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Challenges and research priorities in the context of TWG09: Mathematics and language

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We begin by briefly examining the relevance of the study of language in mathematics education research, as well as some of the collaborative forms in which TWG09 is moving the study of language forward in the field. To provide reasons for the recent contributions by TWG09, we summarise lines of concern and tendencies that come from our reading of the set of papers and posters presented at CERME9. We build on the review work by Morgan (2013) to argue for the consolidation of such a diversity of lines of concern and tendencies in the contemporary agenda of the domain. The discussion of accomplished goals of the agenda points to a number of challenges and priorities in the context of TWG09 – its participants, their interaction and their activity.

Keywords: Language, mathematics education, mathematics education research, understanding, challenges.

OVERVIEW

The study of language in mathematics education research is a relatively young domain, however, with well-organised academic initiatives on an international level. One of the activities promoted by the European Society for Research in Mathematics Education (ERME) is the Thematic Working Group ‘Mathematics and Language’ (see Rønning & Planas, 2013, for a brief historical overview of the group since its origin). The Thematic Working Group ‘Mathematics and Language’ at CERME9 (TWG09) has brought together a collection of papers and posters that analyse a wide spectrum of topics, theoretical traditions and analytic approaches in this domain.

The fact that the study of language is at the core of intersections between many topics and theories inevitably has an effect on the nature, composition and evolution of our group. In 2015, for instance, some senior researchers in the field (i.e., researchers who have been active in the study of mathematics education for many years, although not necessarily keeping a regular focus on the study of language) have come to our group to discuss aspects of their work. They have shared expertise with, on the one hand, senior researchers in the group (i.e., researchers who have been active in the ‘Mathematics and Language’ domain within ERME for many years) and, on the other hand, with a large number of early researchers in the field (i.e., researchers who are new to both the study of mathematics education and the study of language issues with relation to mathematics education).

The purpose of this introductory text is to provide a conceptual and scholarly context for the papers and posters presented at CERME9. The rest of the text is organised into three sections. The first section deals with arguments for the relevance of the study of language in the field. The second section provides a description of how our domain is being constituted in ways that include a number of perspectives on language; following this, we trace a diversity of lines of concern and tendencies which come from our reading of the set of papers and posters. The third section concludes with reflections on how to mould the future activity of participants in TWG09. Collaboration among researchers from different countries, social realities and theoretical traditions are crucial aspects of what is needed to push boundaries further and explore new horizons in the study of language with relation to mathematics teaching, learning and education. One of the problems to be addressed is, in view of what is

needed, what can be done and how it can be done in the years to come.

THE STUDY OF LANGUAGE IN MATHEMATICS EDUCATION

While questions addressing the relationship between language and mathematics have been a focus of study for over 30 years (see, e.g., Pimm, 1987), we still understand little about how and why language develops in interaction with mathematics teaching and learning development. Despite the fact that much remains to be researched, substantial knowledge in this regard is being produced inside and outside of ERME. We have arrived at the present destination – in which our domain is well recognized, established and differentiated in the field – after a long journey.

In 1974, an international symposium on “Interactions between Linguistics and Mathematical Education” was held in Nairobi, Kenya, sponsored by UNESCO in cooperation with ICMI and the Centre for Educational Development Overseas. Up to that moment, there had been no international events focusing on the relationship between mathematics and language. The final report of that symposium (UNESCO, 1974) revealed the lack of studies and research experience in this domain; moreover, it urged the international scientific community to adopt an agenda by identifying key issues, questions and needs at the intersection of mathematics education and language. Five years later, a review paper, with potential for founding an early agenda, was published by Austin and Howson (1979) in *Educational Studies in Mathematics*. A total of 240 references on language and mathematics education were compiled to indicate possible areas for investigation as well as areas in which research activity had already commenced.

In 2015, more than four decades after the Nairobi symposium, the examination of key issues, questions and needs at the intersection of mathematics education and language continues. Some of the newest issues and questions reveal, for instance, the increasing interest in a range of language uses in school mathematics contexts. Such uses may vary from one classroom to another, and more generally among school cultures, histories and pedagogies of teaching, but overall they may be dependent on who the involved users are (Planas, 2014). A large amount of evidence for the complexity of language use can be found in

Mathematics Education and Language Diversity, the abbreviated title for the volume of the New ICMI Study Series edited by Barwell and colleagues (2015), which is one of the latest milestones of the long journey in the consolidation of the study of language in mathematics education.

