Develop mathematical reasoning? – a literature review of tasks and their implementation

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Reasoning has been identified as a core component in mathematical knowledge. Less focus has been on synthesizing research including subprocesses of reasoning such as conjecturing, justification and generalization. Acknowledging the importance of tasks and their implementation, this paper aims at eliciting aspects that has the potential to foster students' mathematical reasoning by means of a systematic literature review. The current main findings suggest a focus on open-ended exploratory tasks and implementation that successively builds on students' mathematical work. Classroom culture and interaction are identified as important, and teachers balance between modelling and students' exploration is recognized.

Introduction

The purpose of this short communication is to present an overview of current results from a systematic literature review with the aim of synthesizing research on mathematical tasks and their implementation to foster mathematical reasoning including the subprocesses such as justification, generalization and explanation. The guiding research question for the review is: what characterize tasks and their implementation in classrooms that has the potential to foster students mathematical reasoning?

Method

The approach for this review follows the framework by Moher et al., (2009) with participants, intervention, comparison, outcome and study design (PICOS) with the order of identification, screening and eligibility. Further it is framed by a configurative approach (Levinsson, 2017) and the analysis follows a thematic synthesis (Noyes et al., 2021) to provide an accessible and direct approach to contribute to the research problem. The data draws from primary studies from EBSCO/ERIC, Thomson Reuters/WoS and Elsevier/Scopus in the searches that was performed in April 2021 by the author. Search terms was: Math*, task and reasoning combined with the OR statement between just*, expla* and generaliz* in titles, abstract or keywords.

Identification yielded 453 studies. Screening abstracts with inclusion criteria: 1) students in primary, high or upper secondary school, 2) mathematical tasks, implementation and reasoning and finally 3) they should include task features and student and teacher interaction reduced sample to 38 articles. Final step of full-text reading following GRADE-CERQual (Lewin et al., 2015) for eligibility gave a final sample of 11 articles. Data extracted included: design (with data generation),

aim/research question, mathematical content, duration, number of participants (teachers and students) and task features and their implementation.

Results

A brief account of current findings regarding task characteristics and implementation is presented in this short communication.

Open-ended, exploratory tasks was the main characteristic identified (Herbst, 2006; Kosyvas, 2016; Martin et al., 2005; Mata-Pereira & da Ponte, 2017; Richardson et al., 2010; Vale et al., 2017). They typically have no apparent solution method and open up for reasoning by offering multiple entry points, strategies and representation. They also involve forming conjectures (Vale et al., 2017) and encourage generalizations (Choppin, 2011; Richardson et al., 2010; Stephens et al., 2015). With the opportunity for multiple strategies they also show potential for making justifications (Huang et al., 2016).

In terms of fostering reasoning several studies include the importance of 'why'-questions from the teacher to justify and evaluate mathematical work (Martin et al., 2005; Mata-Pereira & da Ponte, 2017; Richardson et al., 2010; Stephens et al., 2015; Vale et al., 2017). Attention is also on follow-up questions such as 'do you think this will always work?' or 'why does this always work (e.g., Stephens et al., 2015). Mata-Pereira & da Ponte (2017) suggest that asking why is often not sufficient and focus should be on a sequence of actions to develop reasoning including justification and mathematical argumentation.

It is shown that teachers need to encourage students to express and share ideas (Mata-Pereira & da Ponte, 2017) and students be responsible for their task work (Herbst, 2006; Sidenvall et al., 2015). At the same time the teacher needs to elicit misconceptions (Richardson et al., 2010) and show the way, by modelling, (Choppin, 2011; Herbst, 2006) and also provide appropriate feedback (Bieda, 2010).

Discussion

The current results point at the potential of open-ended tasks and implementation with a balance between students' exploration and teacher modelling. This points to a critical feature of implementation; teachers deliberate decision-making in fostering mathematical reasoning with attention to students learning progress. Methodological issues arise in the analysis of the included papers such as designs with lack of comparison groups and also the (missing) details regarding reporting outcomes. The forthcoming analysis will include synthesis of theoretical conceptualisations of reasoning and subprocess and also a critical evaluation of inclusion/exclusion criteria. Further analysis will also focus on the relationship between research finding and potential for professional development.

References

A complete list of references will be available at the presentation.