Does it Matter what They Say in Mathematics
A study of different communication abilities in the mathematical classroom

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Background
Considering the Swedish students’ lack of success in mathematics, the learning situation in Swedish mathematical classrooms needs further research from different points of view. Swedish students’ average mathematics knowledge has decreased, also from an international perspective. The Swedish curriculum raises demands of individualization, but it has not involved individualization according to the students’ needs. Instead, most of the time students are left to work by themselves with their textbook training skills by personal ability (Johansson, 2006; Skolverket, 2008, 2009; SOU 2004:97). Most of the teachers have abdicated and have given a free hand to a speed individualized teaching, too closely bound by the textbook (Madsén, 2002; Löwing, 2004). The teacher’s main role in the classroom discourse is to help students individually, when they are asking for help. The situation in Swedish mathematical education is disquieting, and there is a need for further research to identify the parts of interaction in the classroom that seem to promote learning, such as teachers’ practices supporting classroom conversations in different learning situations.

In the PISA 2003 framework the students’ enjoyment of and interest in mathematics, instrumental motivation, anxiety and self-concept in mathematics, correlate to students’ performances in mathematics, and that students’ self-confidence in mathematics defines their beliefs about their mathematical competences (OECD, 2004). Boaler (2002) employed a situated lens in a study with focus on classroom practices and the relationship between students’ knowledge production and the characteristics of their learning and teaching environments. The studies were aiming at understanding in what way different approaches have shaped students´ knowledge of mathematics and the relationship between teaching and learning, between knowledge and practice, and between learning and believing. One of the findings was that students learn not less - but different - mathematics, in different learning and teaching environments. The students’ transfer of knowledge is not in the students’ minds, but in the mathematical practice in which they are engaged (Boaler, 2002). A study of Samuelsson (2008) of the situation in the Swedish mathematical classroom indicates the importance of the teacher’s use of strategies to create a supporting climate, which can contribute to a positive attitude towards mathematics. He argues that a variation in teaching methods is important because different choice of classroom settings and working methods draw attention to different competences in mathematics. Löwing (2004) emphasizes that the most important questions for the Swedish teachers in her research study are how to teach with an emphasis on the working methods. She has found that the teachers not had chosen their methods related to the goals of the lesson, about what was meant to be treated or how the educational frames would enable communication.

The Professional standards for teaching mathematic (NCM 1991) presented six standards for teaching: worthwhile mathematical tasks, the student’s and teacher’s role in the discourse, tools for enhancing discourse, the learning environment and analyses of teaching and learning. This study starts from the perspective that communication about mathematics plays a central role for learning, and aim at illuminating teachers’ role in forming a discourse promoting learning environment. The overall aim of the study is to investigate mathematics teachers’ endorsed and enacted principles regarding mathematical communication in the
classroom to identify teachers’ discursive routines to promote learning in mathematics and the students’ ability to develop different competences in mathematics.

Theoretical Perspectives

A Commognitive Approach to the Study of Learning

This study takes its starting point from the Commognitive Framework (Sfard 2008), with its basic tenets in Vygotsky’s theory of the idea that higher mental functions appear first at a social level and later are individualized (Vygotsky 1986). The Commognitive perspective on learning is rooted in the participationist assumption that all uniquely human skills are products of individualization of historically established collective activities (Sfard & Ben-Zvi, 2007). The word commognitive will remind us of the unity of cognitive processes and communication, that human thinking develops through individualization of interpersonal communication. Communication is defined as a collectively performed patterned activity that involves a repertoire of permissible actions and re-actions between the members (Sfard, 2007). Thinking, verbal or not, is defined as individualization of interpersonal communication.

Learning mathematics is tantamount to modifying and extending one’s discourse in mathematics through communication, written or verbal (Sfard, 2007). The discourse in mathematics is recognized by its routines, use of words, visual mediators and narratives of mathematical objects (Sfard, 2008). It has its repertoire of admissible actions and ways of re-actions. The discourse can also be found in a meta-level when expanded with new words and routines (Sfard 2008). From this perspective school type learning is accordingly defined as an activity in which the students have to modify and extend their discursive repertoire. The students in the classroom who engage in the mathematical discourse have the main goal to become more aware of the objects of the discourse. The explorations and explanations are often done with help of well defined meta-rules, specific for the discourse. Object-level learning occurs when the students are reasonably familiar with the objects and meta-rules of the given discourse. Meta-level learning can only happen in a process of individualization. First there is a discourse for others, but gradually if the process of individualization proceeds properly, the student increasingly rationalizes the new discourse. If the discourse for others turns to a discourse for oneself, the student is able to use it in a discourse of her own thinking and becomes capable of using it independently in object-level learning.