Another step in the journey toward the maturity of the domain has been undertaken by Barwell (2014) and Morgan (2014), in their respective synthesis of reasons for the relevance of the study of language in mathematics education in two of the entries in the *Encyclopedia of Mathematics Education*:

The teaching and learning of mathematics depend fundamentally on language. Mathematics classrooms, for example, may feature discussion among students, lectures by the teacher, printed curriculum materials or textbooks, and writing on a blackboard or on a screen. (Barwell, 2014, p. 331)

While some aspects of mathematical language, such as its high degree of abstraction, may be an obstacle to participation for some people, doing mathematics is highly dependent on using its specialized forms of language, not only to communicate with others but even to generate new mathematics. In making this claim, we need to be clearer about what mathematical language is. (Morgan, 2014, p. 388)

During recent years, many new studies, journal articles and conference papers have contributed to reporting empirical findings and accurate theoretical developments in the domain. The creation and revision of knowledge in these works is being guided, either implicitly or explicitly, by common basic questions, whose origins can be traced back to the early work on language and teaching dilemmas by Adler (1998): *Where is language in this? Why does it matter? How can it be researched in ways that are idiosyncratic to mathematics education?* All in all, the existing variety of contemporary lines of concern in the domain can be thought of as different epistemological and analytical strategies of approaching these questions.

COMMON QUESTIONS, DIFFERENT LINES OF CONCERN

In her CERME8 plenary, Morgan (2013) offered a range of possibilities around what language enables mathematics education researchers to study, and how much the study of language challenges the ways in which we carry out research in the field. Moreover, she provided a thorough literature review concerning the work presented in the Thematic Working Group ‘Mathematics and Language’ over recent decades. In that plenary, Morgan claimed that the quality of research on language in mathematics education is influenced by a number of studies whose ideas have been at some time presented and discussed in ERME. We interpret the range of possibilities posed by Morgan (2013) in terms of potential lines of concern which map the contemporary domain and whose research has been initiated, inside and outside of ERME, with different levels of intensity. We refer to research concerning:

- 1) Communication and interaction in mathematics teaching and learning.
- 2) The representational systems in creating/structuring mathematical knowledge.
- 3) The role and use of languages in mathematics education practices.
- 4) The features of codes/registers in the construction of mathematical language.
- 5) The intervention of discourses in knowing and thinking in/about mathematics.

These five lines of concern illustrate how the agenda regarding the study of language in mathematics education has introduced new complexities and, thus, has evolved toward building a domain much wider than that imagined in the 1970s. In this respect, it is not surprising that the lines of concern suggested by Morgan to show the range of possibilities already opened for research in 2013, have emerged from our reading of the papers and posters presented in TWG09 during CERME9. While the limited collection of papers at CERME9 cannot totally reflect the scope and wideness of the contemporary domain, it confirms that some work is being done in each of these five directions. For the purpose of organising the discussion around the

set of papers and posters accepted for presentation at the time of the conference, we used five abbreviated descriptors, respectively aligned with specific dimensions of the indicated lines of concern. These descriptors are:

- 1) Communication, interaction and gestures.
- 2) Epistemic, cognitive and structural aspects.
- 3) Multilingualism and sociocultural aspects.
- 4) Mathematical language and language use.
- 5) Discourse, practices and positioning.

In what follows, we summarise some of the lines of concern and tendencies which can be traced in the collection of papers and posters. As a whole, the process of grouping papers and posters has provided a straightforward picture of how and how much language is approached as a bundle of notions that other notions (gestures, registers, diagrams, talk, multilingual, mathematical objects, etc.) transverse, all of them with a diversity of attributed meanings and understandings. This is why the location of contributions is not univocally determined. It reflects our interpretation of the knowledge privileged by the authors in their texts. We may have overlooked ideas that some of the authors consider essential. Nevertheless, as the intention is to map the work in TWG09 and not to give a detailed account of each single paper or poster, we hope that all authors will see their work represented.

