Support in relation to problem solving - building a common knowledge base?

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We present three closely related projects concerned with supporting students' mathematical problem solving. The projects build on the assumption that problem solving activities are beneficial to students' learning but challenging for teachers to organise. Teachers must find ways to support students' progress in problem solving without removing necessary challenges. The projects deal with this support in different ways, something we intend to use to illustrate the risk that mathematics education research becomes fragmented, making it more difficult for teachers to access and use research results in their professional development. We welcome participants to discuss how closely related research projects like ours can collaborate and complement each other to contribute to a knowledge base that is accessible and useful to teachers.

Introduction

Despite the huge potential to facilitate students' learning that research has attributed to mathematical problem solving (Jonsson et al., 2014), research has consistently found it uncommon to teach mathematics through problem solving (Boesen et al., 2014; Maass et al., 2019). If mathematics education research continues to advocate problem solving as a productive way to teach mathematics, research also needs to identify and propose solutions to the challenges associated with such an approach. Results from such research could offer opportunities for teachers to overcome the challenges and develop their teaching. One of the challenges that teachers face is supporting students during problem-solving, given that any form of support always risks reducing the challenge to the extent that learning opportunities are lost. Therefore, there is a need for tools and strategies that could help teachers to find the right balance between challenge and support. Attending to this need is the focus of three different Swedish research projects in mathematics education. These will briefly be presented below and during the symposium they will serve as an example of research projects that are closely related.

The first project, Ufer – using feedback to encourage students' creative reasoning is a longitudinal, on-going, design research project that involves cooperation with 4 teachers

over the last 6 years. The project aims to empirically develop principles for teachers' actions in interaction with students' during problem solving (Teledahl & Olsson, 2019). Cooperation with teachers includes planning for problem solving with the intent to support students' creative mathematical reasoning (CMR), as described by Lithner (2008). The theoretical point of departure is that mathematics learning is enhanced by teaching that allows for CMR (Jonsson et al., 2014). During the problem-solving situations we document and analyse teacher actions that lead to students' continued CMR. Preliminary results suggest that students should be encouraged to (1) express independent reasoning, (2) develop their reasoning, (3) justify their reasoning and (4) find a way to test their results. Future research aims to describe teacher actions that achieve 1–4.

The second project comprises three interrelated, ongoing large-scale design research projects conducted in collaboration with 50 mathematics teachers at seven different schools, teaching school years 1–12 (Säfström et al., 2021). The aim is to develop and study design principles and tools for supporting teachers' interaction with students during problem-solving, in order to promote students' learning. It rests on previous research regarding the connection between qualities in students' reasoning and their learning (Lithner, 2017) and uses formative assessment (Black & Wiliam, 2009) as a structure for teachers' support. Over iterations of classroom experiments, analysis and development, teachers and researchers build knowledge on students' problem-solving processes, the difficulties students encounter in such processes, the opportunities for students' own construction of mathematical reasoning those difficulties entail, and how teachers can realise those opportunities in their interaction with students. The results include both theoretical insights and practical tools for teachers' interaction with students.

The third project, about how prompts to self-explain can nurture learning, is conducted in collaboration with a teacher in grade 4–6 (Dyrvold & Bergvall, 2019). Self-explanation prompts (SEPs) have previously been defined as questions or elicitations that aim to induce meaningful explanations for oneself to make sense of new information (see e.g. Rittle-Johnson et al., 2017). In this project we seek understanding of the potential of SEPs in collaborative work, based on a social cultural perspective with an emphasis on language. An insight into activities that lead to progress can enhance teachers' possibilities to support students' development and accordingly, the aim of the project is to explore how meaning making takes place in students' joint discussions fostered by SEPs. Analyses of students' discussions during collaborative problem solving reveal five types of recurring meaning making activities in relation to SEPs. SEPs in combination with these activities can be used as tools to support meaning making for example when problem solving does not progress as expected or in a strive to understand a new concept.

During the symposium, we will present what aspects of support during problem solving are foregrounded in each project, how these perspectives contribute to ideas or guidelines for support and how the results could be used by teachers. A natural next step for each project would be to promote and spread their own results, an approach we argue

is not the most fruitful for either the research community or the teaching practice. Such an approach risks causing more fragmentation in the field of mathematics education and hinder teachers' access to and use of research results in their professional development. Therefore, the participants of the symposium are invited to a discussion on the following questions.

- How can related but different projects collaborate to better serve mathematics teachers' professional development?
- How can related but different theoretical perspectives and results complement each other and contribute to a common knowledge base in mathematics education research?

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