Opportunities and challenges of classroom-based research on mathematics and language

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This report is a summary of the questions, comments and issues brought up in the ETC4 panel of three expert researchers on mathematics and language. The purpose of this panel was to discuss: (1) What do we mean by the language of the learner, of the teacher and of mathematics? (2) What are today the opportunities and challenges of classroom-based research on mathematics and language? The major recommendations and position statements included: (i) Develop more nuanced theoretical frameworks for the understanding of the politics of language use in the mathematics classroom (ii) Re-evaluate conceptualizations of languages and speakers in terms of distinctions, differences, dichotomies and difficulties (iii) Conduct more language-related design research for teaching and learning of specific mathematical content areas.

Keywords: Mathematics and language, research domain, opportunities, challenges.

Introduction to the ETC4 panel

This report grows out of the contributions made during a conference panel. Three experts – Richard Barwell, Jenni Ingram and Susanne Prediger – from three parts of the world – Canada, England and Germany – were the members of the panel that took place in Dresden, March 2018, at the Fourth Topic Conference of the European Society of Research in Mathematics Education (ERME). Theoretically, Richard, Jenni and Susanne represent diverse perspectives, and some of their main statements are compiled below. In their brief statements, they complemented each other's knowledge by sharing insights from their respective lines of expertise and by bringing attention to their ways and experiences of building research in the contemporary domain. Núria Planas in her role of moderator had posed in advance two questions for discussion to the panelists:

Question 1. What do we mean by the language of the learner, of the teacher and of mathematics?

Question 2. What are the opportunities and challenges of classroom-based research on mathematics and language, today?

Views on these questions were the context for reflection on what decades of research in mathematics and language teaches us for the present and the future, in terms of relevant issues, recommended actions, emerging directions, as well as strengths, milestones and weaknesses of the domain. This context greatly benefited from discussions with participants during the days of the conference and particularly from the interchange with the panel audience. Moreover, the exploration of ideas that follows owes much to the influence of and interaction with participants of the Thematic Working Group on Mathematics and Language (TWG09) in the more recent conferences of the ERME Society. TWG09 has been a context of opportunities for researchers in the domain to be able to work and think with the support of colleagues from different regions of the world and with different research perspectives. After the summary of comments and recommendations by each panelist, we conclude this report with future steps for improvement of research in the domain. It is important that the next meetings of the TWG09 community provide some continuity in the discussion of these points.

Comments and recommendations by Richard Barwell

The first point I wanted to make was that language diversity is itself diverse. Language is diverse, languages are diverse, and diversity is diverse. Superdiversity refers to the increasingly diverse nature of diversity. The old, stable labels no longer work in analytic terms (even if they form part of everyday ways of talking about language). The idea of superdiversity has been accompanied by changes in how language diversity is conceptualized and examined:

Over a period of several decades –and often emerging in response to issues predating superdiversity– there has been ongoing revision of fundamental ideas (a) about languages, (b) about language groups and speakers, and (c) about communication. Rather than working with homogeneity, stability and boundedness as the starting assumptions, mobility, mixing, political dynamics and historical embedding are now central concerns in the study of languages, language groups and communication (Blommaert & Rampton, 2011, p. 3). So one challenge is to think about how we can research language diversity in mathematics classrooms from a perspective of mobility, mixing, political dynamics and historical embedding.

For an example, consider my two boys (aged 13 and 10). They are British and Canadian, go to school in Quebec in French, and discuss their mathematics homework with me in English or French. They have also spent a few months in school in the UK in English. Their experience illustrates mobility (dual nationality, time in a second country), mixing (use of two main languages), political dynamics (French is the required language of schooling for most children in Quebec, English in the UK, they are from a privileged background), and historical embedding (the use of French and English in Quebec is embedded in a long and contested colonial history).

Our ways of researching often 'fix' participants, classrooms, and languages. We label children as speakers of x, learners of y, etc. We treat languages as monolithic (e.g., variations in accent or pronunciation are considered bad or faulty). Moreover, we often overlook the politics and history of language in mathematics classrooms.

For a second example, consider children in an ethnographic study I conducted a few years ago, all seen as second language learners of English or French. I have many examples of students struggling to solve word problems, or struggling to explain their solutions. This situation can be examined as being strictly about how the students interpret the problems: about how, perhaps, their 'limited' level of English or French 'impedes' a 'correct' understanding of the problem, so that they get a 'wrong' answer or are unable to explain their solution. By paying attention to politics and history, however, other aspects of these situations become apparent. In one situation, the students are from an indigenous background, Cree. Their people and language have been subject to colonization and vicious oppression and the public school system is not necessarily well aligned with their lived experience. Their language is not well recognized in the school system. These dimensions are relevant in understanding their apparent struggles with solving word problems, when these problems are presented in a language that is other, based on situations that are also other.