Communication, interaction and gestures

Six papers by Reinhardtson, Carlsen and Säljö; Nordin and Björklund-Boistrup; Boukafri, Ferrer and Planas; Vogler; Farsani; and García Moreno-Esteva and Hannula, along with one poster by Roubicek, constitute the works in the direction of *Communication, interaction and gestures*. All these authors understand verbal (oral and written) and non-verbal (gestures, facial expression and visual contact) forms of language as communication strategies in classroom interaction. Language, in its verbal and non-verbal forms, is conceived as an instrument of communication, also in its various forms: individual, collective, peer-based, etc. In this way, diverse language use is tantamount to communication, learning and teaching.

In the presented works, we see two major tendencies or emphases that can be found at the intersection of several interrelated lines of concern. One is the tendency of the study of interaction through the study of gestures in classroom contexts of mathematics teaching and learning. In Farsani, for instance, gestures are proven to provide direct data for researchers to examine communication between teachers and learners. Here, a joint finding with the work by García Moreno-Esteva and Hannula is the role of gestures in the production of successful instances of mathematical communication, with a number of opportunities for mathematics teaching and learning. Closely related to the analysis of gestures, the production of intertextuality and multimodal texts to represent classroom data is also examined by these authors.

Another tendency in some of these works is the study of communication through and with digital media as part of the language environment for mathematics teaching and learning. The shift from text-based paper-and-pencil communication to multimodal digital communication is viewed as a qualitative change in the practice of mathematics teaching. It is generally noted that multimodal dynamic texts produced by teachers and students should be reproduced by researchers in different kinds of multimodal dynamic transcripts. Here, the potential interplay between multimodal resources, digital technologies and mathematical modes of communication is discussed by Reinhardtson, Carlsen and Säljö, at a methodological level, through the development, application and evaluation of analytic tools created *ad hoc*.

Epistemic, cognitive and structural aspects

Six papers by Ruthven and Hofmann; Erath and Prediger; Krause; Fetzer and Tiedemann; Meyer; and Mellone and Tortora, together with a poster by Zwetzschler, constitute the collection of works in the direction of *Epistemic, cognitive and structural aspects*. All these papers address the study of ways in which mathematics classroom discourse develops grounds for and access to (school) knowledge and (school) knowledge claims. In this respect, an elusive area of concern regarding epistemic issues in school mathematics has been present in TWG09.

One identifiable tendency in this direction is the conducting of classroom studies. Ruthven and Hofmann introduce the term *epistemic order*, which refers to a system used to describe how ideas are developed and

evaluated in the classroom. Their work expands the classical Initiation-Reply-Evaluation and Initiation-Response-Follow-up patterns of interaction (e.g., Sinclair & Coulthard, 1992) by including codes to explain who is responsible for what, and who takes the initiative. The work by Erath and Prediger also deals with how students participate in the configuration of the mathematics classroom discourse. These authors are interested in understanding how students' learning opportunities relate to forms of participation in the discussion of epistemic issues concerning knowledge about the construction and justification of school mathematics knowledge. The paper by Krause investigates the epistemic function of gestures. In a study of tenth graders, she looks for evidence that gestures may support reasoning actions when mathematical knowledge is constructed.

The other papers are oriented toward how language use relates to what is knowable, which indicates another tendency in this direction of papers. Fetzer and Tiedemann look at the interplay between language and manipulatives. They show how a fairly simple language can become mathematically more complete when it operates in connection with both human and non-human objects. Meyer is concerned with transformations of algebraic expressions, and with how learners convey the structure of an algebraic expression to other learners with the use of language. The paper by Mellone and Tortora is of a more theoretical nature, although based on experience from working with learners. These authors discuss how an idea of ambiguity, often implicit in school mathematics, can be explicitly used in the teaching activity.

Multilingualism and sociocultural aspects

Five papers by Barwell; Poisard, Ní Ríordáin and Le Pipec; Ní Ríordáin and McCluskey; Chronaki, Mountzouri, Zaharaki and Planas; and Klose, together with one poster by Šteflíčková, constitute the collection of works in the direction of *Multilingualism and sociocultural aspects*. All these papers share the basic conceptualisation of the students' languages as pedagogic resources and entries to learning identities, though they may take different perspectives on how language(s) and speakers relate to mathematics teaching and learning.

