INTRODUCTION
LANGUAGE AND MATHEMATICS

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The 21 papers presented to the Working Group were marked by a wide diversity of research focuses and theoretical perspectives. We therefore organised the discussion around five themes:

- Language and thought
- Classroom interaction
- Teacher development
- Theoretical perspectives to describe, analyse and interpret the semiotic aspects of students' mathematical activities
- 'Everyday' and mathematical language and learning

As will be seen from summaries of each of the sections below, there is some overlap between the issues considered in each theme. For example, the use of gesture has become of increasing interest and importance in the field and is found as a focus in papers in several of the themes. Similarly, while the relationship between everyday and mathematical language is a significant theme in its own right, it also emerges as an issue of relevance across other themes.

SECTION 1: 'LANGUAGE' AND THOUGHT

'Language' has a material, and therefore public, surface: either visible (writing and gesture - including sign language) or audible. On the other hand, thinking is invisible and inaudible. Therefore there is a challenge to render it observable, which must of necessity be by indirect observation. This sets up two fundamental tensions:

- Between the individual and the social
- Between implicit and explicit expression

The papers in this section propose different perspectives on how to make sense of the relation between language and thought.

- Focus on gestures, broad view on language (LaCroix)
- Reflection (Schülke/Steinbring)
- Inferential approach (Hußmann/Schacht)
- Argumentation: Toulmin model (Pimm/Sinclair)

- Critical thinking (Aizikovitsch/Amit)

SECTION 2: CLASSROOM INTERACTION

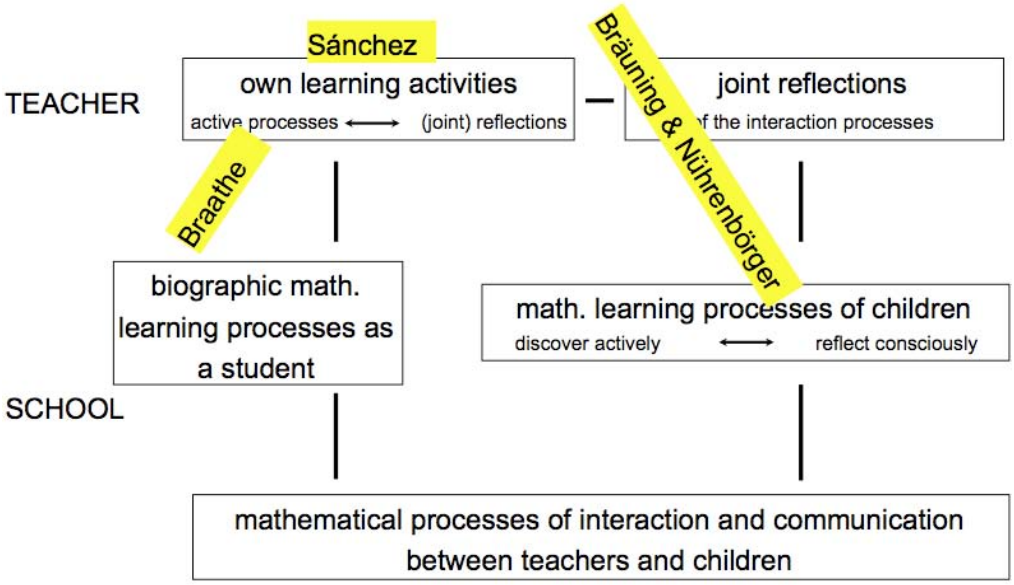
The theme “Classroom interaction” indicates that the papers in this section focus on the whole classroom, the relationships between teacher and students and among students and the role that language plays in establishing these relationships and in building mathematical discourse. The papers use a range of perspectives including the Wittgenstein’s language games, the notion of teacher as improviser, a focus on the use of gesture, shared thinking in group talk, and the interplay between everyday and mathematical discourse, aiming:

- to get deeper insight into processes of giving meaning to words in class (Meyer)
- to show how teacher and pupils co-construct new mathematical ideas using the improvisation metaphor (Dooley)
- to describe the communicative strategies of an experienced teacher when summing up pupil solutions (Bjuland et al.)
- to consider how discourse, as a theoretical and didactical concept, can contribute towards developing mathematics teaching (Riesbeck)

SECTION 3: TEACHERS’ PROFESSIONAL DEVELOPMENT

“Teachers’ professional development” is a major theme of the papers presented by HansJørgen Braathe, Kerstin Bräuning, Marcus Nührenbörger and Mario Sánchez. The understanding of different interaction forms of teachers` distanced view on communication and interaction processes is a necessary condition for their development, as Dewey (1916, 4) pointed out, “society not only continues to exist by transmission, by communication, but it may fairly be said to exist in communication.”