While superdiversity represents a challenge for our research, there are opportunities to move forward. Research in sociolinguistics, sociology, anthropology, etc. has started to develop new approaches on which we can draw. There is an opportunity to develop new theoretical approaches to language diversity in mathematics classrooms that incorporate mobility, mixing, politics and history. For example, the concept of repertoires is now widely used in sociolinguistics, replacing the idea of a speaker knowing a fixed number of named languages (see Barwell, 2018). Instead, speakers are thought of as drawing on repertoires made up of aspects of multiple languages, registers, genres, accents, etc. and these languages, registers, genres, accents, etc. are not seen as fixed either, but as multiple and fluid. There is not one kind of mathematical language, for example.

Speakers draw on parts of their repertoires according to the situation. So one direction for our research could be to examine the nature of students' repertoires in mathematics classrooms. This kind of approach will not result in a neat general theory, but understanding the dynamic nature of students' use of language could be invaluable for informing mathematics teachers, and developing new pedagogical strategies.

Comments and recommendations by Jenni Ingram

Thinking about the differences, we often demark between the language of the teacher, the language of the learner, and the language of mathematics. There is an assumption here that needs to be challenged, that is that there is something that we can call the language of mathematics, the language of the learner or the language of the teacher. In reality, there are languages, or discourses. Richard talks about repertoires that individuals draw upon as a way of conceptualising these multiple and fluid discourses, but his emphasis is on the macro level. These multiple discourses are also apparent at the micro level, and at the individual level of an interaction between a teacher and a student, which are often harder to categorise as belonging to a specific register or language. Moreover, it is often us as researchers who see these categories or repertoires as being relevant to our analyses, not necessarily the teacher and the students themselves. This raises one aspect of the issue of scale that is something we need to consider seriously as an emerging field.

Making distinctions at the level of language, culture, or between the language of mathematics, the language of the learner and the language of the teacher usually results in dichotomies. The language of mathematics is contrasted with everyday language, the language of one particular type of learner is contrasted with another type of learner and so forth. This focuses our attention on differences, not similarities. This focus on differences often leads to a focus on the difficulties. The language of mathematics is hard to learn, some learners have more difficulties in contrast to others, teachers are not using, supporting, including enough mathematical language in their lessons and so forth. As Moschkovich (2018) argues we need to "move away from dichotomies that create unproductive and oversimplified approaches to research phenomena" (p. 41).

These distinctions can be helpful as they give us as researchers a focus, and it is not that we are ignoring the relationship between the three domains, but that we are highlighting or emphasising one aspect over another. They enable us to have a very specific focus on one particular aspect of teaching or learning. They have also been fundamental in examining the social and political aspects of multilingualism in the classroom (Planas & Civil, 2013). Yet too narrow a focus may tell us a great deal about what we are researching but be of little use to teachers or learners, or even other researchers. We also need a balance between more generic foci, such as particular mathematical practices that go across topics, such as argumentation, and specific foci such as what are the issues around the learning of the meaning of the word equation.

Another challenge for our domain is that we need to be more aware of our assumptions, intuitions, and beliefs and how these influence our research. Do we always articulate these or consider the impact of these in our work? In particular, the assumptions we make about what is mathematics, what are mathematical practices, what is mathematical language, what are mathematical meanings, and so on. It is often not as clear-cut as it might seem.

Something that is both a challenge and an opportunity is to bring more cohesion to our body of work. As a domain, we have expanded significantly and drawn upon a wide range of theories and methodologies and these have given us more insight into the role of languages or the role of discourses in both the teaching and learning of mathematics, but we also need to contribute to the

wider field of mathematics education research and beyond. There is a balance to be held but a key question to ask is who is engaging with our research and who do we want to engage with our research? Are we speaking to only our domain? The complexity of what we are researching can make it difficult to communicate in a meaningful way to those from outside the domain. This applies both to other researchers, but possibly more importantly mathematics teachers. It seems to me that a coherent message synthesised from the different contributions is more powerful than one single researcher or one single approach to research. For example, Susanne's design research described below brings together theoretical frameworks for the analysis of language(s) in the mathematics classroom and the design and development of pedagogic resources for the teachers involved. This is not to say that there is just one message, more that there is strength in numbers and different ways to work together both in conducting our research but also in communicating it. At the same time, we need to recognise the complexity of languages, discourse and interaction, and avoid the risk of oversimplification which can narrow both what is taught and how it is taught.

