activation Teaching resources with comprehensive guidance and scaffolds facilitate the arrangement of learning sequences that foster conceptual learning. Teachers need to learn research-based quality criteria that make learning materials effective, so that they can make the right decision when selecting teaching resources for their classes.

References

Lazonder, A. W. & Harmsen, R. (2016). Meta-analysis of inquiry-based learning: Effects of guidance. *Review of Educational Research, 86*(3), 681–718.

Mayer R. E. (2004). Should there be a three-strikes rule against pure discovery learning? *American Psychologist, 59*(1), 14-19.

Möller, K. (2010). Lehrmittel als Tools für die Hand der Lehrkräfte. Ein Mittel zur Unterrichtsentwicklung? *Beiträge zur Lehrerinnen- und Lehrerbildung, 28*(1), 97-108.

Möller, K., Kleickmann, T. & Tröbst, S. (2009). Die forschungsgeleitete Entwicklung von Unterrichtsmaterialien für die frühe naturwissenschaftliche Bildung. *Beiträge zur Lehrerinnen- und Lehrerbildung, 27*(3), 415-423.

Teacher training concept CAMMP - Supporting the establishment of mathematical modeling in school teaching in a sustainable way – Structural Dimension

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1. Teacher training concept CAMMP

CAMMP (Computational and Mathematical Modeling Program) focuses on a well-founded education and training of teachers in the field of mathematical modeling with the aim of promoting the integration of mathematical modeling activities on authentic, relevant questions into mathematics teaching and to advance the development of modeling teaching in schools. The training concept, which has been implemented at the RWTH Aachen since 2016, is based on the assumption of Blum and Borromeo Ferri (2009) who state that as a (future) teacher it is necessary to gather diverse modeling experience in order to design and accompany modeling tasks in a reflective manner (Borromeo Ferri and Blum, 2009, p. 2055). The courses are tightly linked to the pupil activities in the CAMMP teaching and learning laboratory for mathematical modeling. This laboratory has been offering mathematical modeling days and weeks for pupils who have completed grade 9 at the RWTH Aachen University since 2011 and since 2018 at the Karlsruhe Institute for Technology. During the modeling days, the pupils work on everyday problems, such as the functionality of GPS, which were previously worked out didactically and methodically within the framework of a computer-aided learning module. During the modeling weeks, the pupils work on open problems from industry and research in small groups tutored by teachers and scientific staff.

The poster shows as best practice experience how we realize the inclusion of mathematical modeling courses in teacher training at the university level and the implementation of advanced training in in-service teacher workshops.

2. Embedding in teacher training on the university level

As part of the CAMMP training concept, student teachers can actively shape learning situations using authentic modeling tasks with pupils. Our teacher training courses consist of various modules, each with a different focus. These include an introduction to mathematical modeling and the active use of computer-aided teaching materials on modeling problems. An overview of all courses can be found in table 1. The courses attempt to explore the *theoretical*, the *task-related*, the *teaching* and the *diagnostic dimension* of the competencies model by Borromeo Ferri and Blum (2009), which describes the necessary teacher competencies for teaching mathematical modeling, to a varying extent (Borromeo Ferri, 2014, pp. 28).

2.1. Lecture: Application and Modeling

The lecture provides students with solid knowledge in the field of mathematical modeling. After an introduction to the theoretical basics of mathematical modeling from a didactic point of view, the focus is on questions from different fields of application (e.g. natural sciences, engineering and economics). The students work on different learning modules of our modeling days in the pupil role, deepen their knowledge from university courses and experience the role mathematics plays in everyday life, science and research.

2.2. Seminar: Implementation and further development of pupil workshops

The seminar focuses on the training of competences of the teaching and the task-related dimensions. The students carry out complex modeling themselves, develop modeling tasks and accompany the modeling process of pupils within the framework of a modeling day.

The seminar is divided into five consecutive phases. In the **first phase**, students receive an introduction to the didactic theory of mathematical modeling. Typical modeling cycles are explained and discussed with regard to their objectives. In **phase two**, the students independently carry out two selected learning modules of the modeling days and discuss the relevance of the problems, the structure of the materials and the suitability for open modeling with pupils. The students learn methods of mathematical modeling, which especially enhances the competences of the task-related dimension. In the **third phase**, the students take part in a modeling day with a group of pupils while focusing on the diagnostic and task-related dimension. In doing so, they should identify an aspect of the learning module that has potential for further development. In the **fourth phase**, the students further develop the selected aspect and test their changes in practice with a group of pupils. The students collect teaching experiences and test their didactic-methodical acting in a protected area. In the **last phase**, the students reflect on their teaching assignment with the help of a reflection sheet.

2.3. Seminar: Mathematical modeling on a modeling week

The focus of the master's seminar is on the teaching dimension. The students take part in a modeling week as tutors of a small group of pupils. They contribute their acquired competences in the field of pedagogy, didactics and teaching methodology. At the same time, they have the task of developing a question during the first days of the modeling week on the basis of which they want to reflect on their experiences in the role of the teacher. Finally, the students will write a short paper in which they describe the work and results of the group of pupils as well as their experiences as supervising teachers and reflect on their chosen question. In addition to deepening the basics of modeling, the seminar enables intensive teaching experiences in the field of teaching practice of mathematical modeling.

3. Further training for in-service teachers

As part of our continuing training concept, two formats are offered for in-service teachers. These formats partially go hand in hand with the student teacher training courses already described. The first advanced training format is embedded in the modeling weeks for pupils. Together with a research assistant each teacher supervises a group of pupils who are working on an open problem during a modeling week and in addition they complete and work through various learning modules for themselves.

The second format is a further education course in which teachers work on and discuss a learning module of a CAMMP modeling day within the framework of a 1.5 to 4-hour workshop. For the workshops the teachers receive a reader containing the mathematical background, methodological-didactical hints as well as the material of the learning module. The reader should simplify and accompany the preparation of the learning modules for one's own mathematics lessons. The digital worksheets necessary for the work on the learning modules are made available to the teachers.
In order to reach teachers outside the regional environment of CAMMP in Aachen and Karlsruhe, the development of low-threshold teaching materials and the provision of interactive, digital teaching-learning materials is being worked on as part of a cloud project.

References

Blum W., 2015, "Quality Teaching of Mathematical Modelling: What Do We Know, What Can We Do?" In: Cho S. (eds.). *The Proceedings of the 12th International Congress on Mathematical Education*. Springer, Cham, pp. 73-96.

Borromeo Ferri, R. and Blum, W., 2009, “Mathematical Modelling in Teacher Education – Experiences from a Modelling Seminar” In: Durand-Guerrier V., Soury-Lavergne S. and Arzarello F. (eds.). *Proceedings of CERME 6*, Lyon, France, pp. 2046–2055.

Borromeo Ferri, R., 2014, “Mathematical Modeling–The Teachers Responsibility“ In: Dickman B. and Sanfratello A. (eds.). *Proceedings of the Conference on Mathematical Modeling*, Teachers College Columbia University, NYC, pp. 26-31.7

Attachment

Table 1. Overview of the teacher training courses. The share of the dimensions of the competence model in the different courses is sketched out by the nuance of the cell color. The darker, the higher is the share of the dimension in the class. (MD = modeling day, MW = modeling week).

<table>
<tr><th rowspan="2">courses</th><th rowspan="2">time in curriculum</th><th colspan="4">Dimensions of the competence model</th></tr>
<tr><th>Theoretical dimension</th><th>Task related dimension</th><th>Teaching dimension</th><th>Diagnostic dimension</th></tr>
<tr><td>Lecture: Application and modeling (mandatory)</td><td>Bachelor, 3rd semester</td><td>Introduction to mathematical modeling</td><td>Working on several learning modules</td><td>Optional: Support from the CD to the previously self-completed learning module</td><td></td></tr>
<tr><td rowspan="3">Seminar: Implementation and development of workshops (elective)</td><td rowspan="3">Bachelor/ Master, variable semester</td><td rowspan="3">Introduction to mathematical modeling</td><td rowspan="3">Working on several learning modules</td><td>Participation in MD in pupil’s role</td><td>Identification of one aspect of a learning module for further development</td></tr>
<tr><td>Further development of a learning module</td><td rowspan="2">Reflection on the execution of the MT in teacher’s role</td></tr>
<tr><td>Participation in MD in teacher’s role</td></tr>
<tr><td>Seminar: Mathematical modeling on a MW (elective)</td><td>Master, variable semester</td><td>Optional (depends on question)</td><td>Optional (depends on question)</td><td>Supervision of a group of pupils during a MW</td><td>Reflection on modeling process of the pupils’</td></tr>
<tr><td>1.5–4h workshop for teachers</td><td>in-service teachers</td><td>Introduction to one mathematical modeling cycle</td><td>Completing one learning module</td><td></td><td></td></tr>
<tr><td>Workshop for several days for teachers on MW</td><td>in-service teachers</td><td>Introduction to one mathematical modeling cycle</td><td>Completing three learning modules</td><td>Supervision of a group of pupils during a MW</td><td></td></tr>
</table>

Video-reporting of practical activities - a tool for developing and spreading science teacher professional expertise – Material Dimension

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Tuesday, 8 October 2019, 14:00-16:00, KG5 103

1. Introduction

Educational discourse about teacher as an expert professional practitioner is growing in Sweden. In science education, teacher expertise in conducting practical activities constitutes an important part of the professional responsibilities (Hofstein & Lunetta, 2004). Outdoor activities are more demanding from management perspective and conducted mainly by enthusiasts. Creative solutions of organising practical work in science in different contexts are usually teacher-bounded. Anecdotal evidence shows that when the teacher retires or changes workplace his or her favourite equipment and developed lab-instructions tend to be soon forgotten, if they are not became rooted in the traditions and practice of the school. Rephrasing Edwards (2010) we can state that teachers inhabit practices laden with the accumulated knowledge and values necessary to undertake activities and they engage in activities when they possess necessary knowledge and share the values.

This poster presentation reports the study summarising my teaching experience of using video-reporting of practical outdoor activities during science-orientation courses for prospective primary school teachers. The focus of these activities was on developing effective tools for accumulating and spreading teacher expertise in using outdoors contexts in science education.

