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Students' expressions about working successfully with mathematics textbooks

– multimodality and sociomathematical norms in early years

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This paper reports on an ongoing study about students' expressions about mathematics and what is considered successful when working with mathematics textbooks. 18 Year 1 students (7–8 years) working with mathematics textbooks were analysed according to how they used different communication resources, or modes, and sociomathematical norms. The results showed sociomathematical norms about (1) aids that are supportive for solving the exercises in the textbooks, (2) clues that are given in the task design and (3) aspects considered successful by the students. It is stated that there is a tension between using aids and being considered successful in mathematics, which could affect students' possibilities for mathematical learning.

Keywords: Early years, mathematics textbooks, multimodality, sociomathematical norms.

Introduction

Mathematics is for everyone. Therefore, mathematics teaching should be designed so that students' different ways of expressing mathematics are utilized. Mathematics is multimodal (O'Halloran, 2005), which means that different resources for communications, or modes (Kress, 2010), is essential in doing and expressing mathematics. All students' mathematics learning is supported by focusing on the multimodal nature of mathematics and the possibility of expressing mathematics in many ways, with different modes such as images, gestures, speech, and writing. However, if one communication resource, mathematical symbols, already in year 1 has a unique position (Norberg, 2020), students, if possible, choose to avoid other forms of modes, mathematics teaching risks suiting only the students who are already confident with the mathematical symbols.

Students' possibilities to express mathematics in mathematics teaching are affected by the norms in the classroom, what is considered accepted and what is considered desirable. Mathematics textbooks are common learning tools used by more than 75% of students in compulsory schools worldwide (Mullis et al., 2012). The use of textbooks means activities with mutual participation between textbooks and students (Rezat & Sträßer, 2012). In a theory-oriented paper using a socio-didactical tetrahedron Rezat and Sträßer (2012) stated that social and sociomathematical norms are considered essential in students work with mathematics textbooks. Students use textbooks differently (see, for instance, Norberg, 2020; Rezat, 2013). Ewing (2006) stated that students who find working with mathematics textbooks hard are “blamed for their inability to learn” (p. 14). Also, students' individual work with mathematics textbooks is an unexplored research field (e.g., Österholm & Bergqvist, 2013) Therefore, studying sociomathematical norms, normative aspects specific to mathematical activities when students work with mathematics textbooks can create essential knowledge about mathematical

learning. Multimodality entails an approach in which all communication resources are utilized, which further strengthens the study's relevance.

This paper presents preliminary results from an ongoing study built on a reanalysis of data from my PhD project (Norberg, 2020) about students' meaning making when working with mathematics textbooks in Year 1 (7–8 years). The study builds further on students' expressions on what is considered successful or not when working with mathematics textbooks. The study is also a pre-study for a proposed research project. The paper aims to deepen the understanding of students' meaning making when working with mathematics textbooks regarding sociomathematical norms and the use of different modes, clarified by following research questions: *What modes are used in the students' meaning making?* And *What sociomathematical norms related to the use of different modes are conveyed by the students?* I will share my findings so far, and I hope this will be a starting point for discussions that can increase my knowledge of sociomathematical norms linked to students' work with mathematics textbooks. In the long run, a study in this area could provide essential knowledge about what shapes conditions for young students' mathematical learning.

Background

The study reported in this paper derives from the research field of mathematics education and students' experience of working with mathematics textbooks emphasising two different areas, mathematics as a multimodal subject and sociomathematical norms. Besides that, there is also a particular focus on younger students' experiences.

In an introduction of the papers presented in TWG22 at CERME10 and CERME11 (Pepin et al., 2019), the authors stated that one of the directions for future research discussed was to understand better what impact tasks have on students. That is focused on in this paper. Knowing what sociomathematical norms exist when students work with their textbook's better conditions for students' mathematical learning can be created. Another possible direction for further research discussed was to include students, and their learning experiences when designing tasks. The results from this study could contribute to such knowledge.

The subject of mathematics has a long history of using several different modes to create mathematical representations. O'Halloran (2005) describes mathematics as multisemiotic and argues that the strength of the subject of mathematics lies in the fact that the different modes together give more information than the sum of what each mode can contribute. Yackel and Cobb (1996) found in a visit to a classroom for year 2 (7–8 years) that it was central that the students discovered that mathematics could be expressed in different ways. Although mathematics is a multimodal subject, a former study showed that mathematical symbols have a special position and that it is the desirable mode to use to represent mathematics (Norberg, 2020). A conclusion drawn was that striving not to use the images can lead to the students' meaning making not being directed towards the mathematics content that the exercise is designed to offer (Norberg, 2020). This motivates the multimodal approach used in the study reported in this paper.