In these works we see two tendencies. One is the tendency of putting together design experiments and case studies. Chronaki and colleagues examine the

case of a learner whose dominant language is not the language of instruction in a way that leads to the design, implementation and assessment of strategies for language use in mathematics classroom interaction. This approach is also taken by Barwell in his research with bilingual students in Canada. Barwell relates language use and its outcomes to the distinct language identity of certain groups of students in the multicultural mathematics classroom. In particular, he suggests that the construction of mathematical learning in multilingual settings is often guided by views of languages other than the languages of instruction and their speakers, rather than views of mathematical competence, performance and achievement.

A second tendency comes when examining the number of considerations at a political level made by the authors in their papers. All the presented papers in this direction focus on the perspective of languages as resources while considering the dilemmas involved in the choice and use of languages. These dilemmas indicate the extent to which the deficit perspective, in the study of language and language diversity, is more and more contested nowadays, particularly due to the impact in the domain of studies recurrently cited by some of the participants in TWG09 (e.g., Moschkovich, 2002). Poisard, Ní Ríordáin and Le Pipec, for instance, reflect in their paper on some of the enduring compensatory responses in the interpretation of the needs of students whose home languages are different from the language of instruction or the *lingua franca*.

Mathematical language and language use

Six papers by Edmonds-Wathen; Segerby; Tiedemann; Söbbeke; Albano, Coppola and Pacelli; and Engvall, Samuelsson and Forslund, along with one poster by Arce, Conejo and Ortega, comprise the collection of works in the direction of *Mathematical language and language use*. Most of the research focuses on the learning of mathematics at primary, secondary and university levels, while there is also a study in an indigenous population. It is shared an understanding of language use and language development for mathematical development through writing, reading and talking.

We identify a tendency around the analytical distinction of writing, reading and talking. Segerby focuses on the kinds of writing of young children in mathematics lessons. She finds that children write more in calculations as they progress through primary school,

at the expense of transactional and poetic modes. Arce, Conejo and Ortega focus on the diverse uses of written notebooks by students at school secondary level. Albano, Coppola and Pacelli cover writing and reading since the pupils in their study are asked to develop written arguments from reading graphs. They find evidence of the complexity of switching between colloquial and literate registers. In a paper related to talking, Engvall, Samuelsson and Forslund draw conclusions about the relationship between communicative teaching strategies and students' development of procedural and conceptual language. On the other hand, Tiedemann addresses the notion of linguistic norms to examine classroom talking.

All papers in this direction show the extent to which the use of language in mathematical situations is determined by the mathematics, and by the situations and the people interacting within them. The abstractness of mathematics is highlighted, which often influences mathematical language by making visualisation impossible, along with the cultural situatedness of this mathematical language, in which for example the centrality of spatial prepositions is not necessarily true. Taken together, the papers show that there is no common, fixed mathematics constituting the language we use in mathematical situations. From a primary classroom in Germany, where students have to negotiate the linguistic norms of mathematics lessons, to the negotiating of concepts of motion in an Australian indigenous language, language is constituted by specific mathematical situations and by the participants in them. The construction of mathematical meanings as a basis for learning mathematics is therefore in constant interplay with the use of mathematical language.

Discourse, practices and positioning

Six papers by Nachlieli and Tabach; Ingram and Pitt; Wagner, Dicks and Kristmanson; Jung and Schütte; Dooley; and Hess-Green, Heyd-Metzuyanım and Hazzan constitute the collection of work in the direction of *Discourse, practices and positioning*. All these papers address the study of classroom discourse for the identification, production and analysis of interconnected teaching, learning, positioning and identity-work practices. Across papers there is a common tendency concerning theoretical integration and theories networking.