2. Results and conclusions

Open authentic practical activities were suggested to the students to be conducted outdoors (Popov & Engh, 2016), for example on playgrounds, which should be reported with the help of short videos (5-6 min). The activities included formulation of practically solvable problems, preparation of scenarios, practical work outdoors, video-recordings with mobile phones, and the editing and reporting of results.

Practical activities were reported in a broad variety of forms, including fairy tales, competitions, instructional videos, etc. The course participants provided different didactical solutions as to how their videos can be used in science classrooms, for example; as an introduction to new study-topics, as explanations of a phenomenon, or as a point of departure for flipped-classroom arrangements. Students showed possible ways to connect these activities to the national educational policy documents as well as the school science curriculum. They also suggested theoretical justifications of selected forms of doing and presenting activities using for example cultural-historical activity theory. Findings confirmed the effectiveness of out-of-classroom contexts for learning science (Popov, 2015) and the potential of video-reporting in developing science teacher professional expertise.

References

Hofstein, A. & Lunetta, V.N. (2004). The laboratory in science education: Foundations for the twenty-first century. Science Education. Vol.8, N 1, pp. 28-54.

Edwards, A. (2010). Being an expert professional practitioner: the relational turn in expertise. Dordrecht the Netherlands; New York: Springer.

Popov, O., Engh, R. (2016). Utomhusfysik: uppleva, undersöka, utforska. // Outdoor physics: experience, explore, research. [In Swedish] Studentlitteratur. Lund.

Popov, O. (2015). Outdoor Science in Teacher Education. In T. Hansson (Ed.), Contemporary Approaches to Activity Theory: Interdisciplinary Perspectives on Human Behavior. Hershey, PA: IGI Global. pp. 128-142.

Recounting Before Adding makes Teachers Course Leaders and Facilitators – Personal Dimension

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1. Abstract

This PowerPoint presents innovative perspectives in educating math educators from the child's perspective, relating to the topic 1 question 2 about successful programs and essential contents, and to question 6 how primary teachers can become learning community facilitators. Recounting in bundle-numbers allows teachers to secure that no students are left behind.

The three learning levels at the MATHeCADEMY.net allows a teacher to become both a facilitator for a professional learning community and a course leader initiating pyramid-organized professional development locally or globally on the internet. The open source inquiry-based material is organized as individual inspiration, group reflection and school development, thus creating self-sustaining learning communities that ensures sustainability. The learning levels are research based; and by seeing mathematics as a natural science about the physical fact Many, they develop the quantitative competence children bring to school, thus including all students despite diversity as to gender or ethnicity or social or cultural background.

2. Peter, stuck in division, until learning about recounting in flexible bundle-numbers

Being a mathematics teacher in an ordinary class and in an adult class, both showing severe dislike towards division and fractions, Peter is about to give up teaching when he hears about a one-day workshop on curing math dislike by recounting totals in flexible bundle-numbers.

Here 5 sticks are recounted in 2s in three different ways, overload and standard and underload, occurring as outside blocks, and inside bundle-formulas: T = 5 = I I I I I = II I I I = 1*B*3 2s = II II I = 2*B*1 2s = II II II = 3*B*-1 2s. Likewise, if using ten-bundling: T = 57 = 5*B*7 tens = 4*B*17 tens = 6*B*-3 tens; or T = 567 = 56*B*7 = 50*B*67 = 60*B*-33 = 5*BB*6*B*7 tens.

Operations are eased by recounting in over- or underloads:

When dividing 336/7, 336 is bundle-written as 33*B*6. This is recounted as 28*B*56 that divided by 7 gives 4*B*8 or 48; or as 35*B*-14 that divided by 7 gives 5*B*-2 or 4*B*8 or 48.

Likewise, with subtraction: T = 65 – 48 = 6*B*5 – 4*B*8 = 2*B*-3 = 1*B*7 = 17; or T = 65 – 48 = 6*B*5 – 4*B*8 = 5*B*15 – 4*B*8 = 1*B*7 = 17.

Likewise, with multiplication: T = 7 x 48 = 7 x 4*B*8 = 28*B*56 = 33*B*6 = 336.

Likewise, with addition: T = 17 + 48 = 1*B*7 + 4*B*8 = 5*B*15 = 6*B*5 = 65.

A chatroom recommends watching the video 'CupCount and ReCount before you Add' (https://goo.gl/eBRFTy), and to download a 'CupCount & ReCount Booklet' for self-testing. Realizing its innovative potentials, he gives a copy to his colleagues, and they ask the school to arrange a free 1day Skype seminar in curing math dislike by recounting in bundle-numbers.
In the morning they watch the PowerPoint presentation 'Curing Math Dislike' confronting the three forms of mathematics, a pre- and a present and a post-setcentric version.

Present setcentric mathematics is called 'MetaMatism' as a mixture of 'MatheMatism', true inside a classroom but rarely outside where '2+3 = 5' is contradicted by e.g. 2weeks+3days = 17days, and 'MetaMatics', presenting a concept top-down as an example of an abstraction instead of bottom-up as an abstraction from many examples: 'A function IS an example of a set-product', instead of 'a function is a name for a formula with some unspecified numbers.'

The post-setcentric version is called ‘ManyMath’ by seeing mathematics as a natural science about the physical fact Many, to be counted and recounted in bundle-units before being added (or split) next-to or on-top. Here digits are icons with as many sticks as they represent. Likewise, operations iconize bundle-counting: a division broom pushes away bundles, to be stacked by a multiplication lift, to be pulled away by a subtraction rope, to look for unbundled singles, to be placed in a separate stack as decimals, or on-top counted as a fraction of a bundle. A ‘recount-formula‘, T = (T/B)xB, allowing a calculator predict that ‘from T, T/B times, B can be taken away’, occurs as proportionality all over mathematics and science.

The recounting seminar includes two Skype sessions with an external course leader.
Observing ManyMath curing math dislike, the school asks Peter to take in 1year e-learning course at the MATHeCADEMY.net, teaching teachers to teach MatheMatics as ManyMath. Peter here experiences PYRAMIDeDUCATION where 8 are organised in 2 teams of 4 teachers choosing 3 pairs and 2 instructors by turn. An external coach assists the instructors instructing the rest of their team. Each pair works together to solve count&add problems and routine problems; and to carry out an educational task to be reported in an essay rich on observations of examples of cognition, both re-cognition and new cognition, i.e. both assimilation and accommodation. In a pair, each teacher corrects the other’s routine-assignment. Each pair is the opponent on the essay of another pair. Each teacher pays by coaching a new group of 8 teachers.
The four e-learning courses for primary and for secondary school are called CATS, inspired by the fact that, to deal with Many, we Count & Add in Time & Space.

Primary school mathematics is learned through educational sentence-free meetings with the sentence subject, thus developing tacit competences and individual sentences coming from abstractions and validations in the laboratory, i.e. through automatic ‘grasp-to-grasp’ learning. Thus, learning means asking, not the instructor but the subject talked about. Using full number-language sentences with a subject and a verb and a predicate as in the word-language allows modelling from the beginning by recounting both bundles, distances, time periods, money etc.

Secondary school mathematics is learned through educational sentence-loaded tales abstracted from and validated in the laboratory, i.e. through automatic ‘gossip-learning’: Thank you for telling me something new about something I already knew.

The material is inquiry-based with guiding questions. In primary school, the four sets of questions are as follows. COUNT: How to count Many? How to recount 8 in 3s? How to recount 6kg in $ with 2$ per 4kg? How to count in standard bundles? ADD: How to add stacks concretely? How to add stacks abstractly? TIME: How can counting & adding be reversed? How many 3s plus 2 gives 14? Can all operations be reversed? SPACE: How to count plane and spatial properties of stacks and boxes and round objects?

In secondary school, the four sets of questions are as follows. COUNT: How to count possibilities? How to predict unpredictable numbers? ADD: What is a prime number? What is a per-number? How to add per-numbers? TIME: How to predict the terminal number when the change is constant? How to predict the terminal number when the change is variable, but predictable? SPACE: How to predict the position of points and lines? How to use the new calculation technology? QUANTITATIVE LITERATURE, what is that? Does it also have the 3 different genres: fact, fiction and fiddle?

The three MATHeCADEMY.net learning level thus allows Peter to become a facilitator for a local learning community and a course leader initiating pyramid-organized professional development locally or globally on the internet. After coaching a learning pyramid at the school to allow eight other teachers to be trained as facilitators and course leaders, the school may ask Peter to take the

secondary school course also so the school can become as a local centre for curing math dislike, thus allowing students to excel in both primary and secondary mathematics.

References

Tarp, A, 2018, "Mastering Many". Journal of Mathematics Education, vol 11(1), pp. 103-117.

Self-explanatory Learning Material to Improve your Mastery of Many – Material Dimension

Tarp, Allan, MATHeCADEMY.net, Århus C, Denmark
Tuesday, 8 October 2019, 14:00-16:00, KG5 103

1. Abstract

This poster illustrates a hands-on experience with educating math educators from the child's perspective, relating to the topic 2 question 4 about designing innovative self-explanatory material that has large potentials for scaling-up.

It is based on the observation that when asked 'How old next time?', a 3year old will say 4 showing 4 fingers; but will protest when held together two by two by saying 'That is not 4. That is 2 2s', thus rejecting the predication 'four' by insisting on describing what exists, bundles of 2s and 2 of them. Meeting Many, children develop a number-language with full sentences including a subject and a verb and a predicate as in the word-language, as well as 2-dimensional block-numbers with units, neglected by the school's 1-dimensional line-names, making some children count-over by saying 'twenty-ten'. So, the goal of the workshop is to inquire into the mastery of Many children bring to school to see what kind of mathematics occur if allowing the children to develop their already existing quantitative competence under proper guidance.

2. Digits and operations as icons bridging inside signs and outside existence

Matches and a folding ruler show that digits are, not symbols as the alphabet, but sloppy writings of icons having in them as many sticks as they represent: five sticks in the 5-icon, etc.

Operations also are inside icons reflecting outside actions: a division broom pushes away bundles, to be stacked by a multiplication lift, to be pulled by a subtraction rope to identify unbundles ones, to be placed next-to the stack as decimals, or on-top as fractions or negatives, predicted by a 'recount-formula', *T* = (*T/B)*B*, saying 'from T, T/B times, B is taken away'.