Personally, I would like to make a positive difference to students' experiences of learning mathematics in the classroom. Research enables us to gain further understanding of how students learn mathematics, and the practices of classroom mathematics that support students in their learning. Does this research also help to develop teachers' understanding, meaning understanding, not knowledge? For others what matters is making structural or policy changes that benefit our students, and for others still what matters is moving the field itself forward.

Last year I was working with two groups of teachers on developing their students' use of mathematical language during lessons, but taking the teachers' own beliefs about what counted as mathematical language as the focus. There were noticeable differences in what the teachers' focused on but also what they understood from what students said. In one meeting a video showed a student asking one of the teachers when does an expression become and equation. In another meeting, a teacher shared a video of a student stating that an equation included numbers but an expression included letters. Both these groups of teachers subsequently spent considerable time trying to work out what a definition of an equation would be, which examples would count as an equation, which would not, and so forth. I have subsequently also asked this question of my student teachers. On all three occasions no one definition was settled upon, and not all the teachers agreed on what counts as an equation and what does not. Yet before this discussion, we were all treating the word equation as unproblematic. We were assuming that we all had an agreed understanding of what an equation was and were thus focused on how to help students distinguish between equations, expressions, identities, functions, etc. but using prototypical examples. I use this to illustrate the complexity of what we are looking at as well as the assumptions we make about what we are researching.

However, more challenging for me was working with teachers who had different beliefs about what it meant for students to speak mathematically than I did, and to not treat or assume that these beliefs were necessarily 'wrong' or 'worse' than mine. These differences arise out of different meanings that we are all attaching to the word language alongside different values about what it meant to learn mathematics. It is not necessarily the case that one is better than the other, just that they are different. For example, one teacher equated learning mathematical language as learning vocabulary in the group discussions, but in the videos of their practice, she was doing so much more than this. To her this was not about learning language but what it meant to learn mathematics. The distinctions we were making were different, but our values about what students should be doing in the classroom were aligned.

Comments and recommendations by Susanne Prediger

All the three of us, we did not really like Question 1. What do we mean by the language of the learner, of the teacher and of mathematics? This classical distinction between the three languages stems from the earliest articles on language in mathematics (Austin & Howson, 1979), and 40 years after being posed, it seems time to overcome them. I agree to Richard and Jenni that

- "the language" does not work in singular anymore. Due to the superdiversity of modern societies and the complexities of individual language repertoires, plural, "the languages or the language repertoires" must exchange the singular;
- easy categories of students with high or low language proficiency or strong or weak mathematical achievement cannot at all take into account the complexity of superdiversity in today's schools;
- identifying differences between the language of mathematics, the learners and the classrooms (even if posed in plural) risks to result in useless or even dangerous dichotomies;
- even if stating differences does not necessarily imply stating deficits, it is much more insightful to identify the connecting points instead of the differences: where does students' language start from, and along which learning trajectories can we develop it further?

Instead, we are interested in language demands posed by mathematics learning and possibly mediated by the teacher as well as in students' use of their individual language repertoires and their development for and during mathematics learning.

The research in the last forty years has contributed to identifying the diversity of students' repertoires and substantiated the widely accepted claim that mathematics classrooms should build upon the students' diverse language repertoires (Planas, Morgan, & Schütte, 2018; Radford & Barwell, 2016). However, so far, the research has only selectively contributed to realizing this aim in mathematics classroom practices.

This leads me to Question 2. *What are the opportunities and challenges of classroom-based research on mathematics and language, today?*

I agree to Richard and Jenni that classroom-based research on mathematics and language should take into account the politics of language and the complexities of multilingual superdiverse societies without deficit perspectives. Furthermore, it should stop using the dichotomy of language of the learner and of mathematics and talk more about the language demands posed during conceptually rich mathematical learning opportunities.

My personal emphasis is that our research and development activities should be extended from (very insightful!) descriptive and analytical research towards interventionist research which contributes to developing and investigating discursively and mathematically rich learning opportunities for all students. For this, language demands in learning specific mathematical contents have only selectively been specified so far, and teaching learning arrangements are to be developed more consistently. Therefore, my major claims with respect to necessary future research activities is that

- we engage in designing teaching leaning arrangements which build upon students' diverse language repertoires for engaging them in conceptually rich mathematics and develop them further;
- investigate teaching learning processes with respect to different mathematical topics;
- and specify topic-specific language demands for leaning specific mathematical topics in such a detail that language learning goals can be integrated in teaching leaning arrangements.