Sociomathematical norms are related to students' work with mathematics and concern what counts as mathematically sophisticated, accepted, different, efficient, and not (Yackel & Cobb, 1996). Many students find mathematics difficult and have poor self-confidence regarding their mathematical

knowledge, also at earlier stages (Larkin & Jorgensen, 2016). This relates to sociomathematical norms (Yackel & Cobb, 1996) which form conditions for both students and teachers and regulate students' learning. This is supported by Rezat and Sträßer (2012) who concluded that students and teachers act accordingly to their norms in mathematics teaching. In a study of year 1 students (6–7 years) and teachers with data from videotaped lessons during a school year, Perry et al. (2011) concluded that students at this early stage can be engaged successfully in learning mathematics and that teachers play a big part in this. Students are thereby socialized into mathematics teaching culture. Wester et al. (2015) found differences between the students' and the teacher's views of norms and the students participating (14–15 years) expressed that manipulatives should be used when you need to learn something new but that it is better not to use manipulatives for your calculation. All in all, research on students working with textbooks is sparse, sociomathematical norms are important for students meaning making, and a multimodal approach provides a tool for studying all modes used in the communication between student and textbook.

Theoretical approaches

Sociomathematical norms are defined as “normative aspects of mathematical discussions that are specific to students' mathematical activity” (Yackel & Cobb, 1996, p. 458) and derive from a constructive perspective, like multimodal social semiotics. Sociomathematical norms differs from social norms which are general norms about being a student. *Multimodal social semiotics* (see, e.g., Kress, 2010) assumes that all communication is made through various communication resources, or modes. Yackel and Cobb (1996) distinguish between sociomathematical norms that are considered mathematically sophisticated and those considered accepted. The perspective provides tools that can be used both to support researchers to make rational descriptions of mathematical representations, and help structure interpretations of representative functions (Morgan, 2006). Sociomathematical norms contribute with tools to detect which norms are constructed in the classroom. Multimodal social semiotics enables the possibility to analyse all communication in the classrooms, in all modes used.

Central to the project is the student's *meaning making* activities. Students' working with mathematics textbooks is understood as meaning making and focuses on meaning making as a multimodal activity (Kress, 2010). Meaning making is defined as an activity where the individual tries to understand the world around her and happens continuously, everywhere (Kress, 2010). Meaning making takes place in a social, cultural, and historical context and describes the individual's focus. *Multimodality* refers to the perspective's assumption that all communication occurs in different resources for communication, *modes* (Kress, 2010), such as images, gestures, speech, and writing. In multimodality, meaning is attributed to all modes. All modes carry different potentials for meaning making (Jewitt et al., 2016; Kress, 2010), which means that you cannot give the exact same information in, for instance, writing mode and image mode. *Modes* are culturally and socially shaped resources for meaning making and are used in communication and representation (Kress, 2010).

Methodology

Different data types were collected: textbook pages, video transcripts of students working individually with these pages, and the students' solutions to the exercises. Video transcripts and

representations from 18 Year 1 (ages 7–8) students were collected. The school is located in a medium-large city in the centre of Sweden and chosen from a convenience sample. All students in the class whose caregivers had both completed the consent form participated in the study. Before the data collection, I spent a week with the class to get to know the students so that the video recordings would not feel uncomfortable to them. Here, my former work as a compulsory-school teacher was valuable. The aim was to study the students’ work in an as realistic situation as possible. Of course, the most natural situation would have been studying the students in the classroom during mathematics lessons; but, since much of the work with the mathematics textbook consists of working alone in silence, that approach would not yield much insight into the students’ meaning making. Therefore, I studied the meaning making of one student at a time in a room adjacent to the classroom, which made it possible to ask questions to the students during and especially directly after their work.

The video material consists of 450 minutes of film – approximately 25 minutes per student with a tablet in May 2017. The student and I sat at a table, with the tablet placed obliquely above us. In order to influence as little as possible, the student started working on the exercise by herself (or himself). Then, I asked questions to understand how the student was making meaning from the exercise, such as, “Can you tell me how you did this?”, or “I saw that you did something with this image here, can you tell me about that?”.

The textbook series used in this study is widely used in Sweden: *Favorit matematik* (Favourite Mathematics) (Ristola et al., 2012a, 2012b). The pages were chosen based on the results of a quantitative study (Norberg, 2021) using the following criteria: the exercises had to address subtraction as an arithmetic operation, be commonly used in the textbooks, and show breadth based on the different modes were used. The pages were copied in colour and given one at a time. Examples are shown below, with the publisher’s permission (see Figures 1–2). *Exercise* is defined as tasks of the same kind. For example, three exercises are pictured in Figure 1.

