Representations of Practice in Teacher Education and Research—Spotlights on Different Approaches

Orly Buchbinder and Sebastian Kuntze

Abstract Representations of practice provide an opportunity to refer to teachers' professional environment both when designing tasks for teacher education or professional development, and when investigating aspects of teacher expertise. This volume amalgamates contributions by the members of the discussion group on representations of practice, which took place during ICME 13. The discussion group sought to collect experiences with different forms of representations of practice in pre-service and in-service teacher professional development settings, and of the use of representations of practice for researching into aspects of teacher expertise and its development. In this introductory chapter we provide an overview of different approaches to representing practice, and address key methodological issues that came up in the monograph's chapters and in the discussion group's meetings. We suggest four key questions along which such approaches can be discussed.

Keywords Representations of practice · Pre-service teacher education
Professional development for in-service teachers · Analyzing classroom situations

This monograph originated from a discussion group on the representations of practice at the 13th International Congress on Mathematical Education (ICME 13) held in Hamburg, Germany in July 2016. The discussion group aimed to collect and thoroughly examine the role of representations of practice for pre-service and in-service teachers' professional development and for research into teacher expertise. The attendants and the presenters of the discussion group shared an agreement

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that this topic is timely, especially when considering rapid technological developments that offer advanced tools for representing practice. In light of these developments and with the wide use of representations of practice, it is critical to attend to theoretical and methodological issues associated with their design and use.

The use of representations of practice for teacher education and research around the world has a long-standing tradition (Grossman et al. 2009; Herbst and Chazan 2011). Representations of practice can be different types of artefacts such as videos of classrooms or of individual students (e.g., Boaler and Humphreys 2005; Borko 2016), written cases (e.g., Smith et al. 2004), sample student work (Heid et al. 2015), scenarios (Zazkis et al. 2013), animations or story-boards (Herbst et al. 2016a), comic strips (e.g., Herbst et al. 2011), photographs (Carter et al. 1988), and combinations of several types of artefacts. A common, and sometimes implicit assumption underlying the use of representations of practice is that learning of the practice of teaching is a complex, multifaceted, context-specific process, situated in multiple social and cultural contexts. The resulting knowledge of the teaching practice is often held implicitly and is hard to access. Thus, representations serve as mediating tools between the world of professional practice and the educational or the research setting.

In their mediating role representations of practice provide teachers with specific learning opportunities which are close to action and reaction requirements of the classroom, yet they differ from the actual practice. Representations allow teachers to immerse themselves in a particular situation and to establish cognitive and emotional connection with it in ways that might not be possible at the rapid rate of actual classroom interaction. As such, representations of practice afford powerful learning opportunities for teachers to reflect on and analyze classroom situations and instances of individual student thinking (e.g., Santagata and Guarino 2011); envision potential responses to a situation (e.g., Webel and Conner 2015); contemplate various pedagogical moves and their consequences and examine teaching styles, which may be either close or removed from what teachers are familiar with (e.g., Seidel et al. 2011), including international and multicultural perspectives (Clarke et al. 2006; Stigler and Hiebert 1997).

These kinds of experiences provide meaningful support for teacher learning and create rich contexts for research into aspects of teacher expertise, views and convictions (e.g., Shulman 1986; Ball et al. 2008; Kersting et al. 2012; Kuntze 2012), competence facets such as professional vision (Sherin and van Es 2009), teacher noticing in the sense of selective attention (e.g., Seidel et al. 2013) or in the sense of knowledge-based reasoning (e.g., Sherin et al. 2011; Sherin 2007), competency of teachers' analysis of content-specific situations (e.g., Kuntze et al. 2015), mathematical content knowledge (Buchbinder in press; Zazkis et al. 2013), mathematical knowledge for teaching (e.g., Herbst and Kosko 2014), and rationality of teacher decision making (Herbst et al. 2016b).

Some constructs, such as noticing, describe aspects of expertise which are directly connected with classroom situations, while other aspects of teacher expertise, such as the degree of connectedness or coherence of pedagogical content knowledge (e.g., Doerr and Lerman 2009), can be harder to connect with

observations of how teachers deal with representations of practice. The duality of theoretical constructs related to teacher expertise on the one hand and of the case-specific "mini-worlds" opened up by representations of practice on the other hand, raise questions of validity: e.g. "How is the construct reflected in an instrument which uses one or more representations of practice?", questions of relevance, e.g., "How meaningful is the construct for professional requirements in general and for situation-specific contexts, in particular?", and questions of generalizability: e.g. "To what extent does the case-based instrument design afford making inferences about a more general construct related to teacher expertise?" or "To what extent can inferences be made for a targeted group of teachers?"