Since 2009, the work of our MuM-research group in Dortmund tried to contribute to this research agenda in design research methodologies (Gravemeijer & Cobb, 2006). The design research studies have been conducted in collaboration with linguists and language education experts and their different theoretical backgrounds, including functional pragmatics and interactional discourse analysis. The investigation of the initiated teaching learning processes helped us to see sharply that we need to

- focus on discourse practices and the syntactical and lexical means to participate in them;
- engage students in these discourse practices and give them the lexical and syntactical means to successfully participate;
- and develop a good analytical framework, and particularly suitable classroom instructional designs.

Our major goal was always to design mathematics- and language-integrated learning opportunities and to investigate the learning processes we can initiate by these learning opportunities. That means, we use design research methodologies. By these design research studies, we can specify the language demands appearing in mathematics learning processes. I absolutely agree to Jenni and Richard that there are no easy categories for the appearing complexities. These language demands are shaped by the discourse practices required for learning mathematics. According to classroom and design research studies (Erath et al., 2018; Prediger & Zindel, 2017), important discourse practices are reporting procedures, explaining meanings of mathematical concepts, arguing about the match of different representations, and describing general patterns. For these discourse practices, also lexical and syntactical means can be specified, they are partly in the students' repertoire already, and partly need to be learnt. That is why we consider it as very important to identify thoroughly the language demands appearing in the topics pecific learning processes and to support the students to cope with them increasingly.

We have empirical evidence from a big intervention study that such kind of instructional designs can be profitable for tackle an enormous diversity of students' learning pathways. Even those students who were labeled as language proficient profited from the instructional design. So, labelling is not necessary: when we identify the learning needs with respect to monolingual and multilingual language learners, the interventions are also strong for the students who were believed not to need a language focus. Especially, when working more consequently on the students' language for explaining meanings of mathematical concepts, then this intensifies also the mathematics learning processes, we have found this in many of our transcripts and in the quantitative data. In contrast, emphasizing the reporting of procedures seems to hinder mathematics learning. I am grateful that the team is currently so big (including four teachers and facilitators, five postdocs and eight PhD students and me), so we can manage to handle the complexity of the projects.

Jenni has mentioned that this question must include the teachers: How can teachers develop their expertise to foster students' mathematics and language learning? We started to work also on the second question and adopt a similar research methodology. We provide professional development courses and then investigate the teachers' learning pathways, starting from their instructional practices, categories and orientation of what counts in a mathematics- and language integrated classroom. Overall, both Questions 1 and 2 require not treating the language of classrooms, mathematics and learners separately anymore.

Agreements on important issues for present and future research

In this report, Richard, Jenni and Susanne have made the case for a number of reflections of importance to understand the present and future of classroom-based research on mathematics and language. This is not the full text of what was spoken and discussed in the time for the panel, but four central interconnected reflections have been made clear, namely:

- to move away from using potentially unhelpful and possibly harmful dichotomies;
- to use flexible ways of conceptualising language, languages, speakers and diversity;
- and to develop rigorous ways to take into account the socio-political aspects of language, languages and diversity in our research, and make our classroom-based research accessible and useable by teachers.

There is agreement on the ambition to carry out a research that is relevant in the senses of useable and used by mathematics teachers and educators in their mathematics teaching and development. The opening to more realistic diverse views of diversity, languages and speakers has the potential to move the study of mathematics teaching, learning and thinking forward in ways that are applicable to the design and implementation of instructional practice in real classrooms where the languages of the teacher, the learner and the mathematics are diverse. In order to be successful in making our research applicable to classrooms, we must build theory that draws on the experience of teachers and learners in practice. This implies communication and reflection with teachers, and collaboration with them in carrying out design experiments for the creation of powerful learning environments in classroom cultures more inclusive for all learners.

Implicit in classroom-based research is the fact that researchers are familiar with the classrooms they are looking in. This is not always the case when, for instance, they start their interpretations with interactions converted into transcripts by means of technical and personal support. However, it is difficult if not impossible to develop a sense and appreciation of the many layers of diversity and languages of mathematics, learners and teaching without visiting schools and classrooms. In this respect, some of the benefits of the so-called naturalistic approaches to classroom-based research should not be taken for granted, at least in what refers to capturing the naturally occurring classroom as it is. Even when researchers enter the research process from its very beginning through classroom observation, they may visit lessons with closed lists of categories expected to appear in the course of mathematics teaching and learning. Thus, some relevant issues regarding the socio-political dimension of language may be either ignored or finally noted as 'other'. Spending more time in classrooms and visiting schools can help us to understand the extent to which reality is far diverse from what some 'naturalistic' research has envisioned in the past and still at present. The idea that languages are not discrete, monolithic entities strongly emerges when critically observing activity in lessons. One language, one culture and 'average' people simply do not work in representations of real classrooms with real learners and real teachers. It is about not only verbal languages representing several cultures, several languages and singular people, but about the diversity of body and visual languages of specific learners and teachers in interaction.

