Designing to support teachers' reconstruction of instructional design rationales

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This paper is an initial report on an ongoing research and development study conducted with small groups of teachers in Australia. While we do not, at this point, report on research findings, we share some of the conceptualisations that informed the design of the study and the key features of this design. In particular, we aim to clarify why the goals we pursue for teachers' learning are formulated in terms of teachers' reconstruction of the instructional design rationale, what we mean by this, and why these goals shape profoundly how we design resources for teachers.

Keywords: Mathematics teachers' resources, teacher learning, instructional design, instructional sequences.

Resources and teacher learning

This paper is an initial report on an ongoing research and development study that is being conducted with small groups of teachers in Australia. The overarching aim is to contribute to understanding of teachers' learning with resources, in particular in situations, where resources are designed and used to support teachers' transition to instructional practices that aim at ambitious and equitable students' mathematical learning (Jackson, Gibbons, & Sharpe, 2017).

We are conceptualising teacher learning with an instructional resource as a process of documentational genesis (Gueudet & Trouche, 2009; Trouche, Gueudet, & Pepin, in press), an expression of the productive and constructive dialectical relationship between teachers' interpretations of the resource (document) on the one hand, and forms of their participation with this resource (instructional practices) on the other hand. In this context, we aim to clarify why the goals we pursue for teachers' learning are formulated in terms of teachers' reconstruction of the instructional design rationales, what we mean by this, and how these goals shape profoundly how we design resources for teachers. We will foreshadow our anticipated contribution to the questions proposed within the Working Group 3 (instrumentation, competencies, design capacity, expertise).

Developing ambitious teaching practices in mathematics

Teaching inherently involves adapting given (prescribed, shared, or previously used) instructional materials and ideas to specific contingencies of the classroom in which these materials are to be used. It is in this sense that teachers are being viewed as designers of classroom mathematical activities (Pepin, Gueudet, & Trouche, 2017). When the curriculum or the expectations for the nature of classroom mathematical activities change, guidance is needed on which resources to select from and how. Importantly, guidance is also needed on how to make specific adaptations to new resources when addressing the unanticipated challenges that emerge in different classrooms.

In our view as designers of instructional resources, the latter type of guidance is provided by the instructional *rationale* we develop and refine during the process of designing the teachers' resource materials. It primarily consists of conjectures about the collective mathematical development of the classroom community, and how this development can be supported. Rationales of this kind outline a progression of clearly formulated and specific long- and short-term learning goals, as well as key adaptations that made these goals achievable in different classrooms. They also include notions that typically fall within one's pedagogical repertoire, such as how classroom activities can be organized to be most productive and why, and what types of classroom discourse made it possible for students to progress in classrooms where the activities were previously used. This long list of sources of guidance on which we draw when adapting the existing resource to the contingencies of a new classroom should help to clarify that our history of use of the resources and deliberate analysis of this use were essential in making the rationales accessible to us.

While teachers' access to a design rationale is key to their effective use of a new resource, it cannot, in principle, be readily available to them from the outset. Nevertheless, teachers we worked with in past came to reconstruct the rationale in the course of sustained professional development interactions that productively built on both their current instructional practices, and on the designed resources they were learning to use (Visnovska & Cobb, 2013; Visnovska, Cobb, & Dean, 2012). This is why we find it productive to conceptualise teacher learning with novel resources as a process of their increasingly central participation in practices of a community, within which the reconstruction of the rationale is proactively supported (Wenger, 1998).

Collaborating to learn

The first author is developing professional development (PD) collaboration(s) with teachers within a single state primary school (year levels 0 through 6). The design of specific PD interactions was co-developed between the participating teachers, their school-based mathematics couch, and the first author. Up to this point, the first author collaborated with a pair of year 3 teachers over a period of 2 months, followed by collaborating with one year 4 teacher, over another 2 months. The collaborations started in the second half of the 2017 school year and will continue in 2018, when the teachers will start working with new classrooms.