According to this commognitive perspective, the purpose is to study the learning processes in the classroom, and the unit of analysis should be the mathematical discourse, the process in which the individual students participate. Learning is considered as "peripheral participation in a community of practice" (Lave & Wenger, 1991), and to learn mathematics is to become a member in a community of mathematicians (Sfard, 1996).

Knowledge in Mathematics as a Process

In this study knowledge in mathematics is seen as the students’ ability to improve different competences in the learning environments. The research has focus on the teachers’ choice of working methods and design in the classroom related to their goals with the lessons and the students’ capability of improvements. A focal point is to identify the content of different competences in mathematics situation.

The Mathematical Competency Research Framework (MCRF) is used to analyze the data from empirical studies in the classroom (Lithner, 2010). MCRF is inspired by international
mathematics framework (NCTM, 2000; Kilpatrick et al., 2001; Niss and Jensen, 2002) but constructed as a tool for analyzing empirical data with focus on mathematical competences. MCRF is considered as a suitable tool for analyzing the empirical data from different discourse situations in the mathematical classroom, both when the students are working individually with skills and asking the teacher for help and when the students are working together in small groups. The six used competences are: communication ability, applying procedures, problem solving ability, applying representations and connection ability. The different competences can be separated from each other, but they are not independent in relation to each other.

In this study the competences are used in the same way as in MCRF but the communication competence is seen as an all-embracing umbrella, central for the ability to learn mathematics (fig.1) Competence related activity (CRA) has an analytical and a productive aspect. The analytical aspect of the activity has two parts; understanding and interpreting phenomena and processes, and a meta-level consideration such as assessing and judging them (Lithner et al., 2010).

Fig. 1 Used Mathematical competences.

The competence related activities form subcategories to the six competences in the framework to handle the complex concepts related to the classroom activities. Subcategories:

- Understand - take in information related to the competence.
- Do and use – Use one’s knowledge in order to solve tasks in a broad sense. A distinction is made between imitating and constructing
- Judge – evaluate and reflect opinions and conclusions on mathematics and on the activities related to learning, understanding, doing and using mathematics, also on meta-levels. (Lithner et al., 2008)

In this study teachers’ way to communicate mathematics and the students’ opportunities to communicate and develop different competences in mathematics are elucidated and compared in three different types of activities: when the teachers are discussing mathematics or lead a task solving session in a large group, when the students are working with tasks individually or in pairs and when the teachers are guiding the students when they are working together in groups.

Aim, research questions and methods in the different parts of the study

The overall aim of the study is to investigate mathematics teachers’ endorsed and enacted principles regarding mathematical communication in the classroom to identify teachers’ discursive routines to promote and encourage learning in mathematics, and the students’ability to develop different competences in mathematics.

Part I: Interviews of mathematics teachers
Aim: The aim in this part of the study is to investigate teachers' endorsed principles regarding mathematical communication in the classroom to identify teachers’ discursive routines to promote learning in mathematics.

Research questions:
- What narratives do the teachers endorse about the role of the discourse in learning mathematics?
- What narrative do the teachers endorse about ways to foster the students’ mathematical communication in different learning situations?
- What is the expected impact of these students’ learning of mathematics?

Research method:
Semi-structured interview of 18 mathematics teachers in Swedish upper secondary school (60-90 minutes). The audio taped interviews have the nature of a conversation that catch and established the teachers’ reflections of their practice.

Analysis method:
The first step in the analysis is a literal transcription of all sequences when teachers describe their discursive strategies and methods in order to promote and encourage the students’ ability to participate in the classroom discourse. In the next step the data are categorized linked to the teachers’ endorsed narratives of the students’ ability to improve different competences in mathematics in the described learning environments.

Part II: Video- and audio recorded observations of the classroom discourse

Aim: The purpose is to identify and compare the teachers’ enacted principles and different strategies supporting the students’ classroom conversations about mathematics in different situations: in the communication with the whole class, in the communication between the teacher and the students when they are working by their own or together with others.

Research method:
Video- and audio- taped observations in two different classes in the different learning situations.

Analysis method:
In a first step snippets will be chosen from the recorded data: The intention is to be able to compare the participators’ discourse about mathematical objects in the various chosen frames like group work, individual work or working together in the whole class. The data is categorized according to the students’ enacted ability to improve different competences in mathematics in the learning environments. A commognitive method is used in the analysis of the students’ learning, which requires identifying the use of words, mediators, routines and endorsed narratives in the discourses.

Research questions:
What do the teachers actually do to foster students' mathematical communication in different learning situations?
What effect does it have on the students' discourse and learning of mathematics?
Are the teachers’ ways to communicate mathematics with the students’ dissimilar in different learning situations?

References