3. Bundle-counting fingers roots negative numbers and polynomials

To emphasize bundles, the fingers may be bundle-counted as: 0Bundle1, 0*B*2, 0*B*3, 0*B*4, ½*B*, 0*B*6, 0*B*7, and then 0*B*8, 0*B*9, 1*B*0; or 1*B* less2, 1*B*-1, 1*B*0, continuing with 'Viking-counting' one-left (eleven), two left (twelve), and finally BundleBundle as 100. Two-digit numbers are named by their two neighbours: *T* = 68 = 6*B*8 tens = 7*B*-2 tens = 6ten8 = 7ten-2.

Counting ten fingers in 3s introduces bundles of bundles: *T* = ten = 3*B*1 3s = 1*BB*1 3s, leading on to the general number-formula or polynomial *T* = ten = 1**B*^2 + 0**B* + 1*1 3s. Likewise counting in tens, *T* = 345 = 3**BB* + 4**B* + 5*1 = 3**B*^2 + 4**B* + 5*1, showing the four ways to unite numbers (the Arabic meaning of Algebra): on-top addition, multiplication, power and next-to block-addition called integration, all with reverse splitting operations: subtraction, division, factor-finding (root), factor-counting (logarithm), and differentiation.

4. Block-counting cubes roots decimals, fractions and negative numbers

Block-counting 8 cubes in 5s gives 1 5s and 3 unbundled 1s as predicted: *T* = 8 = (8/5)*5 = 1*5 & 3. Placing the 3 1s after the 1 5s roots decimal-writing, *T* = 1.3 5s = 2.-2 5s. Placing the unbundled instead on-top of the block of bundles roots fractions and decimal numbers, *T* = 8 = 1 3/5 5s = 2 -2/5 5s = 2 5s less 2. Counting in tens, *T* = 68 = 6 8/10 tens = 6.8 tens = 7.-2 tens.

5. Recounting roots flexible numbers and proportionality and per-numbers

Recounting in the same unit creates flexible numbers: *T* = 68 = 6.8 tens = 7.-2 tens
Recounting in another unit by asking e.g. '*T* = 3 4s = ? 5s', the recount-formula allows a calculator to predict the answer. Entering 3*4/5, the answer '2.some' shows that a stack of 2 5s can be taken away. Entering 3*4 – 2*5, the answer '2' shows that 3 4s recounts in 5s as 2*B*2 5s or 2.2 5s. Counting 3 in 5s gives a fraction: *T* = 3 = (3/5)*5. Recounting in physical units creates 'per-numbers' as e.g. 2$ per 3kg, or 2$/3kg, bridging the units by recounting in the per-number: Asking '6$ = ?kg', we recount 6 in 2s: *T* = 6$ = (6/2)*2$ = (6/2)*3kg = 9kg; and vice versa.

6. Recounting from tens and to tens roots equations and multiplication tables

Recounting from tens to icons by asking e.g. '*T* = 2.4 tens = 24 = ? 8s' becomes an equation, u*8 = 24, that is easily solved by recounting 24 in 8s as 24 = (24/8)*8 so that the unknown number is u = 24/8, attained by moving 8 to the opposite side with the opposite calculation sign.

Recounting from icons to tens by asking e.g. '*T* = 3 7s = ? tens' we notice that with no ten-button on a calculator, the recount-formula cannot predict the answer. But, it is programmed to give the answer directly by using multiplication alone: *T* = 3 7s = 3*7 = 21 = 2.1 tens, only it leaves out the unit and misplaces the decimal point. The multiplication tables may use 'less-numbers', geometrically on an abacus, or algebraically with brackets: *T* = 3*7 = 3 * (ten, less 3) = 3 * ten, less 3*3 = 3ten, less 9 = 3ten, less (ten less1) = 2ten, less less 1 = 2ten & 1 = 21. And, 7*9 = (ten, less 3)*(ten, less 1) = ten ten, less 3ten, less 1ten, lessless3 = 6ten & 3 = 63.

7. Recounting is exemplified in STEM-formulas

STEM contains multiplication formulas with per-numbers: meter = (meter/sec)*sec = velocity*sec, kg = (kg/cubic-meter)*cubic-meter = density*cubic-meter; force = (force/square-meter)*square-meter = pressure*square-meter; energy = (energy/sec)*sec = Watt*sec; energy = (energy/kg)*kg = heat * kg. Lego-bricks: number = (number/meter)*meter = density*meter.

8. Recounting sides in a block halved by its diagonal roots angles, trigonometry and pi

Recounting a block with base b and height a, halved by its diagonal c, creates per-numbers:
*a = (a/c)*c* = sin*A*c; b = (b/c)*c* = cos*A*c*; *a = (a/b)*b* = tan*A*b*; and $\square\not\approx$ *n**sin(180/*n*).

9. Adding totals on-top and its reverse roots proportionality and differential calculus

Adding 2 3s and 4 5s on-top, the units must be harmonized by recounting. Adding next-to means adding areas, called integral calculus; as when adding per-numbers and fraction that must change to unit-numbers by multiplication, thus creating areas to be added.

Reversing addition by asking e.g. '2 3s and ? 5s total 4 5s or 2 8s' will become equations, 2*3 + u*5 = 4*5 or 2*3 + u*5 = 2*8, solved by moving to opposite side with opposite sign.

10. Grand theory holds conflicting conceptions on concepts

Within philosophy, Platonism and Existentialism argue if concepts are examples of abstractions or abstractions from examples. Within psychology, Vygotsky and Piaget argue if concepts are constructions mediated socially or experienced individually. Within sociology, the agent-structure

debate is about establishing inclusion by accepting the agent's own concepts or establishing exclusion by insisting on teaching and learning institutionalized concepts.

References

Tarp, A, 2018, "Mastering Many", Journal of Mathematics Education, vol 11(1), pp. 103-117.

Mathematics and physics investigations for the whole body and a smartphone in playgrounds and amusement parks – Material Dimension

Pendrill, Ann-Marie, National resource centre for physics education, Lund university, Lund, Sweden
Tuesday, 8 October 2019, 14:00-16:00, KG5 103

1. Smartphone sensors for mathematics and physics teaching

The availability of smartphones and user-friendly apps to take data with their built-in sensors offers many possibilities to scale up the use of real-life examples for STEM teaching. This work focuses on the study of motion in playgrounds and amusement parks, where sensors taken along can measure the forces experienced by the body as it accelerates and rotates. The data recorded can be saved and brought back to the classroom for analysis. Sensor data can also be combined with video recordings from the phone.

Teaching force and motion is a well-known challenge. The traditional mathematical desriptions of bodies in motion rarely connect to human bodies and acceleration often remains an abstract concept. With smartphone sensors, the motions studied need no longer be restricted to constant velocity or uniform acceleration but can include more general motions of everyday life. Playgrounds and amusement parks offer many types of motion that are well suited for investigations using smartphones, although the interpretation of the results is not always straightforward.

Figure 1. Sequence of screen shots at 0.2s interval from a movie of the Family Free Fall Tower "Stjernetårnet" at Tivoli gardens in Copenhagen. Where do you move fastest? Where do you feel heavier than normal - and where do you feel lighter?

2. Scaling up Smartphone use for playgrounds and amusement parks

This poster presents several examples of how this work is scaled up, through material, teacher professional development as well as networking.

2.1. Scaling up with materials

The materials provided for teachers come in many different forms and are available on our www site tivoli.fysik.org. Some of the material will be exhibited on the poster as well as in the materials market.

- Worksheets with different scopes: Simple quizzes, and a number of worksheets with investigations of varying difficulty

- Examples of accelerometer data and analysis
- Checklists and teaching recommendations - building on research from other informal eduational settings and activities
- Web pages presenting examples of student dialogues for different rides
- Movies with examples, as well as sequences of screenshots for discussions (Fig. 1)
- Exercises and problems for material for classroom preparation
- Examples worked through in detail
- Papers presenting different rides in detail
- Research papers analysing student group discussions about rides
- Suggestions for extended follow-up project work

2.2. Scaling up through professional developments and physics days

To lower the threshold for teachers to get involved, we have organized a number of largescale physics or edutainment days, where teachers can bring their classes to amusement parks, as described by Pendrill, Kozma and Theve (2013). Teacher professional development has been offered in different formats to support the preparation and follow-up in the classroom

- Teacher days in amusement parks where teachers in small groups can experience the event from a student perspective, reflect on their experience, collect data and think about questions their students may ask.
- Workshops during teacher conferences, where teachers discuss and work through a few of the more extended problems, highlighting learning challenges and opportunities.

2.3. Scaling up through networking

Social media enables teachers to support each other, in addition to the support provided by organizers or universities. We have found that closed teacher facebook groups offer excellent opportunities for network and support. Networking with educational providers at other parks nationally and internationally, sharing ideas and materials, is another way of scaling up. Additional networking happens through research and development collaborations.

3. Supporting the teacher role

Bringing a class to an amusement park can be very rewarding, but taking the class outside the school always special demands on the teacher role, as discussed e.g. by Pendrill, Kozma and Theve (2013). Teachers may also need personal support to overcome initial thresholds to using phones in STEM teaching, and are often surprised when they discover the possibilities, e.g. seeing the inspiring lesson plans from Vieyra and Vieyra (2019), covering many sensors in addition to accelerometers, gyros and barometers.

Working out forces for the different situations can be challenging, and during the discussion following students initial work, many incomplete force conceptions can be exposed and clarified. The poster will present a number of worked-through examples, including common student responses, collected from a large number of student groups (e.g. Eriksson&Pendrill 2019, Pendrill 2015). Some examples may also be tried in a real life situation in Europapark as a programme special on the day following the conference. (Contact the author at least a week in advance to secure a place.)

