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Implementation through participation: Theoretical considerations and an illustrative case

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This paper explores a particular model of implementation of research: teacher adaption of research procedures and ideas in their classrooms as part of participation in community educational research. The TRAIL (Teacher-Researcher Alliance for Investigating Learning) project seeks to guide the design and conduct of co-learning partnerships between mathematics teachers and mathematics education researchers. In TRAIL, mathematics teachers actively participate in formulating research goals and designing research tools, and then collect data in their classrooms and analyze together the shared data corpus. In the first part of the paper, we present theoretical underpinnings of implementation through participation in TRAIL. In the second part, we examine implementation through participation in an illustrative case, in which a group of teachers designed and explored classroom situations aimed at promoting student questions in the classrooms.

Keywords: Co-learning partnerships, student questions, design and implementation.

Introduction

Implementation of educational research in practice is tricky. On one hand, it is customary to conclude a research paper with suggestions regarding possible implications for practice. For example, when a study includes an intervention component, the researchers may recommend teachers to implement the intervention principles or activities in their classrooms. Or, when a study results in identification of strategies that students engage with, in the context of a mathematical task, the researchers may invite teachers to get acquainted with these strategies in order to better prepare themselves to possible scenarios while enacting similar tasks with their students. On the other hand, it is widely recognized that existing strategies for applying research-based suggestions in practice are far from being satisfactory (Burkhardt & Schoenfeld, 2003). As Kieran, Krainer and Shaughnessy (2012) point out, “[t]he primary responsibility of teachers is *to teach* their students, not to read research papers, and there is some evidence that most teachers don't read such papers very often” (p. 366, emphasis in the original). The scholars then review prevalent strategies by which researchers attempt to familiarize teachers with research findings in various professional development settings and conclude that these strategies, as widespread as they are, have their significant limitations, partly due to the implied view of teachers as recipients or alumni of educational research.

An alternative approach for bridging between research and practice builds on the notions of teachers as stakeholders in educational research, co-producers of professional knowledge, or potential co-producers of scientific knowledge (Kieran et al., 2012; Krainer, 2014). The rationale for this approach stems from in-depth analyses of what teachers may be expected to take to their own practice from mathematics education research. For example, Bishop (1977, cited in Kilpatrick, 1981) points out that teachers can borrow from researchers their procedures, the data and some of research-produced theoretical constructs and models. Even (2003) suggests that mathematics education research is relevant for teachers as means for gaining insights into teaching and learning that might not be gained through practice, such as: “mathematical knowledge is constructed in ways that do not necessarily mirror instruction” or “knowing is a 'slippery' notion” (p. 38). Teachers are more likely to gain access to these kinds of ‘products’ of research as participants in research. Additionally, viewing teachers as co-producers of professional and scientific knowledge rather than recipients of research findings is well aligned with the notion of learning as an active process. It is well documented that students are more likely to succeed in implementing new knowledge when they are actively engaged in co-constructing it. By the same principle, teachers are more likely to implement new knowledge of mathematics education if they are actively engaged in producing it (Taylor, 2017; Wagner, 1997).

The goal of this paper is to draw on the view of teachers as active participants in educational research and present a particular mechanism of research implementation, in which teachers act as partners of mathematics education researchers. In what follows, we unpack this mechanism, first theoretically and then by means of an illustrative example of an authentic study aimed at findings ways to promote meaningful student questions in mathematics lessons. This example demonstrates how teachers can adapt methods and ideas from past research as tools for inquiring into and reflecting on their practice.

Theoretical considerations

To conceptualize and study implementation through participation, we developed a theoretical-organizational framework called TRAIL - Teacher-Researcher Alliance for Investigating Learning. TRAIL consists of a system of theoretical premises and heuristics for guiding the design and conduct of research-practice co-learning partnerships aimed at generating and implementing new knowledge in mathematics education. In this section, we provide a concise outline of the TRAIL framework (for a more detailed discussion, see Koichu & Pinto, 2018).

Underpinnings

The TRAIL framework draws on theoretical constructs and ideas developed in three bodies of the professional literature: the literature on mathematics teacher inquiry, the literature on modes of research-practice partnership and the literature on Citizen Science.