The mathematics couch was part of PD meetings whenever she was available. Her part-time role within the school involves supporting teachers in their mathematics teaching with a particular focus on problem solving. A part-time research assistant, a secondary mathematics teacher on a 2-year study leave from her teaching job, who provided data collection support was also an active participant in PD interactions. It is anticipated that she will continue collaborating with the first author in 2018 when she returns to her teaching of Year 7 students in a high school.

The work meetings with the teachers all took place at the school site, during (or immediately prior to) the teaching hours. The main organizing feature of PD collaborations was a series of classroom teaching events, in which the first author, the classroom teacher, or both, taught lessons informed by the instructional sequence of *Fractions as Measures* (Cortina, Visnovska, & Zuniga, 2014). Mathematical goals for the lessons targeted initial fraction learning, specifically supporting all students to *reason soundly* about the inverse order relation of unit fractions, and, in year 4, about

proper and improper fraction comparisons, including equivalences. The material resources included brochure-like teacher notes on key lessons in the sequence with advise on organization of classroom activities, types of likely student solutions, and possible follow up questions, and student-made rods for measuring unit-fraction lengths relative to a given length—the wooden *stick*

Each classroom session was complemented by 15-60 minute planning and/or debriefing meetings between the first author and the respective teachers. In year 3 collaboration, the second teacher observed the lessons and took an active part in planning and debriefing sessions. Simple pre- and post- data on students' understanding were also collected to provide teachers with additional means of evaluating the impact of the learning experiences on individual students.

Following most of the teaching sessions, the two authors discussed the student learning progress, teachers' perceptions of how their students are learning, and what pedagogical and mathematical issues teachers brought up as they recounted their classroom observations and justified planning decisions. They also planned for types of PD experiences that could be beneficial to teachers and how those could be framed within the existing collaboration structures and routines.

It became abundantly clear within these interactions that the teachers were primarily interested in learning what were the components of the instructional sequence (tasks, organisation of classroom activities). During planning sessions, the teachers' expertise on their students' learning circumstance was essential to making adaptations. At the same time, the researcher contributed the explanations of the design rationale and illustrative examples. In this way, both parties contributed to planning where opportunities emerged for discussions of aspects of the design rationale.

To this point, teachers' interactions with the resource appear to satisfy their need for forming initial interpretations of the resource components, and what they as a teacher 'need to do' in the classroom. We do not suggest that teachers' participation in the co-planning process equipped them to plan sequence activities independently. Instead, we frame these experiences as constitutive of their initial document (cf. Gueudet & Trouche, 2009) for *Fractions as Measures* sequence, one that will be further revised and refined. During the second iteration of the teachers' work with the sequence, in 2018, we will pursue following research questions: (1) Which aspects of the design rationale do the teachers reconstruct independently/collaboratively? (in planning and/or justifying enactment of the lessons) and (2) Which additional aspects of the sequence rationale can be reasonably addressed (or become of interest to teachers) in conversations with the researcher? Data from planning and debriefing sessions will be analysed against similar data from the first iteration with focus on similarities and differences in teachers' justifications of their decisions. We will report on the learning of the research team, and draw implications for designing teachers' resources during the Re(s)sources conference.

Concluding remarks

When it comes to designing for students' mathematical learning, designing for students' guided reinvention of mathematical ideas is a long accepted practice (Gravemeijer, 1999). Designers formulate (and test for viability in classrooms) a progression of mathematical ideas and design successive instructional activities to support the emergence of these ideas in the classroom.

We argue that when it comes to designing for *teacher* learning, the resources cannot *give* teachers the instructional rationales that underpin them. They could, however, (a) identify (and test for viability with teachers) a progression of mathematical and pedagogical ideas that are central to teachers' instructional decision-making and to their reconstruction of the design rationale, and (b) design successive professional experiences to support the emergence of these ideas as teachers interact with the resource (or, more specifically, with the successive *documents* they are creating in the process). Our goal in the ongoing study is to contribute to understanding of teachers' learning with resources in terms of teachers' progressive reconstruction of the rationales that underpin the resource design. While we adopt design research perspective, this focus is directly related to efforts at understanding teachers' design capacity, competencies, expertise, and what is discussed as utilization schemes within the instrumentation process.

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