References

Eriksson U. and Pendrill A.-M. 2019 "Up and down, light and heavy, fast and slow – but where", Physics Education 54 025017

Pendrill A.-M. 2016 "Rotating swings - a theme with variations" Physics Education 51 15014

Pendrill A.-M., Kozma C. and Theve A., 2013 "Teacher Roles in amusement parks" Proceedings ICPE-GIREP, p 591-599

Vieyra C. and Vieyra R. 2019, "Physics Toolbox Apps: Lessons"

www.vieyrasoftware.net/browse-lessons

Diagnosis of difficulties in of handing variables and drawing conclusions by means of the reports of an initial experimental activity – Material Dimension

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1. Abstract

The aim of this paper is limited to the assessment of some science process and skills that prospective Primary teachers (PPTs) should develop. Sixty three PPTs were initiated in scientific practices through Inquiry based Learning (IBL) in groups. This training was started with the so named guided experimental activity (ExA_1): '*Stratification and segregation by mechanical agitating: Which takes precedence: the heavier or the lighter? Don't push yourself too hard, shake them and they´ll detach themselves!*. Instrument for data collection consisted of an open ended questionnaire titled *What have we learned?*, one questionnaire per group, completed during the class following the implementation of the ExA. The results showed that most of the groups identified the relevant variables that may affect the segregation of the objects in the shaking granular material. But vast majority of them failed to set the control of variables carried out. Only a few of them were able to depict the experimental design developed. And they show only partial coherence when drawing conclusions.

Keywords: inquiry-based learning; practical works; scientific practices, control of variables; Prospective Primary Teachers

2. Introduction and objectives

This work is part of a half-way-developed project directed to the initiation of (PPTs) to the processes of scientific inquiry throughout ExA. Particularly, the project deals with the successive implementation of investigating ExA so that both the required autonomy and level of openness of the inquiries to be carried out may grow. This article is a follow-up to previous contributions (Criado et al. 2016[a], Criado et al. 2016[b]) of our work concerning inquiry processes.

The aim of this paper is to assess the main achievements of PPTs in some inquiry skills in an initial ExA developed to diagnose their difficulties in IBL. The initial performance level on identifying variables and its control, on pinpointing the experimental design developed, and the coherence of drawing conclusions are the results presented this time, since problems and hypotheses issues concerning this initial ExA have already been communicated (Criado, et al 2016[a]).

3. Methodological aspects

Sixty three PPTs (organized into 17 groups) were trained to develop scientific practices. This training was started with the so named teacher-guided ExA: '*Stratification and segregation by mechanical agitating: Who takes precedence: the heavier or the lighter? Don't push yourself too hard, shake them and they´ll detach themselves!',* Criado & Garcia-Carmona (2011). It was implemented with the help of a paper and pencil task sheet. Instrument for data collection about the effectiveness of the ExA consisted of an open ended questionnaire titled *What have we learned?*, one questionnaire per group, completed during the class following the implementation of the ExA. The data were analysed by combining methods of inter- and intra-rater analysis.

4. Results

The results showed that most of the groups identified weight, density and volume as the relevant variables that may affect the segregation of the objects that sink or emerge in the shaken granular material. But vast majority of them fail to evoke, to set the control of variables carried out the previous class. One third of the groups were able to depict the experimental design developed to inquiry which of the variables governs the emerging objects process. And finally, the groups showed only partial coherence when drawing conclusions.

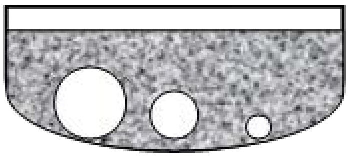

Figure 1. Same (and light) material objects shaking test

Acknowledgements

Project EDU2017-82505-P (2018-2021) "Formación de Futuro Profesorado de Niveles Elementales en los Procesos de la Ciencia y su Didáctica", (Training preservice teachers of elementary levels in Scientific Practices and its Pedagogy). Proyectos I+D, Ministerio de Economía y Competitividad. https://investigacion.us.es/sisius/sis_proyecto.php?idproy=28499

References

Criado & García-Carmona, (2011) "Las experiencias prácticas para el conocimiento del medio (natural y tecnológico) en la formación inicial de maestros. *Investigación en la Escuela*, 74, 73-88. ISSN(on line):2443-9991. https://idus.us.es/xmlui/handle/11441/25975

Criado A.M.; García-Carmona, A.; and Cruz-Guzman, M. (2016[a]), "Identificación de preguntas y formulación de hipótesis en una experiencia de segregación por agitación mecánica. Un estudio con futuro profesorado de Educación Primaria", (*'Indentifiying questions and hypothesis posing on an experience of segregation by mechanical agitation'*). Actas de los 27 Encuentros de Didáctica de las Ciencias Experimentales, pp1333- 1341. Universidad de Badajoz. Spain http://eventos.unex.es/event_detail/2966/detail/27-encuentros-de-didactica-de-las- ciencias-experimentales-andquot;tendiendo-puentes-entre-espana-y-.html.

Criado A.M.; García-Carmona, A.; and Cruz-Guzman, M. (2016[b]) 'An experience with soap films in preservice Primary teachers training on inquiry-based Science learning' Conference: 'Educating the educators II: international approaches to scaling-up profesional development in mathematics and science education'. http://educating-the-educators.ph-freiburg.de/ programme/presenters-listEducating the Educators II.

Scaling up PD through the exchange of good practice – Structural Dimension

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Tuesday, 8 October 2019, 14:00-16:00, KG5 103

1. Abstract

Science on Stage Europe is a network for STEM teachers focusing on the exchange of good practice teaching ideas by identifying them on local and bringing them to European level and back into the countries. By spreading innovative teaching concepts among Europe's STEM teachers and creating new teaching material from teachers for teachers Science on Stage contributes to improve STEM teaching by supporting educators in their professional development and growth.

2. Proposal

The non-profit association Science on Stage Europe aims to scale up professional development of teachers to improve the quality of teaching in science, technology, engineering and mathematics (STEM). This is achieved by enabling STEM teachers of primary and secondary schools to exchange their teaching concepts and experience and to create new resources from teachers for teachers in cross border collaborations.
A network of National Steering Committees (NSCs) in more than 30 countries provides the interface to the respective national STEM teacher communities.

3. Identifying local good-practice to disseminate them on a national level

There are many teachers in primary and secondary schools in Europe who set good practice examples in their classes day by day.
Through the Science on Stage network it is possible to identify them on a local level and to present them on a national level: The NSCs have regular national events which teachers apply for with their good practice examples. There the teachers show their projects to their colleagues at stands in a fair, in workshops or lectures. The local ideas get recognition on a national level.
At these events the best ideas are chosen by a national expert jury to be presented by the respective teachers at the European Science on Stage festivals.

4. What is a good practice example?

The overall criteria for a “Science on Stage project” are that it
1. promotes students interest in science
2. refers to everyday life
3. has a sustainable effect
4. is feasible to reproduce in an everyday school setting and can be financed with reasonable expenses
5. promotes inquiry-based learning

5. Spreading national concepts at European level

Every two years Science on Stage Europe organises Europe’s biggest STEM teaching festival.
Each time hosted by a different country, the event brings together up to 450 STEM teachers from all across Europe to **share and exchange their ideas and concepts for a successful STEM education** from primary to secondary school.
The participants present their most innovative teaching ideas to their international colleagues at stands, in workshops and in on-stage-presentations. Following the principle 'from teachers for teachers' the festival supports the continuous professional development of the educators.

6. Bringing good practice examples back to national and local levels, enabling cross-national collaborations

The European festivals are the starting point for a wide range of national follow-up activities as the teaching concepts from the European festival find their way to teacher trainings and teaching materials after the event via follow-up activities, **spreading these ideas in other countries** and giving the opportunity to create new good practice examples through **enabling teachers from different countries to collaborate**.
These collaborations (Joint Projects) find their way back to the European level as it is possible for collaborating teachers to directly apply for the European Science on Stage festival.

7. Science on Stage inspires teachers, but how exactly do teachers benefit from taking part?

How do teachers benefit from Science on Stage? The latest evaluation study on the European Science on Stage festival 2017 carried out by Tanja Tajmel and Ingo Salzmann from Concordia University, Montréal, has demonstrated that Science on Stage has a sustainable impact on the continuous professional development of STEM teachers.

Specific focus was on the key objectives, which are sharing ideas, the continuous professional development, and the dissemination of teaching concepts among Europe. Indeed, 90% of the participating teachers find many inspiring ideas for their STEM lessons and actually incorporate them in their own classrooms.
However, the teachers do not only appreciate to get new ideas, but also the possibility to gain and maintain international contacts.

Another long-term evaluation by Tanja Tajmel summarizes data collected from 2008 to 2012. The results demonstrate that the exchange of teachers through the association's activities has a positive effect on the motivation for and joy in their professional life.

The improvement of STEM education and thus the promotion of students to become scientific literate people consider a career in science, ICT and engineering, is a good way to reduce the skills gap and to enable students to find their way in our digital society.

8. International projects, developing teaching material from teachers for teachers

Another outcome is the development of teaching material for STEM lessons. Science on Stage gathers STEM teachers from different European countries to develop materials for their colleagues throughout Europe and beyond. Each project is motivated by a current educational topic such as coding, language promotion or smartphones in STEM education (e.g. "Coding in STEM Education" or "Lilu's House – Language Skills through Experiments").
The teachers apply with their ideas as participants. A group of coordinators, who are teachers themselves, select them to work over a period of 2 years with 2 face-to-face meetings. The participants work as authors of the teaching units in international teams. Science on Stage publishes these concepts in different languages and disseminate them across Europe (free order or download).

Through this chain of activities Science on Stage assures that local good practice examples are spread as wide as possible, through personal exchange new projects and teaching material are created. The acknowledgement of the work and expertise of teachers raises the motivation and therefore contributes to the continuous professional development of European STEM teachers.

A CASE STUDY ON CONSTANT VELOCITY MOVEMENT WITH TECHNOLOGICAL EDUCATIONAL KITS – Personal Dimension

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Tuesday, 8 October 2019, 14:00-16:00, KG5 103

1. Introduction

The importance of STEM (Science-Technology-Engineering-Mathematics) education has been increasing day by day. The rise of the Science, Technology, Engineering and Mathematics (STEM) education movement over the past 20 years, particularly in western education systems, has placed technology and engineering education firmly on the agenda in many countries (Blackley and Howell 2015). However, rise of the STEM interest, there is no consensus on which content serves STEM education. STEM is thought as a multidisciplinary approach to learning that can be used to integrate knowledge from the separate STEM subjects into existing science, technology, engineering design-based studies, or problem-based learning strategies (Julia and Antoli, 2018). In this study, Vazquez (2013) states that the content of two or more disciplines close to two disciplines and skills training are developed in order to deepen the knowledge and skills within the inter-disciplinary (Inter) STEM

framework. In spite of the researches, studies on the nature of STEM and increasing interest in STEM fields are insufficient (Falk et al., 2016). Moreover, educational researchers emphasize that qualitative studies should be increased in order to understand what the students have achieved STEM (Museus, Palmer, Davis & Maramba, 2011).

