ERME column

regularly presented by Jason Cooper and Frode Rønning

In this issue, with a contribution by
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CERME Thematic Working Groups

We continue the initiative of introducing the CERME working groups, which we began in the September 2017 issue, focusing on ways in which European research in the field of mathematics education may be interesting or relevant for people working in pure and applied mathematics. Our aim is to enrich the ERME community with new participants, who may benefit from hearing about research methods and findings and contribute to future CERMEs.

Introducing CERME Thematic Working Group 23 – Implementation of Research Findings in Mathematics Education

Mario Sánchez Aguilar, Linda Marie Ahl, Morten Misfeldt and Boris Koichu

Over five decades, the field of mathematics education research has generated a wealth of innovations aimed at improving the teaching and learning of mathematics. However, while mathematics education research has produced solid findings related to fundamental phenomena in teaching and learning mathematics (see Dreyfus [2] for an overview of solid findings published on the pages of the EMS Newsletter), has constructed elaborate theoretical frameworks to investigate and analyze teaching and learning, and has developed rich and consistent suggestions for didactic design, the effect of all these on teaching on a large scale has nevertheless been weak. How the innovations that work well in a research laboratory could be applied in practice remains an open and challenging problem to solve. Addressing this problem, Thematic Working Group 23 "Implementation of Research Findings in Mathematics Education" (TWG23) is a forum dedicated to presenting and discussing studies focused on elucidating the enablers and general conditions that favor or inhibit the implementation in practice of research findings and innovations generated in our research field.

There are obvious reasons for focusing on implementation and implementability in mathematics education. Indeed, many researchers and practitioners have identified issues related to scaling up and making work and results of mathematics education research available to a larger audience. Even though these issues are omnipresent in mathematics teaching, they are rarely addressed as a stand-alone issue. This disparity was the outset of establishing TWG23 in 2017. Hence TWG23 elevates covert concerns about mathematics education research as being "usable" and "making a difference in practice" to a more overt phenomenon named "implementation."

The papers presented in TWG23 illustrate experiences of implementation of research findings in practice – either small or large scale – where the object of the implementation and the implementation process are clearly identified. For instance, there are studies informing how particular treatments, interventions, or didactic designs work in different contexts and with different populations. Likewise, theoretical papers addressing diverse characterizations of implementation in mathematics education have been presented. Overall, the discussions in the group have evolved around the question: how can we bring the accumulated research knowledge into practice?

We posit that the work of the TWG23 is relevant to the readers of the EMS Magazine – particularly those mathematicians involved in tertiary mathematics education and in projects aimed at enhancing teaching mathematics at school level – because of the difficulties that students, including high-achievers, experience in moving from secondary to tertiary education. Such a transition has been identified as a major issue for mathematics departments across Europe and their students (Koichu–Pinto [5]), and described as an educational crisis (Gregorio et al. [3]). This situation suggests a reconsideration and reform of both school and university mathematics teaching practices. Familiarity with research findings on implementation of educational innovations, and even participation in mathematics education implementation research, may be instrumental for mathematics departments and university mathematics teachers interested in improving their students' educational experiences. The interest in implementing innovations in mathematics teaching at the tertiary level, and reporting the results in mathematics didactic journals, can be seen in an ongoing systematic review of the field of implementation research. (The systematic review is done in the project *Implementation research as an emerging field of mathematics education,* financed by the *Swedish Research*

Council.) Preliminary results show that the studies that address the tertiary level are few, but that most have been written in recent years, which we interpret as increased interest.

Evolution of TWG23

TWG23 is one of the newest thematic working groups of the CERME congress. Its first appearance was at the CERME10 congress (2017), led by Uffe Thomas Jankvist (Aarhus University, Denmark), Mario Sánchez Aguilar (National Polytechnic Institute, Mexico), Jonas Bergman Ärlebäck (Linköping University, Sweden) and Kjersti Wæge (Norwegian University of Science and Technology, Norway). At CERME10, the working group undertook initial attempts to make sense of "implementation" as a phenomenon. In the call for papers for TWG23 at CERME10, the construct "implementation research" was considered rather broadly, as systematic exploration of different kinds of didactical design, from task design, lesson design, teaching modules, and courses, to the design of entire programs at all educational levels. Furthermore, "implementation research" was inclusively operationalized as research on aspects of developmental projects, intervention projects, as well as research on aspects of the development and use of educational media (e.g., textbooks, software, and computer-enhanced learning platforms). Fourteen papers and one poster were presented in TWG23 at CERME10. Most of them reported on small-scale studies addressing aspects of how adapted research results and findings can inform practices in schools or other educational settings.

For CERME11, held in 2019, the focus of TWG23 drifted from discussing particular small-scale projects to an effort to articulate what implementation research in mathematics education actually is or can be. Twelve papers and two posters were presented and served as a basis for theorizing implementation research. At this point in the development of the TWG, several bibliographical references were put forward for clarifying and organizing the key notions related to implementation research in mathematics education. In particular, the work of Rogers [6] on diffusion of innovations, of Century and Cassata [1] on conceptualizing implementation of innovations, and of Stein et al. [7] on stages of implementation were brought to the center of the discussion. A first collective attempt within TWG23 to formulate a chain of definitions of the key concepts of "innovation," "implementation" and "implementation research in mathematics education" was undertaken. At the end of this collective discussion, the group formulated the following definition:

Implementation is a change-oriented process of adapting and enacting a particular resource (e.g., an idea, a tool, an innovation, a framework, a theory, an action plan, a curriculum, a policy) that occurs in partnership of two communities, *a community of the resource proponents* (CRP) and *a community of the resource adapters* (CRA). These communities differ but can intersect. At the beginning of the process, the CRP has the ultimate agency over the resource. The process of adapting a resource by CRA includes some of the following: (1) constructing an agency over the resource, (2) changes in ways of communicating, and (3) changes in practice. Accordingly, *implementation research in mathematics education* is research that focuses on aspects of implementation, as specified above, in the context of mathematics education.