Design of research instruments or professional development activities, addressing the constructs mentioned above, involves a vast range of considerations. There is a multi-faceted spectrum of decisions to make when choosing the format of the representation and its mode of use. Representations of practice may vary along multiple aspects, such as whether they are created by teacher educators/researchers or by the participating teachers themselves, whether they are staged or show an authentic classroom situation, whether situations are taken from teachers' own classrooms or the classroom of other teachers. They may vary by the amount of contextual information they bring, from video, which is considered as most context-rich, to static images realized with non-descript characters, to a written text vignette, with minimal context information. In addition, multiple methodological decisions must be made regarding the kinds of prompts to accompany the representations, and their formats: open or forced-choice; regarding the mode of interaction with the representation: individual or group; and regarding the nature of facilitation: open and exploratory or oriented toward a specific goal.

To guide the discussion of these complex issues in our discussion group we introduced a set of key questions:

- How can representations of practice encourage and afford pre-service and in-service teacher professional development, and by what means?
- How can representations of practice help to investigate aspects of teacher expertise, beliefs and conceptions?
- What kinds of methodological challenges emerge when designing opportunities for professional learning which make use of representations of practice? How can these challenges be addressed?
- What methodological challenges emerge when designing research settings based on representations of practice? How can these challenges be addressed?

Consequently, these questions also guided the writing of the chapters for this monograph, after the conference. The chapters in this volume were contributed by many of the presenters, panelists, and participants of the discussion group. The authors share insights from their own experiences with using representations of practice in their work as teacher educators and/or researchers, and offer their unique perspectives on some of the critical issues raised in the discussion group.

The first three chapters of this volume concentrate on representations of practice in video format. Karen Koellner, Nanette Seago, and Jennifer Jacobs report from their work with videotaped classroom situations in in-service teacher professional development with a specific empirical focus on the reported use of information from video cases by the participating teachers. Starting from the noticing concept as key framework, the chapter deals with the relationship between participating teachers' noticing of teacher actions in video cases and the development of their own classroom practice. The video cases in this project are framed by specific materials, which aim to foster mathematical content knowledge by demonstrating their significance for learning in the classroom. Based on a qualitative analysis of group interview data, the authors distinguish between different types of users according to the participating teachers' reports on the aspects of video and corresponding curriculum materials on transformational geometry they did or did not implement in their own practice. The findings suggest that teachers used information from the video cases in different ways, depending on the teachers' school context and their experiences in the professional development project. The authors conclude that even if representations of practice are a good way of underpinning the significance of specific content and of showing the enactment of acceding this content, additional research should be undertaken to further explore the relationship between noticing and the teachers' uptake of the stimuli provided in the professional development for their own classroom practice.

Jessica Hoth, Gabriele Kaiser, Martina Döhrmann, Johannes König, and Sigrid Blömeke present an analysis from the context of the Teacher Education and Development Study in Mathematics—Follow Up (TEDS-FU). In this study, three video vignettes were used to assess so-called situation-specific skills as components of noticing and teachers' professional competences. The staged video vignettes lasted three to five minutes and covered different topics. In-service teachers were asked to answer several questions about each video, related to both general pedagogical knowledge and to pedagogical content knowledge. The empirical part of the chapter concentrates on a qualitative coding of answers to one question related to one vignette, in which a primary student presented an incomplete and incorrect solution, which might be attributed to the way the teacher introduced the task. The results show that the in-service teachers' answers covered a relatively wide spectrum of views, which were condensed to thematic categories. Some of these categories appear to be related to scores in other variables measured by the TEDS-FU instruments. This suggests that in-service teachers who have noticed specific aspects of the classroom situation shown in the video representation tended to succeed on other test parts, e.g. the (shortened) TEDS-M pedagogical content knowledge test.

Sebastian Kuntze discusses a video-based in-service teacher professional development project foregrounded in the participants' learning related to aspects of instructional quality. The project focused on the participating teachers' criteria-based observation related to cognitive activation, intensity of argumentation, and learning from mistakes. Video representations of practice from authentic classrooms were used as learning opportunities in order to further develop the teachers' professional

knowledge. Two more video cases were used in the video-based evaluation research on the professional development of in-service teachers participating in the project. The findings suggest that the participating teachers' situation-related views, addressed in the professional development, changed significantly with respect to more positive views of discourse in the classroom. Moreover, these findings were supported by participants' rating of the perceived similarity of the videotaped classrooms with their own classroom practices. Against these findings, the chapter discusses how representations of practice can encourage in-service teacher professional development and related evaluation research.