The literature on mathematics teacher inquiry tells us that different types of inquiry are (or at least should be) inseparable parts of teaching as a professional occupation (Menter, Elliot, Hulme, Lewin, & Lowden, 2011; Watson & Barton, 2011). We learn from the literature that the term *teacher inquiry* is used broadly, so that it embraces mathematical modes of inquiry, practitioner educational research, and other forms of inquiry that teachers engage with in their daily work, when preparing to the lessons, conducting them or reflecting on them. For the purposes of this study, we draw on Menter et al.’s (2011) in conceptualizing *teacher inquiry* as a systematic effort to develop and disseminate new knowledge or understanding in an educational setting carried out by someone working in that setting, in collaboration with practitioners working in similar settings and with education researchers.

The literature on research-practice partnerships tells us that different forms of interactions between teachers and researchers have different pragmatic, moral and political expectations and implications for the involved parties. Particularly relevant for this article is a co-learning partnership, as described by Wagner (1997). In co-learning partnerships, researchers and practitioners join forces to inquire together and aid one another in order to learn something new and worthwhile about their worlds and themselves. The goals, methods and principles of inquiry are negotiated openly to maximize the learning and professional growth of both sides. Therefore, co-learning agreements essentially reduce asymmetry in the roles of the researchers and practitioners. Such agreements make the border between conducting research and implementing it somewhat blurred.

Finally, the TRAIL framework is informed by the literature on Citizen Science (CS). CS is a rapidly growing form of conducting scientific research that involves members of the public in association with scientists to collectively gather, categorize or analyze large quantities of data in order to address real-world problems (Bonney et al., 2009). We learn from Bonney et al. (2009) that an option to engage different participants in the same study at different levels of participation should be thought through when planning a CS project. We also learn, from Wiggins and Crowston (2011), that CS projects can be conducted by local communities that collaborate with researchers as consultants who assist the members of the community to turn their concerns into researchable questions and to construct feasible procedures for pursuing the questions and disseminating the results.

In the case of interest, the teachers were engaged in a research cycle that included design and implementation of classroom activities inspired by past research and by the participants' experiences. The teachers were encouraged to participate in research not only for personal professional growth and improvement of their practices, but also for the joy of being part in producing new knowledge. Likewise, the researchers (the authors of the paper) were interested not only in pursuing their research agenda with the help of the teachers, but also in refining the agenda so that it would be aligned with the teacher-participants agendas.

The TRIAL framework

Based on the described underpinnings, we have formulated, in Koichu and Pinto (2018), the TRAIL premises and heuristics. Four premises are particularly relevant to the concerns of this article.

Professional Growth through Involvement in Research premise: Active involvement in the various stages of educational research generates opportunities for teachers to enhance their abilities to engage effectively in inquiry, noticing and reflection as part of the day-to-day practice.

Authenticity premise: Teachers' engagement in research is more likely to produce positive effects if conducted in the context of an authentic educational research rather than an exercise in doing research. Accordingly, it is advantageous for teachers and researchers to take part in research that is drawn by questions of potential importance to both communities.

Choice premise: Teacher participation in educational research can be stable and productive if the teachers can choose in which research projects to take part, in what capacity and to which extent.

Shared Agency premise: Alliance of the communities of teachers and education researchers can be stable and productive if the opportunity to share the agency over the partnership is available for both communities. This means that individual members of each community are to be involved in the partnership in ways that can advance their peculiar goals and needs, including the needs to contribute, develop professionally and have room for expressing personal creativity.

A relevant subset of TRAIL design heuristics is as follows.

- The research goals and questions that underlie TRAIL partnerships are openly negotiated and deal with issues that have the potential to resonate with dilemmas and challenges that mathematics teachers encounter in their daily work at the level of a class, a small group or an individual student.

- TRAIL partnership must have "clear utility" for practitioners that can be convincingly communicated without heavily relying on the scientific literature in which the research is situated. In a similar vein, a TRAIL partnership must have "clear utility" for researchers, that is, have the potential to yield insights of importance to the education research community at large.

- TRAIL partnerships enable teachers to be involved as research assistants or researchers, but not as objects of research. However, both teacher-participants and researcher-participants can be objects of a study about aspects of TRAIL.

- TRAIL partnerships employ accessible data-collection and data-analysis procedures. We call a research procedure accessible if it can be mastered by an interested individual with no background in education research after a brief training period, and if its use requires reasonable time and effort. Examples include: conducting a questionnaire in a classroom, writing a reflective summary of a lesson, or responding to a summary by another participant.

- TRAIL partnerships offer channels of interaction among the participants as well as channels for providing feedback on contributions of the participants. For example, a teacher who contributes a summary of her lesson to the shared database of the project will obtain structured feedback on his or her contribution from the fellow participants and from the researchers.