In the statements of the three panellists, we find a situated empirical research root and the proposal of change in focus from conventional naturalistic views toward critically views of classroom research. Richard has mentioned one of his ethnographic studies in mathematics classroom of second language learners, Jenni her work with various groups of teachers, and Susanne her developmental projects and design research program. The emphasis on collaborative professional development, design research programs and ethnographic studies with teams of researchers and teachers is a way of promoting classroom research that realistically –and not only naturalistically– represents the complexity of languages involved in mathematics teaching and learning. In dealing with this

complexity, numerous artificial dichotomies are to be overcome, particularly those separating languages into mathematical and non-mathematical, academic and colloquial, pure and mixed, average or normal and singular or exceptional, and so forth. Immediate collaborative environments –like those mentioned by Richard, Jenni and Susanne– are a great opportunity of expanding, improving and sharing our understanding of how mathematics classroom discourses work as well as how mathematics teachers think about their work, including their language use in teaching, and their learners, including their languages.

We may enter a research process –and a mathematics classroom– by assuming that the expert teacher will share our language of mathematics –or taking the example by Jenni, the same understanding of what an equation is–. This is an assumption that prepares the identification of certain meanings and the fabrication of certain categories for the interpretation of the language of the teacher. By emphasizing the role of learners for us as researchers, other aspects and categories different to those prepared in advance for observation might appear. This lead us to end with one more commonality in the words of the three panellists: the suggestion of newer roles for researchers and less transparent ways of producing research. In the move toward more realistically representing languages and speakers in mathematics classrooms, researchers need to place themselves as learners with different skills and knowledge to offer. They need to give visibility to their roles and intentions in the research process, as well as to the assumptions made about what community is being researched, which are their languages and why, so that classroom participants can also experience their roles and communicate their perceptions in ways that contribute to uncovering more and richer languages.

References

Austin, J. L., & Howson, A. G. (1979). Language and mathematical education. Educational Studies in Mathematics, 10, 161-197.

Barwell, R. (2018). From language as a resource to sources of meaning in multilingual mathematics classrooms. The Journal of Mathematical Behavior, 50, 155-168.

Blommaert, J., & Rampton, B. (2011). Language and superdiversity. Diversities, 13(2), 1-21.

Erath, K., Prediger, S., Quasthoff, U., & Heller, V. (submitted). Discourse competence as important part of academic language proficiency in mathematics classrooms: The case of explaining to learn and learning to explain. Submitted to Educational Studies in Mathematics.

Gravemeijer, K., & Cobb, P. (2006). Design research from a learning design perspective. In J. V. D. Akker, K. Gravemeijer, S. McKenney, & N. Nieveen (Eds.), Educational design research: The design, development and evaluation of programs, processes and products (pp. 17-51). London, UK: Routledge.

Moschkovich, J. N. (2018). Recommendations for research on language and learning mathematics. In J. Moschkovich, D. Wagner, A. Bose, J. Rodrigues Mendes, & M. Schütte, (Eds.), Language and communication in mathematics education: International perspectives (pp. 37-47). Cham, Switzerland: Springer.

Planas, N. & Civil, M. (2013). Language-as-resource and language-as-political: Tensions in the bilingual mathematics classroom. Mathematics Education Research Journal, 25, 361-378.

Planas, N., Morgan, C., & Schütte, M. (2018). Mathematics education and language: Lessons and directions from two decades of research. In T. Dreyfus, M. Artigue, D. Potari, S. Prediger, & K.

Ruthven (Eds.), Developing research in mathematics educaton: Twenty Years of communication, cooperation and collaboration in Europe (pp. 196-210). London, UK: Routledge.

Prediger, S., & Zindel, C. (2017). School academic language demands for understanding functional relationships: A design research project on the role of language in reading and learning. EURASIA Journal of Mathematics, Science and Technology Education, 13(7b), 4157-4188.

Radford, L., & Barwell, R. (2016). Language in mathematics education research. In A. Gutiérrez, G. Leder, & P. Boero (Eds.), The second handbook of research on the psychology of mathematics education. The journey continues (pp. 275-313). Rotterdam, Netherlands: Sense Publishers.