Introduction to the papers of TWG23:

Implementation of research findings in mathematics education

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In this introduction, we briefly present selected theoretical constructs relevant for the Thematic Working Group 23 (TWG23). We first address the topic of “implementation research” by looking into other research fields and domains where this topic is well-developed. Drawing on a taxonomy of so-called “implementation science” in health-care, we attempt to categorize the papers and posters of TWG23 according to their “implementation research aim” (Nilsen, 2015). Using this taxonomy, we elaborate on future perspectives for the TWG by relating to ongoing discussions in mathematics education research.

Keywords: Research findings, research results, theory to practice, implementation research.

A need for creating a new CERME Thematic Working Group

With almost five decades of accumulated knowledge, research findings, theoretical frameworks and experiences, the field of mathematics education research now has quite a bit to offer to the ongoing teaching and learning of mathematics in primary, secondary and tertiary education. Regardless of the well-known long and winding “journey” that research results must travel before finding an actual foothold within practice, results from mathematics education research nowadays seem to be present to a much larger extent in practice than ever before – not to say that there is anything strange in this, but rather it is probably only natural given that the field has matured and become successively more and more established over the years.

Indeed, as researchers in mathematics education, we are frequently involved in putting previous empirical results and findings as well as theoretical constructs based on these to good use in mathematics classrooms, mathematics programs, mathematics teacher education, in-service teacher training, etc. In several countries there are ongoing developmental projects that rely heavily on previously documented research results. However, as researchers we often find ourselves in a peculiar situation when wanting to report on these activities, since such accounts do not necessarily fall under the usual paradigm of “research in mathematics education” and do not in a clear-cut manner qualify as either “empirical” or “theoretical research”. To assist in closing this “gap” the purpose of creating a new thematic working group focusing on aspects and issues related to the implementation of research results and findings, is to provide a venue for discussing, collecting and advance the “implementation research” aspects of our activities.
Implementation research and its aims

In relation to research on actual implementations, mathematics education may profit from other disciplines or areas, where research on implementations is further ahead. Healthcare is one such area, where since 2006 an entire journal has been devoted to “implementation science” (the name of the journal as well). Although the journal of course publishes several empirical studies related to various aspects of implementations, it occasionally also offers theoretical studies focusing on “implementation research” itself. One such theoretical contribution is the study by Nilsen (2015), who proposes a taxonomy consisting of five categories of theoretical approaches in order to make “sense of implementation theories, models and frameworks” (p. 1). Nilsen describes implementation science as “the scientific study of methods to promote the systematic uptake of research findings and other EBPs [evidence-based practices] into routine practice to improve the quality and effectiveness” (p. 2). Although Nilsen focuses on the case of health care, the definition seems adaptable and applicable also to the field of teaching and learning of mathematics. As part of the background for the taxonomy, Nilsen states that “Implementation science has progressed towards increased use of theoretical approaches to provide better understanding and explanation of how and why implementation succeeds or fails” (p. 1). According to Nilsen, the theoretical approaches used in implementation science have three overarching aims:

1. describing and/or guiding the process of translating research into practice (process models);
2. understanding and/or explaining what influences implementation outcomes (determinant frameworks, classic theories, implementation theories); and
3. evaluating implementation (evaluation frameworks).

The five categories of theoretical approaches consist of those provided in parentheses following the aims above. For aim 1, process models serve the purpose of breaking down the translation process into smaller steps, stages or phases. For aim 3, evaluation frameworks serve the purpose of assisting in evaluating the success – or lack thereof – of a given implementation. More interestingly, perhaps, are the theoretical approaches associated with aim 2. Determinant frameworks specify types of determinants that act as barriers and enablers that influence implementation outcomes, or even specify relationships between types of determinants. Classic theories are defined as those originating from fields external to implementation science, e.g. psychology, sociology or organizational theory that can be applied to understand or explain aspects of implementation. Finally, implementation theories are defined as those which have been developed from scratch within the field of implementation science.