At first glance, it seems difficult for these areas to be included in the curriculum as a single course discipline. However, the integration of science and mathematics has long been recognized as a mechanism for making students and students more meaningful in science and mathematics. Effective practices in science and mathematics education also contribute to STEM integration (Stohlmann et al., 2012). Steps are taken to develop teachers 'and students' course materials along with the attitudes about STEM education. One of these is calculators developed by Texas Instruments. These calculators used for mathematics education in the beginning are intended to be used in science education while developing different sensors over time. However, in the literature, there are not enough studies on the contribution of Texas instruments and sensors to science education. In this study, the situation created by the use of Texas instruments technological education kits in STEM education of secondary school science students was examined.

2. Method

For this purpose, six females and 6 males were attending the 7th grade of a secondary school and a 16-hour study was conducted. The case study was preferred from the qualitative research method. In order to collect the data, speed pre-knowledge test developed by the researchers and then semi-structured interview form were used. As an application, 5 questions were applied to the students. In this application, the students were asked questions in the direction of the constant velocity movement section gains in the 6th class force and movement unit. The students were then given a 40-minute training on how to measure using the Texas Instruments CX CAS calculator and the GoMotion motion sensor. The students were then asked to use the Texas Instruments CX-CAS calculator and the GoMotion motion sensor to measure the velocity of the objects they saw in their environment and to draw and record the graphics. The test was then re-applied as a posttest. In this way, it has been tried to observe how enriched the learning experiences of students. Then, a semi-structured form consisting of six questions was applied to the students.

3. Results and Recommendation

It was seen that students used the contents of science-mathematics and technology together. When the first practice had some misconceptions about the concept of speed, units and drawings, they showed improvements in graphic reading and conceptual level following their studies with technological training kits. After the semi-structured interview, it was concluded that the students enjoyed working with technological educational kits and their motivation increased. In the use of a multi-dimensional approach such as STEM education, it is thought that technological educational kits could contribute to the conceptual framework in science education.

References

Blackley, S., & Howell, J. (2015). A STEM narrative: 15 years in the making. *Australian Journal of Teacher Education*, *40*(7), 102–112.

Falk, J. H., Staus, N., Dierking, L. D., Penuel, W., Wyld, J. & Bailey, D. (2016). Understanding youth STEM interest pathways within a single community: The Synergies project*, International Journal of Science Education, Part B, 6(*4), 369-384, DOI: 10.1080/21548455.2015.1093670

Julia. C., & Antoli, J.O. (2018). Impact of implementing a long-term STEM-based active learning course on students' motivation. Int J Technol Des Educ (2019) 29:303–327 https://doi.org/10.1007/s 10798-018-9441-8

Huntley, M. A. (1998). Design and implementation of a framework for defining integrated mathematics and science education. *School Science and Mathematics, 98*(6), 320‐ 327.

Museus, S. D., Palmer, R. T., Davis, R. J., Maramba, D. (2011). Special issue: Racial and ethnic minority students' success in STEM education. *ASHE High Educ Rep 36*(6), 1–140.
Stohlmann, M., Moore, T., & Roehrig, G. (2012). Considerations for teaching integrated STEM education. *Journal of Pre-College Engineering Education Research, 2*(1), 28-34.
Vasquez, J. A., Sneider, C., & Comer, M. (2013). *STEM lesson essentials, grades 3-8: Integrating science, technology, engineering, and mathematics*. Portsmouth, NH: Heinemann.

Materials for Promoting Problem Solving and Experiencing the Beauty of Mathematics – Material Dimension

Olsen, James, Department of Mathematics and Philosophy Western Illinois University Macomb, IL 61455 USA, Macomb, United States
Tuesday, 8 October 2019, 14:00-16:00, KG5 103

1. How the poster relates to the overall conference theme:

I feel that we can scale up the abilities of our teacher educators and our teachers (and therefore, our students) to better convey the beauty of mathematics and provide inquiry-based learning experiences, which will improve mathematical understanding and higher-order thinking. I will provide classroom tasks and materials for inquiry-based learning of mathematics.

2. The work to be presented on the poster (who, what, etc.):

My goal and purpose is to provide a collection of wonderful geometry problems so that people can develop a connected understanding of mathematics and higher-order thinking, see the beauty of mathematics, and experience the joy of mathematical reasoning, as a human experience. These geometry problems are intended to be used as tasks in the classroom in an inquiry-based learning environment.

3. From which perspective will these materials address the topic:

These problems can be used by teacher educators in professional development settings and can be used by teachers of pre-university students as well as university-level students.

4. How the poster relates to the *materials dimension:*

It is often difficult for teacher educators and teachers to select worthwhile mathematical tasks for problem solving. (Sometimes due to the overwhelming availability of problems.) The problems I'll be sharing have been selected because they

- Are accessible,
- Do not require complex theorems to be solved,
- Promote mathematical reasoning,
- Often combine algebraic and geometric thinking,
- Can be solved in more than one way,
- Convey the beauty of mathematics.

My intention is that the classroom materials are in a ready-to-be-used form.

References:

National Governors Association Center for Best Practices, Council of Chief State School Officers. (2010). *Common Core State Standards for Mathematics*. Washington D.C. Published by National Governors Association Center for Best Practices, Council of Chief State School Officers

Su, Francis. (2017) *Mathematics for Human Flourishing*. Retiring Presidential Address at the AMS-MAA Joint Winter Meetings. mathyawp.wordpress.com/2017/01/08/mathematics-for-human-flourishing/
U.S. Department of Education. (2008). *The Final Report of the National Mathematics Advisory Panel*. Washington D.C.

Progressions of prospective primary teachers skills in handing variables and drawing conclusions when they are trained by Experimental Activities – Material Dimension

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García-Carmona, Antonio, Departamento Didáctica de las Ciencias. Universidad de Sevilla., Seville, Spain
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Tuesday, 8 October 2019, 14:00-16:00, KG5 103

1. Abstract

Inquiry-based learning (IBL) strategies are dealt with in our research about Experimental Activities (ExA) in prospective primary teachers´ (PPT) Science training. To determine the quality of a sequence of several ExA programed a pilot study was conducted. This paper shows some of the results obtained. Sixty-three PPTs were initiated in scientific practices. Implementation was ensured by progressive scaffolding, instruction and interim data. Instrument for data collection consisted of the open-ended (but oriented) reports of the groups about the activities done. Several aspects of IBL were studied with our project: Problems, hypotheses, variable identification, control of variable strategy (CVS), and degree of coherence when drawing conclusions (CinC). This paper concerns the latest. Results showed that the CVS, as well as the CinC were difficulties detected in most of the groups at the beginning of the training program. 'Ad hoc' instruction and scaffolding were implemented with the aim of addressing each of this difficulties. But growing demand for high order processes were required throughout the implementation of the ExA sequence, as less teacher-guided ExAs were done. Competence skills in IBL of PPTs improved to a different degree depending on the familiarity with the topic addressed in de ExA

Keywords: inquiry-based learning; practical works; scientific practices, control of variables; Prospective Primary Teachers

2. Introduction and objectives

This work is part of a half-way-developed project directed to the initiation of (PPTs) to the processes of scientific inquiry throughout ExA. Particularly, the project deals with the successive implementation of investigating ExA so that both the required autonomy and level of openness of the inquiries to be carried out may grow. This article is a follow-up of our previous work (Criado, García-Carmona & Cruz-Guzmán, 2016). The aim of the current paper is to show intermediate gains of PPTs in some inquiry skills such as CVS as well as CinC in the course of two intermediate tasks developed with special scaffolding to solve their first detected difficulties.

3. Methodological aspects

Sixty three PPTs (organized into 17 groups) were trained to develop scientific practices. This training was started with a guided ExA_1, whose analysis showed the following goals to achieve: 'improving appropriate wording in problem formulation', 'clarifying the CVS' and 'being consistent when

drawing conclusions from the current ExA developed'. This issues were addressed in a two-step-approach: 1) A task of preparing a data table for data collection to inquiry about the influential factors in the germination of seeds (legume seeds); 2) New IBL ExA involving chromatograms of felt tip pen inks (ExA_2).

4. Results and Discussion

Interim data revealed that both CVS and CinC were difficulties detected in most of the groups at the beginning of the training program. So 'ad hoc' instruction and scaffolding were implemented with the aim of addressing each of these emerging difficulties. But growing demand of high order processes were required throughout the implementation of the IBL-ExA sequence, as less teacher-guided ExAs were done. PPTs competence skills in IBL improved to a different degree depending on the familiarity with the topic addressed in de ExA. All the groups were able to prepare a data table for data collection to inquiry about the influential of light and water irrigation in the germination of legume seeds. One third of the overall groups could set their owns problems in the chromatogram ExA and the half of them just kept the problem example proposed by the teacher. Most of the groups formulated reasoned assumptions in the role of founded hypotheses. Only one third of the sample explicitly recognized to have designed a CVS, confirming what Schwichow et al (2015) report, and Schichow suggests: returning to the issue on several occasions is needed. However, CinC results quite satisfactory in the chromatogram ExA. This reinforce the necessity for increased training in various aspects as CVS, and to develop a persevering attitude in reaching conclusions, returning to the questions raised and the hypothesis formulated at the beginning of the process.

Acknowledgements

Project EDU2017-82505-P (2018-2021) "Formación de Futuro Profesorado de Niveles Elementales en los Procesos de la Ciencia y su Didáctica", (*Training preservice teachers of elementary levels in Scientific Practices and its Pedagogy*). Proyectos I+D, Ministerio de Economía y Competitividad. https:// investigacion.us.es/sisius/sis_proyecto.php?idproy=28499

References

Aydoğdu, B. (2015) Examining preservice science teachers' skills of formulating hypotheses and identifying variables. Asia-Pacific Forum on Science Learning and Teaching, 16, (1), Article 4, p.1. https://www.ied.edu.hk/apfslt/download/v16_issue1_files/aydogdu.pdf

Criado, A.M.; García-Carmona, A.; & Cruz-Guzman, M. (2016). An experience with soap films in preservice Primary teachers training on inquiry-based Science learning' Conference: 'Educating the educators II: international approaches to scaling-up profesional development in mathematics and science education'.