Nachieli and Tabach, along with Hess-Green, Heyd-Metzuyanin and Hazzan, address discourse in mathematics classrooms through a variety of theoretical perspectives such as commognition (Sfard, 2008), discursive psychology and theories of identity, while Wagner, Dicks and Kristmanson develop connections between socio-linguistics, pragmatics and theories of positioning for the purpose of their research. More generally, different authors base their notion of discourse on different theoretical approaches. Some of the papers are focused on socio-cultural approaches where discourse is not seen merely as individual word meaning or as linguistic utterances located in a classroom; here, the authors embrace theories of language where the subject is seen as a social, historical and political interlocutor. Mathematical discourse is related to varied ways of talking, reading, representing, interacting, moving, silencing, believing, valuing, identifying, performing and acting.

The tendency in these papers appears at the intersection of a diversity of lines of concern, whose collective reading provides opportunities to unpack the discourse(s), diversity, ethics and epistemologies of learning mathematics. In Nachieli and Tabach, and also in Ingram and Pitt, we find the study of the construction of competency and success in the course of classroom interactions where different representations of 'competent' and 'successful' students are at play. Moreover, we find the study of the role of vague language and politeness in mathematical conversations in Dooley, of notions of uncertainty in students' discourses related to prediction and conjecturing in Wagner, Dicks and Kristmanson, of young children's participation in decontextualised mathematical discourse in Jung and Schütte, and of emotions in experiences of discourses on achievement and learning in Hess-Green, Heyd-Metzuyanin and Hazzan, amongst other lines of concern.

WHERE TO GO FROM HERE

In this final section, we build on our discussion of the contemporary research agenda of our domain inside and outside of ERME, to shortly reflect on the potential of TWG09 – its participants, their interaction and their activity – in the further refinement and development of this agenda. We see TWG09 not only as a space for researchers who share interests concerning language issues in mathematics education, but more importantly as a space for researchers who may have

an influence on each other through their interactions at the time of the conferences and during the in-between periods. This second perspective represents a mature stage in the process of constructing a group with a strong scientific identity, capable of quality group work.

By the end of CERME9, the team of co-leaders asked participants of TWG09 to suggest reflections on how to mould the future activity in the group. An e-mail communication sent by one of the participants, who was attending her first CERME, revealed her vision of TWG09 as a rich space though still in an early stage of group work maturity. This is an instance of what this participant shared with us:

It is important to get to see, as a group, the enormous challenges waiting for us to work on them. What I have missed though, is explicit consideration of how we are going to organize the near future so that we face these challenges by building on each other. (Participant of TWG09 at CERME9, e-mail communication)

This participant critically raised the issue of building on each other as a group. This is an insightful comment on the importance of building seriously on relevant work and ideas by other participants in order to strengthen the domain and our potential as contributors to its progress. The view by this participant may not be unique. We must continue to learn how academic collaboration within TWG09 can be reinforced in order to jointly face the many challenges posed at present and in the years to come in the study of language in mathematics education, both inside and outside of ERME.

Collaboration and regular work within the context of our group can contribute to moving the international agenda forward in directions that address, for example, the role and use of gestures in the bilingual mathematics classroom, the anticipation of forms of interaction for dialogic-based class discussion, the development of cross-linguistic analysis of mathematical cognition, the evaluation of content- and language-integrated approaches to learning, or the introduction of multimodal resources for the benefit of mathematics thinking. All in all, TWG09 – its participants, their interaction and their activity – can contribute to expanding our knowledge of a number of issues, questions and needs, with implications for

the achievement of quality mathematics instruction and equitable learning environments. By building on each other, we can learn more about how talk and interaction develop throughout mathematical activity. We can particularly learn how preferences for exploratory talk and inquiry-based lessons are validated by rigorous empirical work, and how variations of these preferences have an effect at different stages of mathematical learning. Insights from research in this domain can assist in developing interventions to improve mathematics teaching and learning practices. Thus, one of the challenges is to conduct and promote research that increases our understanding of how mathematics teaching and learning develops, but that also allows us to identify effective strategies and ways of improvement in practice.

It is our hope that the following set of papers and posters will stimulate interest in and appreciation of work across a wide number of language aspects. Regardless of the aspects that we decide to highlight in our work, the centrality of language must always be kept in mind. We invite our colleagues in the field, as well as teachers, teacher educators, curriculum developers, policy makers, etc., to think along with us.

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