Implementation research aims of the papers and posters in TWG23

TWG23 received 16 papers prior to the congress. At the congress 14 papers and 1 poster were presented. In the light of Nilsen's three aims of implementation research (or science), most of the studies presented in TWG23 at CERME 10 in Dublin concerned aim 1, addressing aspects of how to adapt research results and findings to practices in schools or other learning situations. A few of the presented studies touch upon aim 3, i.e. evaluation frameworks. Although it is seldom the main focus of the studies presented, aspects related to aim 2 occasionally surface. We shall return to
potential reasons for this distribution, but first we will use Nilsen’s framework to categorize and briefly discuss the papers and posters in TWG23 presented at CERME 10.

In line with Nilsen’s aim 1 to guide the process of translating research into practice, Ärlebäck describes and discusses the framing of, and experiences from, a project that combines research, practice, and teachers’ professional development based on the tenets of the “Models and Modeling Perspective” on teaching and learning. Besides providing a general description of the methodological considerations in the project design, the paper describes how the accumulated results and experiences in the research literature on so-called model eliciting activities are used to inform the design, implementation and evaluation of activities aiming at introducing functions to grade 8 students. The focus of the paper is on the implementation, and aims to show how the teacher in question realized the offered perspective and tools in practice. The work presented by Aguilar, Castañeda and González-Polo aligns with aim 1 as it illustrates how research results generated in the field of mathematics education can be implemented in the design of mathematics textbook tasks. In particular, it is shown how research findings related to representation registers and to the conceptualization of the concept of function as a process are used in the design of textbook tasks for upper secondary level. The poster by Chandia and Montes matches with aim 1, since they report a professional development strategy for teachers focused on improving students’ and teachers’ problem solving skills. The professional development strategy by Chandia and Montes incorporates research results related to the creation of professional development systems in mathematics. Bulien presents theoretical and methodological arguments for the design and implementation of a research based course for pre-service teachers aimed at clarifying and strengthen the connection between didactical and mathematical theories to in-school teaching activities. Drawing on a design experiment methodology and the theory of communities of practice, Bulien elaborates on a “Mathematics Didactics Planning Tool” for teaching in different classroom situations. Thus, this study also relates more closely to Nilsen’s aim 1. Jankvist and Niss deal with the research-based design and implementation aspects of a so-called “detection test” in relation to upper secondary school students’ difficulties with mathematical conventions, concepts and concept formation, in particular those related to equation solving. In a similar manner, Ahl addresses the design of a detection test related to students’ difficulties with proportional reasoning. Hence, both these studies deal with Nilsen’s first aim, that is, translating carefully selected research results from mathematics education into suitable test items. Based on the answers of 405 Year 1 upper secondary school students, Jankvist and Niss also address aspects of evaluation (aim 3). Another research report that corresponds to aim 1 is the one by Kjeldsen and Blomhøj. In their work, research findings on students’ concept formation and the digital tutorial genre are brought to use in the teaching of a first year calculus course. They present and discuss a theory-based design and its implementation for students’ productions of video tutorials aimed at supporting their understanding of the limit concept. It could be said that this work is also related to the aim 3 delineated by Nilsen, since the study examines whether the designed learning environment supports the students’ formation of key concepts in calculus or not.

The paper by Valenta and Wæge touches on both aim 1 and aim 2 of Nilsen’s taxonomy. The paper describes a course aimed at supporting in-service teachers’ learning of ambitious mathematics teaching. The design of the course is based on a project called “Learning in, from, and for Teaching Practice Teacher Education Project” (aim 1). In addition, the particular question addressed in the
paper is coupled to aim 2, since it focuses on the learning potential in the interactions between in-service teachers and course instructors during the public rehearsals that are the key innovative feature of the designed course and manifested through cycles of enactment and investigation. The theoretical paper by Nilsson, Ryve and Larsson align with Nilsen’s second aim (understanding and/or explaining what influences implementation outcomes). They draw upon a systematic literature review on productive classroom practice to construct a framework for categorizing theories aiming at supporting teachers’ actions in mathematical classroom practices. They do so by relating to theories and literature on educational policy research, professional development research and implementation research. Related to a larger scale early intervention program, Lindenskov and Kirsted touch upon aspects of Nilsen’s aim 2. More precisely, they discuss teachers’ perception of “theory” and barriers these may lead to, when implementing research results in practice. In addition, they also address aspects of the translation of theoretical constructs to the teachers as well as the suitability of these constructs provided a given context of practice. The study reported by Tamborg, Allsopp, Fougt and Misfeldt clearly falls with Nilsen’s category of studies related to developing determinant frameworks (aim 2), since it investigates the role the local supervisor (enabler) in the implementation of a mathematics teacher training program.