- TRAIL partnerships comply with the ethics codes for conducting educational research. In particular, the shared databased of a TRAIL partnership should consist only of properly anonymized data.

An illustrative case

A group of 25 experienced high-school mathematics teachers participated in a 60-hour professional development program (PD hereafter) during the 2017-18 school year. Broadly speaking, the PD's goals were to enhance their participants as leaders of their school communities. About 1/3 of the PD's time, and the final assignment, were devoted to designing and conducting a pilot TRAIL study.

From researchers' perspective

At the first meeting with the participants, we briefly introduced the project and offered the group the following question: Suppose your school hires a professional mathematics education researcher in order to help you improve your practice, what questions about your teaching or your students' learning would you like to ask him or her to explore? The teacher responses were highly diverse. For example: "*What can mathematics education research offer for my teaching?*"; "*How can I help my students to deal with the stress of matriculation exams?*"; "*How to teach in a heterogeneous class?*"; "*What is the validity and reliability of the tests that I offer in my classes?*"; "*How can I encourage my students to be more independent?*"; "*How can I know if my students really understand me?*"; "*Which questions do I ask in my lessons and how these questions affect student learning?*"; "*How can technology help me in teaching trigo?*" The rest of the meeting consisted of the negotiation towards a short list of research topics that would be researchable and of interest for both the teacher-participants and the researcher-participants. We chose to inquire into two topics: (1) the roles of questions asked during the lessons and (2) indicators of student “understanding”. By the end of the meeting, each teacher-participant enlisted herself in one of two sub-groups that corresponded to the two chosen topics.

The second meeting was conducted in two sub-groups. We prepared for each group a three-page document for orienting the teachers of how the chosen topic can be explored. Each file consisted of a brief literature review and elaborated summaries of two studies chosen by us as examples. A study used in both documents, by Leikin, Koichu, Berman and Dinur (2017), discerned different types of questions (e.g., *elaboration questions* and *clarification questions*). The study also exemplified how transcripts of task-based classroom discussions can be analyzed according to the types of the questions students ask in order to gain insight into the understandings students develop. The paper contained four classroom episodes; two episodes in the context of proving in geometry, and two – in the context of exploration of functions. A common characteristic of the episodes was that the student questions have not been elicited but arose spontaneously. The feasibility of designing such situations in the teacher-participants classes was discussed. The discussions in sub-group (1) converged to the realization that teachers ask much more questions than students do and that creating situations rich with the student questions is a challenge that can be handled in a variety of ways. The discussion in sub-group (2) resulted in realization that students' understanding cannot be assessed directly but ways of understanding can sometimes be induced from student questions and responses. An additional discussion at that meeting was about data-collection tools. We considered a videotaped episode from VIDEO-LM study (Karsenty & Arcavi, 2017) and discussed affordances and limitations of videotaping, audiotaping and making notes.

For the third meeting, we prepared a draft of a research program based on the inputs from the second meeting. The sub-groups were reunited. The document included the following questions:

> RQ1: How do experienced mathematics teachers construct in their lessons situations that are rich with student questions? What are characteristics of these situations?
>
> RQ2: What types of questions do students ask in these situations?
>
> RQ3: How can student questions be used as indicators of their ways of understanding of the material taught?

The document also included our suggestions for the next steps, including a time schedule. The first stage was to refine and agree upon the research program. At the second stage, each teacher was required to plan one or more classroom activities that would be appropriate for addressing the above research questions and discuss her ideas with peers in an online forum. The third stage consisted of the individual data collection: each teacher was required to enact his or her ideas in a classroom and document three classroom episodes. It was up to each teacher either to try the same activity in three classes or enact three different activities in the same class. The fourth stage was planned as a group discussion, at the next meeting, of the classroom experiences. It was also planned to discuss at that meeting how to create the shared database of the study and how to conduct data analysis. The last two stages consisted the data analysis and writing final reports.

This plan was fully realized. Each stage was supported by a corresponding document prepared by us and shared with the teacher-participants. Of note is that the program was devised so that it left room for teacher choices. In particular, it left room for choosing individually appropriate mathematical content and context. The teachers were also encouraged to choose two out of three research questions to address and two out of three data-collection tools. It is also of note that the agreed program left room as to whether to implement the research procedures from the studies considered as examples or to devise their own procedures in spirit of the considered examples.

