



Fostering the Mathematics Learning of Language Learners: Introduction to Trends and Issues in Research and Professional Development

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ABSTRACT

The introduction of the EURASIA Special Issue argues why fostering the mathematics learning of (monolingual and multilingual) language learners is crucial with respect to equitable access to mathematics. It provides a structured list of parallel questions for research and design on the classroom level as well as on the professional development level. The overview on the articles of the special issue shows how widely the field must be spanned in order to grasp the complexities of the learning content (language demands specific to mathematical topics and genres), the learners' and the teachers' processes.

Keywords: language demands, language learners, mathematics learning, professional development

RELEVANCE FOR CONSIDERING LANGUAGE LEARNERS IN MATHEMATICS EDUCATION RESEARCH

The role of language for mathematics learning has been in the focus of research in mathematics education since three decades (e.g. Pimm, 1987; Ellerton & Clarkson, 1996). Language has been identified as *learning medium* and as *learning goal* (Lampert & Cobb, 2003). The increasing research focus on equity and access for all learners (Secada, 1992; DIME, 2007) has added a third function, language as *unequally distributed learning prerequisite*, since limited language proficiency in the language of instruction can constrain the mathematical learning opportunities in mathematics classrooms (Snow & Uccelli, 2009). This does not only apply to students whose family language differs from the language of instruction (students with minority languages or immigrant status, Haag, Heppt, Stanat, Kuhl, & Pant, 2013; OECD,

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2007; Barwell et al., 2016) but also for monolingual students with under-privileged socio-economic status (Heinze, Reiss, Rudolph-Albert, Herwartz-Emden & Braun, 2009; Prediger, Wilhelm, Büchter, Benholz, & Gürsoy, 2015). That is why monolingual and multilingual students with low language proficiency in the language of instruction are subsumed under the unifying construct “language learners” in this volume (cf. Moschkovich, 2010a).

Raising Important Questions on the Level of Classrooms and Professional Development

The gap in the mathematics achievement of students with high and low language proficiency has often been shown in large scale studies (e.g. OECD, 2007; Haag et al., 2013; Prediger et al., 2015), but these studies alone cannot provide an empirical foundation for fostering the mathematics learning of language learners. Instead, many further questions must be answered, in parallel for the level of classrooms and professional development (PD):

Questions that need to be addressed in research and design on the classroom level:

- (Q1) What language demands are most relevant in mathematics classrooms?
- (Q2) How can instructional approaches be designed to support language learners’ access to mathematics and the required language? How can these approaches, in the case of multilingual learners, connect to the students’ language resources?
- (Q3) Which effects and challenges do different instructional approaches have for supporting language learners in mathematics classrooms?

Questions leading research and design on the level of professional development:

- (Q4) What do mathematics teachers need to learn for being able to support language learners in mathematics classrooms?
- (Q5) How can PD be designed to enable teachers to support language learners?
- (Q6) Which effects and challenges do different PD approaches have for enabling teachers to support language learners in mathematics classrooms?

Contributions to Specifying Language Demand for Language Learners in Mathematics Classrooms (Q1)

Although all articles in the special issue focus on language learning in mathematics, only two articles explicitly address the WHAT-question of what language demands are crucial for mathematics learning (Q1).

- Rezat & Rezat (2017) investigate language demands connected to the mathematics-specific genre of geometric construction texts. They argue why the text level must be considered in research, as genre-specific aspects must be taken into account and should be articulated with the students explicitly. This study gives an interesting example for the communicative function of language in the mathematics classroom.
- Prediger & Zindel (2017) suggest a research program how topic-specific language demands can be specified empirically in a design research framework (Prediger, Gravemeijer, & Confrey, 2015). They show for the mathematical topic of functional

relationships that video-based learning process studies are required to extrapolate language demands in learning processes, e.g. of developing conceptual understanding. The discourse practice of explaining is tightly connected to lexical demands on the word level, but also to syntactical demands on the sentence level. The article focuses on the epistemic function of language, i.e. the tight connection between mathematical thinking and language.

Furthermore, implicit contributions to the research program of specifying language demands are provided by two further articles:

- Moschkovich's (2017) deconstruction of early research on language specifics and number names make clear that number names alone are not the most crucial language demand in mathematics classrooms, not even in early arithmetic. Instead, wider discourse practices must be taken into consideration. Her article shows that when multiple languages are involved (e.g. for multilingual students), then the languages do not determine what is thought in each language frame because learners activate their multilingual repertoire as a whole, not separately.
- Hagena, Leiss, and Schwippert (2017) show that general reading proficiency may not be the main language demand in the mathematics classroom, since an intervention for fostering general reading abilities does not increase the ability to solve word problems in mathematics.

All these studies call for addressing and investigating language demands not in a generic way, in terms of some form of general 'academic' language, but in a subject-specific or even topic-specific way. The unit of investigation can for example be a specific genre such as geometric construction texts or a specific mathematical topic such as functional relationship or fractions (as claimed by Moschkovich, 2010b). This research agenda will have to continue in further studies.

Contributions to Developing and Investigating Instructional Approaches On Classroom Level (Q2-Q3)

Although the HOW-question is logically subordinated to the WHAT-question (van den Heuvel-Panhuizen, 2005), most studies combine both, specify what to learn and investigate how students can learn them. The design of instructional approaches is often combined with a qualitative or quantitative investigation of the initiated teaching and learning processes or learning outcomes. As Planas (2014) has called for, these studies aim at better understanding mechanisms and effects of teaching interventions on students' topic specific mathematics learning:

- Hagena et al. (2017) show in a randomized controlled trial that fostering students' general reading proficiency does not increase their ability to crack word problems. Whereas controlled trials without significant effects are mostly not published, the editors of the special issue found this negative results specifically important as it

contributes to empirically founding the knowledge that language and mathematics learning cannot be fostered separately.