Amit and Portnov-Neeman’s work can be related to the aims 1 and 3 proposed by Nilsen. They report on the implementation of a methodology used to teach reading and mathematics called “Explicit Teaching Method” focused on teaching students the “working backwards strategy” for solving non-routine mathematical problems; on the other hand, the effect of using the explicit teaching method as a means to learn the working backwards strategy is evaluated. Koichu and Keller position their paper as so-called design-based implementation research (DBIR) (see later). They present an evaluation framework (aim 3) to analyze and theorize their attempts in creating and sustaining online exploratory problem-solving discussion forums using the conceptual tools provided by Rogers’ “Theory of Diffusion of Innovation”. Ejersbo and Misfeldt report on a design-based research (DBR) project related to developing numeracy in grades K-3. This study too focuses specifically on evaluation aspects (aim 3), not least in terms of improving the design being implemented as well as the future of the project at the local school. Kuzle’s work somehow touches all three aims outlined by Nilsen. She reports on a collaborative project between educational researchers and practitioners with the goal of developing a problem-solving curriculum for grade 6 students using DBR. The curriculum was developed and implemented based on problem solving research and theory, and through the evaluation of its implementation objective and subjective factors that inhibited the full-implementation of the curriculum were identified.

**Implementation of research findings in mathematics education**

As seen above, a few aspects of aim 2 were touched upon in the papers and posters of TWG23, and some papers also considered aim 3. Still, aim 1 appears to be the dominant one among the reported studies. This, however, is not so strange since actual “implementation research” within the field of mathematics education must be regarded as a relatively new trend. This is of course due to the field of mathematics education itself not being much older than fifty years, but at the same time it is mature enough to have produced a sound basis of research results to actually be implemented into the practice of teaching and learning mathematics. Engaged in such implementation-oriented endeavors, researchers in mathematics education work systematically at different levels to establish
evidence-based solutions to the problems and challenges faced by practitioners and learners. Whether the research carried out is empirical or theoretical in nature, implementation of research findings and results is at the core of the research activities, either in the form of evaluating and furthering actual practices or materials etc., or to deepen our theoretical understanding to facilitate, guide and support various future implementations. Hence, and as already illustrated by the papers of TWG23, implementation of research findings and results in mathematics education can take many forms and expressions. Further examples from the literature are: in the design of experiments (e.g. Cobb, Confrey, diSessa, Lehrer & Schauble, 2003) and mathematical tasks (e.g. Margolinas, 2013); as tools for professional development of in-service and pre-service mathematics teachers (e.g. Tsamir, 2008; Sánchez, 2011). The research findings and results that are implemented as part of systematic research are typically empirical results, theoretical results in terms of frameworks of different kinds, or some mixture of the two. Still, such findings and results usually fall within Nilsen’s first and third aims, whereas results directly concerning aim 2 are scarcely touched upon.