From teacher-participants' perspective

The concluding task of the PD was a term-paper assignment in which the participating teachers presented findings and conclusions from their analysis of data collected in one lesson activity they designed, and one lesson activity designed by another participant. An analysis of the teachers' products is beyond the scope of this paper, yet in this section we provide a glimpse into one aspect of research implementation, as reflected in the reports of two teachers: Michelle and Libby.

Both Michelle and Libby included in their reports elaborated reflections on their goals, dilemmas and decisions while enacting the research program. Michelle noted in her introduction that she was always curious to find out to what extent teachers' professed values and beliefs, including her own, actually shape teaching practices and learning environments in the classroom. Accordingly, she chose to explore RQ1 and RQ3, recognizing an opportunity to investigate this issue in the context of a belief that was collectively endorsed by the PD teachers: students would gain a deeper understanding of the material taught if they ask more questions in lessons. She specifically looked to examine whether other teachers' reflections on their practices and on student learning will be aligned with this professed belief. To this end, she chose to analyze interventions of a teacher who was teaching at the same grade level she was teaching, believing she would be more sensitive to implicit considerations and assumptions guiding the other teacher as she was designing and conducting the intervention. Similarly, while analyzing her own intervention, Michelle discussed in length her own considerations and assumptions. Thus, Michelle drew on the research literature and the research questions to reflect on and inquire into her practice and her colleagues' practice in accordance with her own agenda.

In the introduction of her term paper, Libby notes that she generally agrees with Leikin et al. (2017) that student questions are instrumental in the development of understanding, but that after reading the paper she was left wondering whether "silence […] could also be considered as a form of student-teacher interaction", and what would silence afford in terms of student questions. In her assignment, Libby wanted to investigate this issue by comparing the affordances of different teaching approaches to student questions. Accordingly, she designed three lesson episodes, one in which she would "restrain as much as possible from intervening in the classroom discussion", one in which she would "try to guide students towards answers […] without providing the solution", and one where she would "take up the reins" and "be the center of discussion". While presenting her analysis of these episodes, Libby noted that she found the categorization between *elaboration questions* and *clarification questions* proposed by Leikin et al. (2017) was insufficient for distinguishing student questions in the data she collected. Accordingly, she suggested refining the category elaboration questions into two sub categories, and illustrated this refinement in her analysis.

Michelle and Libby's reflections on their decisions throughout the term-paper assignment indicate that they drew on research methods and constructs in their inquiries. They interpreted the agreed in the group research questions in light of their own goals for professional growth, and made consequent decisions regarding data collection and analysis. We consider this a particular case of implementation through participation, as discussed in the next section.

Concluding remarks

In the literature on implementation research in education (e.g., Century & Cassata, 2016), the word "implementation" is sometimes paired with such objects as "innovation", "program" or "reform" (as in "implementation of an innovation"). Such collocations frequently imply co-existence of two distinctly different agencies, creators of an innovation or a program and those who put it into practice. Tensions and issues related to alignment and coordination between these agencies are repeatedly pointed out (e.g., Penuel, Fishman, Cheng, & Sabelli, 2011). Simultaneously, there are voices (e.g., Century & Cassata, 2016; Penuel et al., 2011) that treat implementation of an innovative idea as a multiparty enterprise. We join these voices by presenting and illustrating the TRAIL framework.

TRAIL is a theoretical-organizational tool for devising and conducting co-learning partnerships between teachers and researchers. As illustrated, teacher-participants in a TRAIL study typically consider the products of past studies critically, and draw on them mainly as a resource supporting reflection on and inquiry into their practice. Thus, in TRAIL, the distinction between practitioner inquiry and implementation of research in practice is blurred, and teachers act as co-producers of new knowledge rather than as consumers of the existing knowledge (Kieran et al., 2012). Of note is that while only a few of the participating teachers referred explicitly in their works to the research literature they had been exposed to, many teachers stressed in their feedbacks the importance of exposure to and active participation in educational research to their professional growth.

In summary, this paper illustrates some of the theoretical and practical considerations underlying implementation of research products through teacher participation in research. More precisely, we treat *implementation of research* as active adaptation of research ideas and procedures by practicing mathematics teachers while being involved in doing authentic educational research, in collaboration with mathematics education researchers. We put forward an idea that past research products are likely to influence practice (also) when they are adapted rather than adopted, and when implementation is not the goal but a means on the way to resolving pedagogical problems of importance to the teachers. To this end, the implementation of research products can be seen as intertwining ideas developed by others with one's own experiences and ideas.

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