After the CERME11 congress, Uffe Thomas Jankvist and Jonas Bergman Ärlebäck left their positions as TWG23 leaders, being replaced by Ana Kuzle (University of Potsdam, Germany) and Morten Misfeldt (by this time affiliated to Aalborg University, Denmark). Two editorial projects related to TWG23 and led by some of its members emerged. First, a new research journal entitled *Implementation and Replication Studies in Mathematics Education* (IRME) was established; Uffe Thomas Jankvist, Mario Sánchez Aguilar, Morten Misfeldt, and Boris Koichu assumed the positions of the editors. IRME focuses on implementation and replication research that communicates and investigates initiatives aiming to improve the teaching and learning of mathematics by using knowledge from mathematics education research and by re-implementing it in new contexts. Second, the thematic issue "Implementation and implementability of mathematics education research" in the research journal *ZDM – Mathematics Education* was conceived, with Boris Koichu, Mario Sánchez Aguilar, and Morten Misfeldt as guest editors [4].

The most recent meeting of TWG23 took place in the online congress CERME12 (2022). At this stage, Ana Kuzle and Kjersti Wæge stepped down from their positions as group leaders and were replaced by Boris Koichu (Weizmann Institute of Science, Israel) and Rikke Maagaard Gregersen (Aarhus University, Denmark). Rikke Maagaard Gregersen participated in the planning of TWG23 at CERME12, but was unable to participate in the congress so that Linda Marie Ahl (Uppsala University, Sweden) stepped in. The focus of the group's discussions was broadened and deepened at this online meeting, thus reflecting the fact that the participants of the TWG have gained more experience in implementation research. Notably, the occurrence of papers on large-scale projects increased significantly, which paved the way for broad and deep discussions. TWG23 at CERME12 received 18 contributions (15 papers and three posters). The contributions were organized in five thematic categories:

- Implementation of problem-solving and problem-posing approaches.
- Implementation of teaching models and teachers' perspectives on implementation.
- Conditions for sustainable implementations.
- Diagnostics tasks, instructional sequences, and curriculum design.
- Implementation of programming, computational thinking, and other digital technologies.

Recent discussions in TWG23

The most recent discussions within TWG23 focused on issues of scale and upscaling, particularly on the purposes that small-scale and large-scale implementation-related studies can attain under a theoretical umbrella of implementation research. There has also been a focus on the conceptualization of "stakeholder" and how this notion can be used to refine different types of analysis of implementation projects. Another recent discussion has been related to the notion of "change" in implementation research, and the need for theories of change that could be used to design, understand, and evaluate implementations.

In connection to scale and upscaling, the participants of TWG23 at CERME12 reinforced the need for both small-scale and large-scale studies because they play different roles in the accumulation of knowledge about implementation in mathematics education. The group pointed out the need to further discuss the strategies required to make decisions about which types of studies can provide the most useful information for different parts of the implementation process. Also, it is necessary to further clarify the concept of "stakeholders" and progress our knowledge base for involving more stakeholders, including mathematics teachers, mathematicians and mathematics education researchers in implementation projects. In relation to "change," the TWG23 participants at CERME12 agreed that the tension between "intended change" and "achieved change" in an implementation project is a delicate question of interest for our research field. We thus see a continuing need to discuss the question of how program theory and theory of change can be used to design, understand, and evaluate implementations.

These discussions about the notions of scale, stakeholder, and change will hopefully continue when TWG23 meets again at CERME13 in Budapest in 2023. We are expecting to have rich discussions in this new meeting of the TWG23 which could allow us to further develop key notions of implementation research and broaden our knowledge about the factors that influence the implementation of educational innovations based on mathematics education research. We invite everyone with an interest in implementation research to contribute their ideas to this vibrant and continually developing thematic working group.

References

[1] J. Century and A. Cassata, Implementation research: Finding common ground on what, how, why, where, and who. *Rev. Res. Educ.* **40**, 169–215 (2016)

[2] T. Dreyfus, What are solid findings in mathematics education? In: *Proceedings of the tenth congress of the European Society for Research in Mathematics Education* (CERME10), DCU Institute of Education and ERME, 57–62 (2017)

[3] F. Gregorio, P. Di Martino and P. Iannone, The secondary-tertiary transition in mathematics. Successful students in crisis. *Eur. Math. Soc. Newsl.* **113**, 45–47 (2019)

[4] B. Koichu, M. S. Aguilar, M. Misfeldt, Implementation-related research in mathematics education: the search for identity. *ZDM Math. Educ.* **53**, 975–989 (2021)

[5] B. Koichu and A. Pinto, The secondary-tertiary transition in mathematics. What are our current challenges and what can we do about them? *Eur. Math. Soc. Newsl.* **112**, 34–35 (2019)

[6] E. M. Rogers, *Diffusion of innovations*. The Free Press of Glencoe Division of The Macmillan Co., New York (1962)

[7] M. K. Stein, J. Remillard and M. S. Smith, How curriculum influences student learning. In *Second handbook of research on mathematics teaching and learning*, National Council of Teachers of Mathematics, 319–369 (2007)

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