Schwichow, M.; Zimmerman, C; Croker, S.; & Hartig, H. (2016). What students learn from hands-on activities? Journal of Research in Science Teaching, 53(7), 980–1002.

Algorithms Unplugged for schools – Material Dimension

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Jakutienė, Vida, Vilnius University, Vilnius, Lithuania

Meškauskienė, Asta, Vilnius University, Vilnius, Lithuania

Tuesday, 8 October 2019, 14:00-16:00, KG5 103

1. Introduction

Computational thinking (CT) is an ability to solve problems. CT can be used to support problem solving across all disciplines. Jeannette M. Wing described CT as “solving problems, designing systems, and understanding human behaviour, by drawing on the concepts fundamental to computer science“ (2006). From the viewpoint of educators the development of CT includes both productive thinking and active student-oriented methods, materials and teaching content. Therefore, the questions how to develop students’ CT during lessons and after them need to be discussed. One of the way is to solve tasks directed to develop students’ CT. For this purpose teachers have to know how to develop such tasks and how to solve them. Diversity in learning material is very important for motivation students to developing their CT. The international challenge Bebras on informatics and CT offers a lot of resources (tasks) for students of all ages. Algorithms compose the main part of CT, algoritmical thinking is important for mathematics as well. That’s why PISA 2021 are going to include CT in mathematical literacy: “Mathematical literacy goes beyond problem solving, to a deeper level, that of mathematical reasoning and computational thinking, which provides the intellectual acumen behind problem solving in the 21st century.” (PISA, 2018).

2. Computational thinking and Bebras challenge

CT skills include pattern recognition, decomposition, determining which (if any) computing tools could be employed in analysing or solving a problem, and defining algorithms as part of a detailed solution. By foregrounding the importance of CT, the framework anticipates a reflection by participating countries on the role of CT in mathematics curricula and pedagogy. CT involves problem-solving process that includes following characteristics (Dagiene, Sentance, 2016): (1) Formulating problems in a way that a computer can effectively carry out; (2) Logically organizing and analysing data; (3) Representing data through abstractions such as models and simulations; (4) Automating solutions through algorithmic thinking (a series of ordered steps); (5) Identifying, analysing, and implementing possible solutions with the goal of achieving the most efficient and effective combination of steps and resources; (6) Generalizing and transferring the solving process to a wide variety of problems.

The Bebras challenge on informatics and CT promotes problem solving skills and informatics concepts including the ability to break down complex tasks into simpler components, algorithm design, pattern recognition, pattern generalisation and abstraction.

Bebras tasks contain concepts of about nearly all areas of informatics – half of them are devoted to algorithms and fit to develop mathematical literacy as well. Usually a short story introduces a task and states a problem, technology are not used, but to solve the task some kind of computational thinking must be applied. There are tasks about concept categories of information representation, algorithms, programming, logic, encryption and many other.

3. Examples of the unplugged tasks for developing computational thinking

Example 1. Two beavers build a dam and need to do 7 tasks: A(7), B(5), C(8), D(13), E(7), F(1), G(2). The numbers in the brackets indicate working hours. Some tasks must be completed before others can be started - the precedence relations are represented by the arrows. For example the task D(13) can be started only when A and B are completed. We added Start and Finish, which is just a convenience that allows us to visualise and get a directed graph.

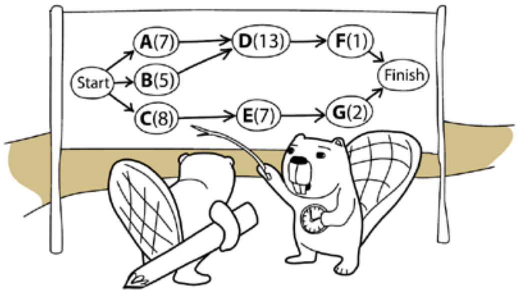


Figure 1. Two beavers are working

The Decreasing-Time Algorithm is applied to this task. The algorithm is based on a simple strategy: Do the longer jobs first and save the shorter jobs for last.
Example 2: Five beaver lodges (A, B, C, D, E) are located as shown in Figure 2. Beaver family would like to connect these five lodges by a water channel. The work of building the channel system connecting any two lodges is proportional to the distance between the lodges. Help beaver family to find the length of the channel network needed least amount of work.

Use Kruskal's algorithm.

1. Find the shortest channel (if there is more than one, pick one at random). Mark it.
2. Find the next shortest, unmarked channel. If it forms a circuit with already marked channels, discard it, and remove it from further selection. If it doesn't, then mark it.
3. Repeat step 2 until all beaver lodges are connected.

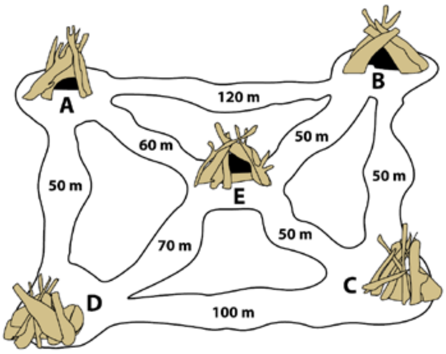


Figure 2. Building a channel

A spanning tree is conception is used in this task. A spanning tree is a tree that spans (reaches out to) all the vertices of the original graph.

References

Dagienė, V., & Sentance, S. 2016. It's Computational Thinking! Bebras Tasks in the Curriculum. In International Conference on Informatics in Schools: Situation, Evolution, and Perspectives, pp. 28-39. Springer International Publishing.

PISA 2021 Mathematics Framework (First draft), 2018. 45th meeting of the PISA Governing Board, 23-25 April, Stockholm, Sweden.

Wing. J. 2006, Computational thinking.Communications ofthe ACM, 49, pp 33–35.

Appendix 1

The Bebras Challenge on Informatics and Computational Thinking

Bebras is an international initiative aiming to promote Informatics (Computer Science, or Computing) and computational thinking among school students at all ages (https://www.bebras.org). 68 countries are involved in the Bebras at the moment.

Table 1. Number of students participated in the Bebras (2018)

Country	Participants		Country	Participant
Australia	43164		Austria	32675
Azerbaijan	5153		Belarus	150237
Belgium	4400		Bosnia and Herzegovina	9732
Bulgaria	514		Canada	18874
China	46053		Chinese Taipei	118332
Croatia	22887		Cyprus	606
Czechia	79988		Estonia	3458
Finland	5373		France	682053
Germany	373406		Hong Kong	4659
Hungary	25464		Iceland	1355
India	136607		Indonesia	5065
Iran	3107		Ireland	6851
Israel	250		Italy	51297
Japan	5128		Kazakhstan	2995
Latvia	17574		Lithuania	44136
Macedonia	25372		Malaysia	4879
Mongolia	251		Netherlands	18852
New Zealand	330		Pakistan	8754
Poland	22540		Portugal	160
Republic of South Africa	22058		Romania	14976
Russian Federation	12909		Serbia	50168
Singapore	1352		Slovakia	77928
Slovenia	33590		South Korea	25455
Spain	671		Sweden	5499
Switzerland	21313		Thailand	4132
Turkey	68484		Ukraine	117885
United Kingdom	201911		United States of America.	46699
Vietnam	12954			

Research papers and other resources on Bebras challenge are litened in website: https://www.bebras. org/?q=publications

Materials Market

Materials Market

Tuesday, 8 October 2019, 12:30-16:00, KG5 104

Introduction

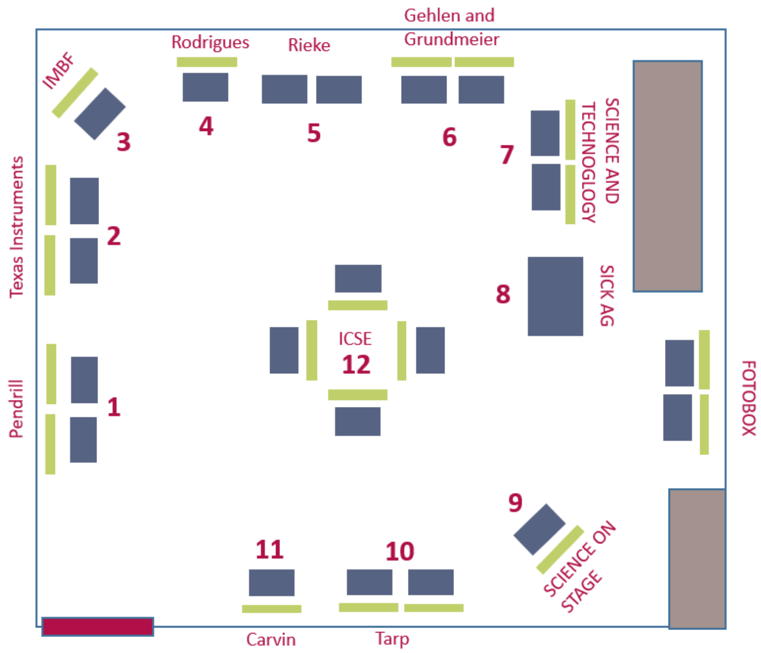
The International Centre for STEM Education (ICSE) is located at the University of Education in Freiburg, Germany and focuses on practice-related research and its transfer into practice. ICSE sustainably links stakeholders from research, practice, policy and industry, nationally as well as internationally through the ICSE consortium.

The ultimate aim of ICSE is to help improve STEM (Science, Technology, Engineering and Mathematics) education across Europe. That is, to give students insights into authentic features of STEM subjects and their connection to real-life contexts, to raise achievement levels in STEM subjects and to make science literacy accessible to all students, no matter their gender, their cultural or socioeconomic background. Thereby, ICSE intends to promote the interest of young people in STEM career

STEM education is becoming more and more important in professional and everyday life. Representatives from Industry, Research and Schools present **innovative** and **inspiring** materials to show how exciting STEM education can be.