Libuše Samková explores the potential of concept cartoons for investigating pre-service teachers' professional knowledge. Whereas concept cartoons have first been suggested as learning opportunities for elementary students, they offer the possibility of gaining deep insight into content-related components of pre-service teachers' knowledge, and their analysis of hypothetical students' conceptions. The chapter refers to a theoretical background around components of professional knowledge and sketches how concept cartoons have been developed in earlier studies. On this basis, Samková developed the setting of a study with pre-service teachers, who were preparing to teach in primary schools. The author emphasizes the diagnostic potential of concept cartoons, and the results indicate that content knowledge and pedagogical content knowledge components are interwoven in the pre-service teachers' answers. The chapter argues that concept cartoons—as artificially designed representations of practice in connection with relevant theory—offer unique affordances for teacher education settings in order to diagnose and promote professional knowledge.

Students' thinking also plays a core role in the representations of practice presented by Corey Webel, Kimberly Conner, and Wenmin Zhao. The authors used the online tools provided by the Lesson*Sketch* platform in order to design what they call—teaching simulations—for pre-service elementary teachers. In addition to noticing students' thinking and reflecting on teaching, such teaching simulations offer opportunities for pedagogical action, for example, around teacher questioning techniques. In particular, the participating pre-service teachers are asked to make pedagogical choices within a simulated teaching situation and reflect on the consequences of these choices. This allows a learner (e.g., a pre-service teacher) to "test out" various decisions and draw conclusions by comparing outcomes. Some challenges with this approach are that learners bring their own criteria into their evaluations of outcomes, so learning depends on carefully crafted choices and outcomes.

Marita Friesen and Sebastian Kuntze focus on research about the teachers' competence of analyzing classroom situations pertaining to the use of mathematical representations. In this larger research context, the use of representations of practice appears as a core methodological feature in order to investigate the teachers' analysis. However, as the role of different vignette formats such as text, comic or video has hardly been explored in prior research, the chapter presents results from a format-aware research design including text, comic, and video vignettes. This research design allows comparisons of presentation format through a multi-matrix

distribution of vignettes in several test booklets, and through a Rasch analysis of the participants' answers. In addition, the participants' reported engagement with the vignettes has been measured on four dimensions: authenticity, immersion, motivation, and resonance. The results indicate that for the teachers' competence of analyzing, the vignette format did neither produce significant differences nor impede the empirical unidimensionality of the competence construct as tested through Rasch modeling. Moreover the perceived immersion, motivation, and resonance did not differ for vignette formats either. The authors conclude that despite systematic design differences in the format of representing practice such as temporality, the different vignette formats are equally suitable for assessing the competence construct examined in this research.

Orly Buchbinder and Alice Cook analyzed scripts written by pre-service elementary and middle school teachers of mathematics to examine their mathematical and pedagogical knowledge pertaining to proving, with the particular focus on the roles of examples in proving. The participating pre-service teachers completed a multi-step instructional module. A critical element of the module was writing a one-page script—a continuation of a given classroom scenario—showing students presenting their arguments and challenging each other regarding which of their quadrilaterals constitute a counterexample to a certain geometrical statement. The analysis of the written scripts revealed three out of four theorized categories of mathematical knowledge for teaching of proving, and a category of general pedagogical knowledge. The results point to the importance of strengthening pre-service teachers' subject matter knowledge of geometry and of the logical aspects of proving, as prerequisite knowledge for implementing productive pedagogical practices. The chapter also highlights the potential of using representations of practice, produced by teachers, such as scripts, for enhancing professional knowledge and as a research tool.

The monograph concludes with two commentaries by Dan Chazan and Rina Zazkis, who joined the discussion group, during the ICME 13 conference, as discussants. These commentary chapters further examine the issues brought up in the chapters against the backdrop of the discussants' areas of expertise around the theory and practice of the use of representations.

This monograph does not intend to provide comprehensive answers to all the key questions—naturally, the chapters address only some of them. In all of the chapters and for all of the key questions presented above, the mediating role of representations of practice between teachers as individual learners on the one hand and professional development goals or research target constructs on the other hand is crucial. Each chapter proposes a different way of dealing with this mediating role, and each presents a different perspective on the advantages but also on the methodological challenges related to this mediating role. By providing spotlights in this sense, this collection of chapters and commentaries builds on, and contributes to the growing body of work on designing and using representations of practice for teacher education and research. We hope that it will inspire more research in this area to support teacher education and professional development of mathematics teachers.

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