As seen from the presented research studies of TWG23, implementation of research findings may have connections with research areas already existing in the field of mathematics education. One such example, although not reported in TWG23 at CERME 10, is that of lesson study. In the lesson study approach, lessons are designed and analyzed as a means to improve mathematics teaching in the classroom, but also as a means for professional development of mathematics teachers. Another existing research area, represented in TWG23, is that of task design. Hence, from the presented papers, it is clear that “implementation research” encompasses different kinds and formats (textbooks, apps, software, etc.) of didactical designs and products, stretching from task design, over teaching modules, courses, to entire programs – on all educational levels. Yet an example is that of design-based research (DBR), where results might take the form of a teaching module that successively and iteratively have been envisioned, designed, applied, analyzed and redesigned. The result is the final design as well as measures of how successful the design has proven to be. However, to focus on the implementation aspect of DBR means to not only focus on the end product and its success in achieving what was set out to do, but also to seriously take into account the “design phase” of the design research cycle. That is, the phase where the researcher identifies a learning problem and then uses available research results to design a (preliminary) product or tool that can help students in overcoming this learning problem. A primary concern then becomes to focus precisely on the way research knowledge is applied to generate some type of educational product. Elements of these concerns are addressed by Fishman and colleagues (2013), who forefront the implementation aspects of DBR in a research approach they call design-based implementation research (DBIR) – a framework also used in a few of the papers presented in TWG23. In short, DBIR has:

“(1) a focus on persistent problems of practice from multiple stakeholders’ perspectives; (2) a commitment to iterative, collaborative design; (3) a concern with developing theory and knowledge related to both classroom learning and implementation through systematic inquiry; and (4) a concern with developing capacity for sustaining change in systems.” (Fishman and colleagues, 2013, pp. 136-137)

More generally, an important aspect when implementing research findings and results into practice is to focus on what Burton (2005) has called the methodology of the research conducted. Burton
argues that researchers in mathematics education in general pay little or no attention to explaining and motivating the rationale for the actual research design they apply to be able to draw the conclusions they report when writing up their research. This “craft knowledge” of the researcher is in a way silent. In Burton’s opinion, accounts of research is full of descriptions of how results were obtained (i.e. what the explicit methods applied were), whereas elaborations on why choices were made and decisions taken in order to arrive at conclusions are rarely found. The how-question concerns the methods used by the researcher to undertake his or her research, while the why-question focuses on the rationale for the research design, i.e. the methodology. That more emphasis should be put explicitly on the methodology has also been put forward by for example Wellington (2000), who describes methodology as “the activity or business of choosing, reflecting upon, evaluating and justifying the methods you use” (p. 22). He further argues that it is necessary to know the methodology of a piece of research to be able to impartially judge and assess it. TWG23 provides a venue and forum for researchers to discuss how to best put research results to use in practice alongside the accompanying rationale for why. In this sense, TWG23 has as one of its primary foci methodologies for initiating and institutionalizing research-based implementation designs. Over time, the activities of such a group could also make us wiser on the actual usefulness of our various research results, constructs, and frameworks.

Perspectives for the TWG at future CERMEs

Although the main focus of TWG23 seems currently to be on Nilsen’s first aim, and to some extent the third aim, in time the TWG may potentially contribute much more to the second aim: in identifying determinants across various countries; in identifying relevant classical theories external to mathematics education, which may help to understand or explain implementations; and last but not least in developing homegrown implementation theories of mathematics education. This was also reflected in the evaluation of the TWG, where the question was asked: What shall be TWG23’s contribution of knowledge to the field of mathematics education? The participants of the TWG collectively phrased the following “vision” for the group:

“We want to explore a wide variety of ‘good examples’ of implementing research findings and results (back) into practice in order to improve the teaching and learning of mathematics at all educational levels on a research-based foundation. Over time we may begin to look into the aspects of research on implementations, potential requirements for these to function, etc.”

Hence, for the future of TWG23, it may be envisioned that the TWG could come to consist of a core of researchers interested in these aspects (Nilsen’s second aim). But at the same time, a group like TWG23 is also a place for mathematics education researchers to go when wanting to report and discuss on any “intermediate” activities of either designing new research projects or developmental work, before the activities may result in more traditional research to be reported in other TWGs. In this sense, TWG23 also provides a forum for mathematics educators at CERME to “come and go” from one congress to another.

To put it a bit boldly, it is our hope that this TWG can assist in filling the “gap” of where to report on implementation activities in our research community, while at the same time act as a “bridge” between research and practice.

References