Content

1. **Anne Maria Pendrill:** Forces and motion in playground and amusement parks: Physics for the whole body
2. **Texas Instruments:** Curriculum aligned PD for technology enhanced STEM teaching and learning settings
3. **IMBF:** Examples of the present Research Project at the Institute of Mathematical Education, Freiburg
4. **Carlos Rodriguez:** Bluetooth Door Locks.
5. **Jan Rieke:** Automated Cocktail Machine
6. **Gehlen/Grundmeier:** Experimental Experience of Textiles
7. **Science and Technology:**
    - Smartphone Microscope
    - Modern Electric Kit for Students
8. **Sick AG:** Deep Learning: An Enabling



Technology for Sensor Intelligence

9. **Science on Stage:** Materials from Teachers for Teachers
10. **Allan Tarp:** Recounting totals in icon-units and in tens before adding them next-to and on-top
11. **Jada Carvin:** Intercultural Learning Outside of School
12. **ICSE:**
    - Mathematical/Physical Optical Illusions
    - Escape Rooms in Math Education
    - Exploring Space with a Weatherballoon in STEM Education
    - Growing Bioluminescenct Algae as a STEM Project

13. **Discover Industry:** Science Truck

Abstracts

1. Anne Maria Pendrill: Forces and motion in playground and amusement parks: Physics for the whole body

Amusement parks and playground offer many examples for discussions which can support student learning and help elucidate persistent conceptual difficulties concerning force and motion. The mathematical description of motion, as seen from outside, can be combined with the inside perspective of the body experiencing the forces required to change motion. This helps challenge incomplete understanding. However, since this is not the traditional way to teach mechanics, teachers often need scaffolding to bring the class outside the classroom to learn mathematics and physics, or to bring real life examples into the classroom (Pendrill, Kozma and Theve, 2013). The access to many sensors on modern phones facilitates data collection, and follow-up analysis in the classroom. The materials to be presented include assignments for students, developed and tested iteratively. Analysis of written responses to exam questions, as well as small-group discussions and interviews have been used in the development. In addition to student materials, deeper analyses of the mathematics and physics involved in the tasks is provided for teachers. For many cases we have also published papers presenting the relevant theoretical analysis together with reports of common student difficulties and evidence of learning. Some of the worksheets presented can be applied to rides in the Europapark, including Teacup rides, Family Free Fall Towers (Figure 1) (Eriksson and Pendrill), Rotating Swings (Pendrill, 2015) and Rockin' Tug (Pendrill and Rohlen 2011).

Participants who are interested in trying investigations first hand are welcome to take part in a teacher day in Europapark on the day following the conference but need to contact the author at least a week in advance.

2. Texas Instruments: Curriculum aligned PD for technology enhanced STEM teaching and learning settings

T³ Europe is the European branch of a worldwide educator network. T³ [T-cubed] stands for Teachers Teaching with Technology. T³ Europe is an association of ~250 STEM (Science, Technology, Engineering and Mathematics) teachers that serves as an umbrella body for 12 country organizations to provide quality professional development, classroom-proven content and integrated state-of-the-art classroom pedagogy. For more than 20 years, T³ Europe has fostered a culture of cooperation, collaboration and sharing of expertise among educators from classroom teachers to policy makers.

At ETE III we will exhibit various practical examples regarding the integration of purpose-built technology in STEM classrooms across Europe. The materials will highlight how math, science and STEM education is approached differently in different countries, and how this feeds back to local PD structures and formats.

3. IMBF: Examples of the present Research Project at the Institute of Mathematical Education, Freiburg

4. Carlos Rodriguez: Bluetooth Door Locks.

We present a Bluetooth-based door lock system, controlled with a smartphone. This door lock system opens and closes by an electric impulse, which is controlled by an Arduino via a smartphone-app. This was a student project.

5. Jan Rieke: Automated Cocktail Machine

Our cocktail-machine automatically mixes non-alcoholic cocktails. Recipes can be changed electronically via app. This was a student project.

6. Gehlen/Grundmeier: Experimental Experience of Textiles

The Department of Fashion and Textiles at the University of Education Freiburg developed, tested, and evaluated a series of 88 textile-related didactical experiment cards of teaching and learning materials in the book “Experimental Experience of Textiles 7-10” within the frame of a multi-year subject-specific didactical research project. The 10 TEXperten®- experiments from the basic module "Fascination with Fibers, Threads, and Surfaces” and the expert module “Textiles – our second skin” are applicable for both science and technology-oriented textile instruction as well as in the science classroom. Independent experimentation allows pupils to discover the characteristics and profiles of modern textiles while developing basic knowledge of textiles and their underlying scientific principles. The pupils appreciate the textile industry and its products in the context of aesthetics, functionality, and sustainability, so that the experiments can also be introduced from the perspective of education for sustainable development and consumer education. The combination of innovative materials and information on textile and fashion trades can facilitate action-oriented career guidance.

7. Science and Technology: Smartphone Microscope

We will present how smartphones can be turned into microscopes and show several applications for schools. Furthermore, we introduce a technics kit for students, giving a modern, practical and exciting introduction to the field of electronics.

8. Sick AG: Deep Learning: An Enabling Technology for Sensor Intelligence

We demonstrate two interactive applications to visualize Deep Learning Methods in Industry. The first application classifies participants drawings in given classes (house, ladder, butterfly, unknown). The second application comes from the wood-industry and needs 200ms interference-time per picture.

9. Science on Stage: Materials from Teachers for Teachers

By spreading innovative teaching concepts among Europe’s STEM teachers and creating new teaching material from teachers for teachers, Science on Stage contributes to improve STEM teaching by supporting educators in their professional development and growth. Coding in STEM Education, Football in Science Teaching, Language Promotion with Experiments: Science on Stage

offers a wide range of classroom materials for STEM teachers of all school levels (primary and secondary level). Through its network of more than 30 European countries the non-profit association gathers STEM teachers to develop materials for their colleagues. In small working groups they collaborate and share their experiences over a period of 2 years and test their teaching units in their classes before publishing. Each project is motivated by a current educational topic such as coding in STEM education or language promotion. Science on Stage publishes these concepts in different languages and disseminates them across Europe. All resources are available on www.science-on-stage.eu online for free and also on the Scientix platform.At the materials market Science on Stage will present teaching materials such as Coding in STEM Education, about the use of smartphones in STEM lessons, promotion of language skills in primary school. Furthermore, we give an overview about the activities, benefits and possibilities for teachers to participate: The European Science on Stage festival 2019 in Cascais, Portugal, the European Code League, the teacher exchange program and teacher trainings.

10. Allan Tarp: Recounting totals in icon-units and in tens before adding them next-to and on-top

At the conference the plan is to exhibit the MATHeCADEMY.net's three levels for developing mastery of Many individually, school- and nation-wise, and globally. The focus is on a teacher being emotionally touched by the student's learning problems and wanting to cure math dislike. The background is the math dislike often occurs when teaching division.

The aim is to, by seeing how the CATS approach cures math dislike, a teacher is mobilized to be a facilitator in a one-day Skype seminar as well as a course leader by taking a one-year online training in the CATS approach to math education: to master Many, we Count and Add in Time and Space on a primary and on a secondary level. Accepting and developing the mastery of Many children bring to school, the material emphasizes bundle- and block-counting and recounting totals in icon-units and in tens before adding them next-to and on-top.

The school subjects concerned are mathematics and STEM subjects. The language available is English. The material was designed by Allan Tarp as part of a phd project and was applied and developed when hired as a web-based distance education educator at pre-service education in Denmark and draws upon experiences from a period as a visiting professor at an in-service and pre-service teacher training academy in South Africa.

The material as well as the CATS teacher training program for primary and for secondary teachers is available at the MATHeCADEMY.net website which may be franchised freely by any university, together with MrAlTarp YouTube videos.

Bedsides allowing educators to be educated as facilitators and course leaders, the material also allows migrants and refugees to be educated as STEM educators able to return to help develop or rebuild their countries.

11. Jada Carvin: Intercultural Learning Outside of School

This PD material was designed within the Erasmus+ project IncluSMe (Intercultural learning in Science and Mathematics initial teacher education - https://inclusme-project.eu/) aiming at enriching high education curricula equipping future teachers to deal with an expanding number of refugees and immigrant youths entering the educational system. It is of high value to educate the educators to increase prospective teachers' intercultural understanding of science teaching based on an intercultural pedagogical practice that focuses on dynamics and interactions occurring between learners having diverse cultural background, making backgrounds or contrasts visible and understandable (Lee and Luykx, 2007). This PD material was piloted at the summer school in Prague 2018 attended by prospective science teachers from eight European nations. It is focused on intercultural science learning outside of school (Rennie, 2014), and its goals are to enable prospective teachers to:

- Become aware of the benefits of “outside of school” opportunities for learning scientific concepts and procedures in an intercultural context;
- Learn to value the importance of concrete out-of-school experiences to bridge communication/language problems;
- Appreciate intercultural background and pre-knowledge of students as resources rather than barriers for learning scientific concepts and procedures;
- Develop pedagogical approaches by using different arenas (e.g. urban or rural areas, museums, local factories) – to promote creativity, language learning and conceptual understanding;
- Develop competency in teaching topics related to the diversity of nature (ecology/evolution/ energy/nutrient cycles) in an intercultural context.

12. ICSE:

Escape Rooms in Math Education: Escape rooms became extremely popular in the recent years. Participants of escape rooms usually need to combine their individual strengths and abilities to be successful. This concept is easily adaptable to math lessons, is extremely encouraging for students and has several didactical advantages. We present methods how to prepare escape rooms effectively and also demonstrate the concept of an escape box.

Growing Bioluminescenct Algae as a STEM Project. The beauty of shining oceans in the night, mating fireflies and soon glowing plants will maybe replace streetlamps. Bioluminescence is an extremely fascinating and current topic in science. We demonstrate bioluminescent algae and bacteria and how they can be grown and sustained in science classes. We will show how students can use these bacteria to investigate water and air-quality.

Mathematical/Physical optical illusions. The mathematician and engineer Kokichi Sugihara is famous for his astonishing optical illusions. For example, he constructed geometric bodies with irritating mirror image. We will present seven 3d-printed examples of these bodies and explain the geometric background. Additionally, will give crafting templates to produce such bodies with scissor and paper.