- Prediger and Zindel (2017) present a design how to foster the conceptual understanding of language learners by design principles of relating registers and systematic variation of texts. In the qualitative investigation of the initiated learning processes, they show how conceptual compaction of mathematical concepts is aligned with language condensation; these empirical insights contribute to elaborating the theory of the epistemic function of language.
- Schüler-Meyer's (2017) research is embedded in a project that builds upon multilingual students' resources (Barwell, 2009), here in their home language Turkish. He investigates the functioning of a bilingual German-Turkish intervention for fostering the students' conceptual understanding of fractions. As this instructional approach has led to very different learning gains for different students, the article presents an in-depth analysis with respect to students' identities as multilingual learners. It shows how the fruitfulness of the students' learning processes is shaped by the interactive co-construction of students' identities. Hence, a design principle is not per se productive or not, but heavily depends on the conditions of enactment in the classroom.
- In a similar sense, Rezat and Rezat's (2017) brief empirical insight into one teachers' ways of teaching the mathematics-specific genre of geometric construction texts provide starting points for problematizing challenges while fostering a mathematics-specific genre.
- Finally, Short (2017) presents an instructional approach in the SIOP-model which has been developed over decades and proven to be effective for robust language learning gains under different conditions of implementation. The model is based on the idea of systematically combining mathematical and language learning goals in each lesson and provides the teachers with concrete planning and realization tools.

These articles show that integrating mathematics and language learning can be beneficial for fostering students' learning, with respect to mathematical as well as language learning goals. However, the implementation in classrooms is shown to be a complex challenge for most teachers, that is why teacher professional development must also be taken into account.

Contributions to Specifying What Teachers Should Know and How They Can Be Promoted to Learn to Support Language Learners (Q4-Q6)

The described studies on the classroom level already provide interesting answers to the questions of what teachers need to learn:

- Language demands comprise much more than general reading proficiency (Hagena et al., 2017) or technical words like number names (Moschkovich, 2017). The language demands in mathematics classrooms have to be specified more holistically by starting from the text level with subject-specific genres (Rezat & Rezat, 2017) or from the discourse level by starting with topic-specific discourse practices (like explaining

meanings of the mathematical topic 'functional relationships', Prediger & Zindel, 2017). This is consequently done in the SIOP model described by Short (2017).

- Language learning for increasing mathematics achievement cannot be separated from mathematics learning (Hagena et al., 2017), instead, language and content integrated approaches are necessary (Short, 2017; Prediger & Zindel, 2017; Schüler-Meyer, 2017; Rezat & Rezat, 2017).
- Instructional approaches should take into considerations multilingual language resources, if existent, and how they are enacted in the classroom (Moschkovich, 2017; Schüler-Meyer, 2017).

In line with these research results on the classroom level, three articles explicitly treat the level of professional development. These articles contribute not only to the What-question, but also to the how-question on the PD level:

- The SIOP model (Short, 2017) which has been developed for the classroom level has been disseminated in various implementation projects. Accordingly, the author can draw on a lot of evidence and experience to address questions of what teachers need to learn for enabling them to work with the language and content integrated instructional approach of SIOP successfully. In her article, she summarizes results on effects and conditions of several implementation studies.
- In a similar manner, Hajer and Norén (2017) based their specification of what teachers need to learn starting from research and design on the classroom level. In their article, they present the content of an online-PD-module for professional development which is disseminated in Sweden. The module shows nicely what it means to consequently integrate language and mathematics.
- The third article by Lange and Meaney (2017) on the PD level investigates a teachers' individual professionalization process when trying to foster primary students' writing in mathematics classrooms. Although being intensively accompanied by facilitators, the process shows the institutional and individual complexities which promote or constrain teachers' development.

Different Research Approaches

In sum, the eight articles of the special issue provide a wide picture of the current trends and issues on research on the classroom and professional development level. All articles share the basic assumption that language should be investigated as learning medium, learning goal and unequally distributed learning prerequisite, and all articles contribute to showing why this must be done subject-specifically.

Above that, the special issue shows the need for diverse research approaches. The broad range of research foci for investigating questions of fostering the mathematics learning of language learners, under a classroom learning perspective (Q1-Q3), and under a professional development perspective (Q4-Q6), goes hand in hand with a broad range of approaches:

- Rezat and Rezat (2017) and Moschkovich (2017) mainly present theoretical analyses which are strengthened by references to empirical (descriptive) findings.
- In contrast, the other articles all start from designing approaches for students or teachers (e.g., Hajer & Norén, 2017) and five of them then empirically investigate their functioning:
 - Quantitative methods are applied by Hagena et al. (2017) and Short (2017) for providing quantitative evidence for the (non-)effectiveness of approaches,
 - The others investigate the initiated teaching learning processes qualitatively (Schüler-Meyer, 2017; Prediger & Zindel, 2017; Lange & Meaney, 2017), showing the complexities
 - of the connection between language and mathematics (Prediger & Zindel, 2017),
 - of student learning in interaction (Schüler-Meyer, 2017)
 - and of teacher learning (Lange & Meaney, 2017).

All the different approaches rest upon a common foundation: All of these five studies could not have been conducted without first designing learning opportunities, and this is an important progress in the research on language and mathematics. By collecting these different questions, research approaches and highly interesting findings in one special issue, the editors hope to initiate a further vivid research discourse on how to foster the mathematics learning of language learners. This would be an important step for enhancing equity.

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