Each paper analysed ideas and thoughts expressed by teachers in written and oral form. But each paper deals with different aspects and schemas of professional development. The following diagram is separated in two levels: “teacher with distance to communication processes in school” and “the mathematical learning and teaching in school”. The level “Teacher” means that teachers are integrated in two different activities: On the one hand their own mathematical learning activities, and on the other hand their joint reflections. Each teacher has biographical mathematical learning processes. This aspect is located in-between the levels “Teacher” and “School”. The 2nd level “School” includes the mathematical learning processes of children and the interaction between teachers and children.



Each paper highlights not only different aspects and methodological approaches to teachers` professional development, but also refers to different theoretical frameworks – like positioning theory, inquiry cooperation model, epistemological and interactional theory. The variety of the theories deepens and broadens the insights in the special conditions of teachers` interactions and learning processes connected to language and mathematics.

References

Dewey, J. (1916) *Democracy and education*. New York: The Free Press.

SECTION 4: THEORETICAL PERSPECTIVES TO DESCRIBE, ANALYZE AND INTERPRET THE SEMIOTIC ASPECTS OF STUDENTS' MATHEMATICAL ACTIVITIES

A common aspect of the four papers of this theme is the fact that their structure consists in the presentation of a *new* or *adapted* theoretical tool (or perspective), followed by some examples that are chosen to illustrate (and, possibly, discuss) the use and the potential of the proposed tool (or perspective). A *common*, problematic situation in mathematics education is particularly relevant in the *specific case* of these papers: the plurality of theoretical references (from different disciplines: linguistics, epistemology, psychology, sociology…) brings a proliferation of theoretical tools. Two legitimate questions are related to the previous remark: what educational need/problem should the theoretical tools (or perspectives) satisfy? And what effective educational implications do they have?

Boero and Morselli present a **comprehensive** tool derived from Habermas' construct of "rational behaviour" to describe and analyse student use of algebraic language. By integrating Blumer's "Symbolic interactionism" and Latour's "Actor -network - theory", Fetzer offers a perspective to analyse classroom interaction and discuss related interpretations. Font et al. present "Objectual metaphors", a particular kind of

(Lakoff & Nunez) “Grounding metaphor”, as a tool to analyze and discuss how the classroom discourse helps to develop students’ comprehension of the non ostensive mathematical objects. Morgan and Alshwaikh argue that a multi-semiotic environment not only affords rich potential for developing mathematical concepts, but may also affect more fundamentally the goals of student activity.

The discussion of the group of papers demonstrated openness to alternative theoretical perspectives. Not only may we consider what we can learn from others but attending to different perspectives serves to sharpen our understanding of our own theories. However, there are problems with the proliferation of theories that need to be managed, showing how various perspectives may be useful while being alert to the possibilities and constraints of combining or ‘merging’ theories. There is also felt to be a need to maintain links with the original sources of theoretical perspectives.

Theoretical ideas also have implications with respect to practice. They can provide language to help researchers see new aspects of practice. Moreover, through being introduced to theoretical ideas, teachers could develop awareness of complexities of the classroom

SECTION 5: ‘EVERYDAY’ AND MATHEMATICAL LANGUAGE AND LEARNING

All four papers of this theme group are in various ways occupied with links between everyday and mathematical concepts. Analysing classroom data the authors identify attempts to create such links. The discussion of the development of scientific concepts in children can be traced back to Vygotsky who describes this as a cooperative process between an adult and the child. Kyriakides discusses diagrams as a mediating tool in learning about fraction multiplication and points to an episode where the introduction of everyday language, instead of trying to remember an algorithm, proved to be an effective link to the scientific concept. On the other hand, Schütte describes an episode having to do with adding fractions, where the scientific concept *least common multiple* is lying behind. The teacher mainly uses everyday language, and the link to the scientific concept and her assisting function in the pupils’ development of mathematical language seem to be lost. In the paper by Vogel and Huth, the focus is on a combinatorial problem where two first graders, assisted by an adult, gradually start to use technical terms and the practical context become less and less important. Rønning studies a situation where the pupils are measuring milk, and where both teacher and pupils are moving back and forth between an everyday situation and a school situation. The two situations involve different semiotic representations and also different goals and actions, which can be seen to create a certain tension.

The following topics for discussion were identified.

- The function of everyday language in learning mathematics
- The function of diagrams in learning mathematics

– The teacher as a model for learning technical (scientific) language.