Exploring Space with a Weatherballoon and a Raspberry Pi. A weather balloon is capable of ascending to a height of 40km. Equipped with a camera and a small computer such a balloon can film earth from the stratosphere and conduct scientific experiments in space as measuring radiation, temperature and air pressure. The start of a weather balloon into the stratosphere can be realized as a project in secondary schools, focusing on interdisciplinary work. We will present an assembled balloon, show a video of a stratospheric flight, explain challenges and opportunities of such a project.

13. Discover Industry: Science Truck

Working in industry is monotonous and dreary, engineers are boring nerds… DISCOVER INDUSTRY contradicts this prejudice and proves the opposite: On five stations participants of the materials market solve typical industry problems: Use a 3d-scanner, test a prototype in a wind tunnel or program an industry robot.

Other

ETE Network Lounge

SLOT 1 Connecting Researchers: Monday, 7 October 2019, 15:00-16:20, KG5 103
SLOT 2 Connecting STEM PD Centres: Monday, 7 October 2019, 16:40-18:00, KG5 103
SLOT 3 Connecting Policy-Makers: Tuesday, 8 October 2019, 9:00-10:20, KG5 103
SLOT 4 Connecting Industry: Tuesday, 8 October 2019, 10:40-12:00, KG5 103
SLOT 5 Connecting ALL STEM Professionals: Tuesday, 8 October 2019, 14:00-16:00, KG5 103

Do you want to meet like-minded individuals? Are you eager to hear what others from your working-field are doing? Are you looking forward to new possibilities for cooperation with institutions from all over the world?

The ETE Network Lounge is your place to be!

Come to **KG 5, Room 103** for champagne, interesting chats and an interactive network chart. Leave your trace on our smartboard and get surprised about the many connections you might already have without knowing!

Foto by Coloubox.de/question.mark

ETE Fotobox

Tuesday, 8 October 2019, 12:30-16:00, KG5 104

Everybody should STEM

On the second day of the conference you will have an exceptional chance to reflect on your personal opinion about the field of STEM (science, technology, engineering and mathematics) and bring it out into the world.

From 12:30 o'clock, right in the middle of the Materials Market, you can take your time to finish one or all of the following sentences and make your own poster/posters:

„Without STEM…“
„What I love about STEM…“
„STEM is to me…“

After finishing your poster, we will take a professional photo and make an exhibition, thus broadly presenting international ideas and opinions on STEM.

We would love for you to post your posters on social media using one or all of the following hashtags: #ETEIII, #IloveaboutSTEM, #WithoutSTEM, #STEM!

Foto by Colourbox.de/Roman

HAVE FUN!

Programme Special: Curiosity and Wonder - Essential Ingredients in teaching STEM

Brunello, Andrea, Jet Propulsion Theatre – Arditodesio Company, Trento, Italy | Physics Department University of Trento, Trento, Italy

Tuesday, 8 October 2019, 16:10-16:30, Aula

Abstract

Playwrights, novelists and storytellers know that generating curiosity and wonder in their audience is a sure way to keep them engaged. We argue that the same techniques that are used in creating a successful theatrical play can be used in teaching STEM. After all, emotion is a gateway to knowledge. But what are these techniques? And how do we apply them in a classroom setting? In this brief talk I will introduce some ideas and personal experiences with scientific playwriting (Jet Propoulsion Theatre) applied to science communication.

Biography:

Andrea Brunello, PhD in Physics, actor and playwright, is the director of Jet Propulsion Theatre, a laboratory for the theatrical creation connected to science, the people of science and the scientific tale, in full coordination with the Laboratory for the Communication of the Physical Sciences at the University of Trento (Italy). Andrea has written and performed plays all over Europe as well as Africa and the United States. His work is centred on the idea that science shapes the way we look at the world and it can therefore become prime material for engaging storytelling and gripping dramaturgy.

Foto by Monica Condini-MoniQue Foto

Programme Special Science Show - Experiments with Fire

Joachim Lerch

Tuesday, 8 Oktober 2019, 17:15-17:45, Aula

Abstract:

Through impressive experiments in Science shows, students can be inspired and motivated for the natural sciences. This motivation often positively affects the school lessons afterwards. If the experiments are still explained and some students are involved, Science shows can be an enrichment to STEM education.

Biography:

Joachim started as an aircraft mechanic and studied math, physics and technology to become a teacher. As a teacher trainer he worked for the ministry of education. In 1998 he founded „Science & Technologie e.V.", a non-profit organization, to promote science and technology and is still its president. In 2000 he started the first German Science Festival in Freiburg. Ever since, this festival takes place twice every year.

2001 Joachim founded EUSEA (European Science Engagement Association) – the international network of science festivals and was its president until 2004. He has published more than 30 books and articles, under it also three children's books on science.

Foto by Europa-Park

Activity Recommendation – Teacher day in Europapark

organized by Ann-Marie Pendrill
Wednesday, 9 October 2019, 10:00-16:00, Europapark

Abstract:

After the conference Educating the Educators III you are invited to a teacher day in Europapark on 9 October, 10-16, where Professor Ann-Marie Pendrill will share experiences of using amusement parks for STEM teaching and teacher professional development. We will have the opportunity to study STEM in some of the rides and discuss different formats for school visits to amusement parks and how universities and companies may be involved. The Europapark generously provides a conference room for up to 60 participants and free entrance to the park. Participants only need to pay for lunch and snacks. Read more at http://tivoli.fysik.org/english/europapark/.


Foto by Maja Kristin Nylander

Biography:

Ann-Marie Pendrill is Director of the Swedish National Resource Centre for Physics Education. She has used amusement parks in physics teaching since 1995. Her articles about the work can be found at http://tivoli.fysik.org/english/articles/. Contact Ann-Marie at resurscentrum@fysik.lu.se if you are interested in participating.

MaSDiV Policy Seminar (by invitation only) - Initiating and Sustaining Cooperation for Innovation in STEM Education – Strategies and Communication for Cooperation between different stakeholders

Tuesday, 8 October 2019, 11:00-13:00, KA 101

Collaboration between different stakeholders in education is vital for implementing and mainstreaming innovative STEM education at school. In order to reach out to large numbers of teachers, all stakeholders in the field Professional Development need to cooperate. In the European project MaSDiV, for instance, Ministry-University tandems from each partner country ensure cooperation between the policy and research level to achieve the highest possible impact. However, cooperation is not always moving straight forward, as different stakeholders have different aims, agendas and schedules. In order to enhance cooperation between different stakeholders, a particular policy seminar is set up as an international forum to reflect and exchange experiences in cooperating on both, the National as well as the European level.

The Policy Seminar is part of MaSDiV`s final conference, Educating the Educators III, hosted by ICSE, ICSE Consortium and MaSDiV. The opening speech performed by Mónika Kepe-Holmberg, EU - DG Education, Youth, Sport and Culture, illuminates the importance of cooperation on the European level. Subsequently, experts will present recent models and examples of best practices of cooperation in Europe: Dr. Marta Romero Ariza, University of Jaén, and Rubén Durán Dominguez, Spanish Ministry of Education and Vocational Training (INTEF), present their successful cooperation between policy and research. Marc Durando, EUN, amplifies the cooperation between policy and industry using the example of the European Schoolnet. The cooperation between research and

industry is exemplified by Dr. Josette Farugia, University of Malta, and Jeannette Axisa, Transport Malta.

In the subsequent world café, policy makers, researchers and stakeholders in the field of Professional Development from all over Europe are invited to discuss and reflect on various questions concerning the approach and implementation of successful cooperation: Strategies and communication, benefits, risks and challenges.

This is an internal meeting by invitation only.

Conference hosts

MaSDiV

MaSDiV (2017-2020) is a EU funded project that aims to support maths and science teachers in accommodating cultural, socioeconomic and performance related diversity in their classrooms. Central to this project is the inclusion of a social and intercultural dimension in maths and science classes. Teachers shall be equipped to foster students' understanding of fundamental values of our society through their maths and science lessons.

Innovative teaching approaches, such as inquiry based learning and intercultural learning, create inclusive class environments that help to enhance the achievement levels of all students. By applying these approaches, teachers can actively support their students in the process of becoming well-informed and critically-reflected citizens.

The concrete measures of MaSDiV are the development, the evaluation and the dissemination of an innovative professional development course for teachers, who are teaching secondary school. Research facilities and ministries from six different European countries are working closely together in this project. The evaluation process will be conducted by the renowned IPN at the Universität Kiel in Germany.

ICSE & ICSE Consortium

The International Centre for STEM Education (ICSE) is located at the University of Education in Freiburg, Germany and focuses on practice-related research and its transfer into practice. ICSE sustainably links stakeholders from research, practice, policy and industry, nationally as well as internationally through the ICSE consortium.

The ultimate aim of ICSE is to help improve STEM education across Europe. That is, to give students insights into authentic features of STEM subjects and their connection to real-life contexts, to raise achievement levels in STEM subjects and to make science literacy accessible to all students, regardless of gender and cultural or socioeconomic backgrounds. Thereby, ICSE intends to promote the interest of young people in STEM careers.

The **ICSE Consortium was founded in 2017 and endeavors to lead the field of transfer-oriented research and development in STEM education**. It wants to set standards for a **high-impact international collaboration of higher education and research institutes.** The consortium is comprised of the following 16 research institutes:

- Austria, University of Innsbruck
- Austria, University of Klagenfurt
- Bulgaria, Institute of Mathematics and Informatics at the Bulgarian Academy of Sciences
- Cyprus, University of Nicosia
- Czech Republic, Charles University
- Germany, International STEM Centre, University of Education Freiburg
- Germany, Leibniz Institute for Science and Mathematics Education (IPN) in Kiel
- Greece, National and Kapodistrian University of Athens
- Lithuania, Vilnius University
- Malta, University of Malta
- Netherlands, Utrecht University
- Norway, Norwegian University of Science and Technology
- Slovak Republic, Constantine the Philosopher University in Nitra
- Spain, University of Jaén
- Sweden, Jönköping University
- Turkey, Hacettepe University

Conference supporter

DZLM – German Centre for Mathematics and 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 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.