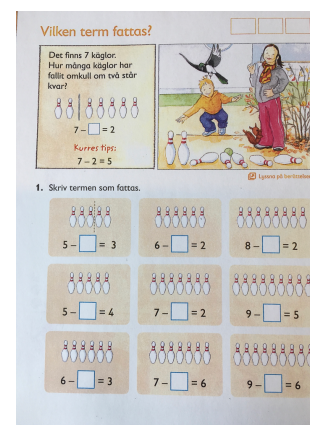
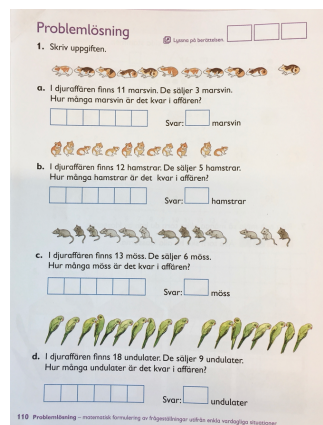
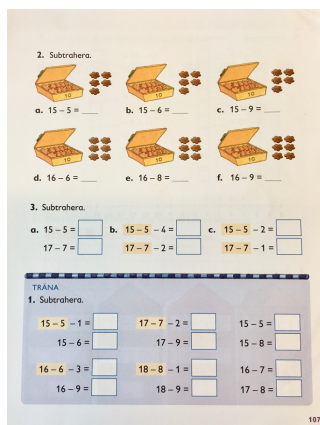


Figure 1: Exercise 1, Ristola et al. (2012b). p. 107. Illustrator: Rajamäki, M.

Figure 2: Exercise 2, Ristola et al. (2012b). p. 110. Illustrator: Rajamäki, M.

Figure 3: Exercise 3, Ristola et al. (2012a). p. 150. Illustrator: Rajamäki, M.

Framework for Analysis

The analysis stems from the research questions and, the categories developed inductively. Due to the multimodal approach, the video transcripts were first transcribed under three separate columns following different modes: speech, images, and body language. This answers to the first research question. In the image column, the students' use of images was documented and instances of a student drawing a picture to support her calculation. The body language column communication made with the body was documented, such as pointing, using finger-counting, shaking the head, e.g. The textbook pages and the students' solutions to the exercises were used as support for the analysis, for instance, for discovering which task the student focused on or how she/he represented the answer on the paper. In the next step, I was looking for expressions for how the student used the mathematics textbook, both things emphasised as good working methods (considered mathematically sophisticated, Yackel & Cobb, 1996) and those emphasised as less good (considered acceptable, Yackel & Cobb, 1996). This was understood as sociomathematical norms regarding the use of the mathematics book. After that, the transcripts were coded by reading through the material several times and highlighted using a colour code. Then condensed meanings were summarised in a matrix, from which various categories emerged. This answers to the second research question.

Preliminary results

Students expressed norms about *Aids supporting the calculation*, *Clues in the task designs supporting the calculation* and *What is considered as successful when working with mathematics textbooks* when working with the textbooks. The multimodal assumption is noticeable in the results as communication in all modes (for instance, images, gestures, mathematical symbols) are made visible.

Aids supporting the calculation

The norms that emerged in terms of aids supporting the calculation was:

(1) use *finger-counting*, which showed in two different ways in the data. One way was to hide the fingers under the table, which indicate that the student should preferably not use the fingers. However, another way was to do the finger calculation above the table, in front of us, indicating that other students did not have the understanding that finger-counting should be made without showing. This could indicate that there might be different norms according to different students in the classroom, this must be studied further.

(2) *draw an image*, which was used for support even though there were images in the exercises.

The student draws an image in order to support her calculation (Figure 1).

Me: Is it possible to use the images in the exercise to do the calculations?

Student: Yes, I think so, but I didn't see how to.

(3) *ask the teacher or a friend*, some students suggested one of these options, and some suggested both options connected to how to work with the mathematics textbook. This could refer to social norms instead of sociomathematical norms and needs to be studied more deeply to know whether this norm is connected to mathematics teaching or teaching in general. There can be differences between subjects when it comes to asking for support.

(4) to use a *number line*, which refers to a number line that the students place before them during mathematics teaching.

Clues in the task designs supporting the calculation

Norms about clues in the task-design that hold information about how to solve the tasks was expressed in the data. The students expressed clues from:

(1) *to read the instruction and/or guide boxes*, one expression was that you only read as far as you need to understand.

“I read to here (points at the middle of the sentence instruction the exercise), and then I understood what to do.”

This category could also refer to social norms and needs to be studied more to know whether this is connected to mathematics teaching or teaching in general, due to differences between subjects.

(2) the number of empty pre-drawn boxes indicate how long the answer should be

The student solves the task with the guinea pigs (Figure 2) but frowns when he realises that one of the boxes in the answer remains empty. He then erases what he had written.

Me: Why did you erase? Do you think it was wrong?

Student: No but, it shouldn't be like that. It shouldn't be empty boxes... (He thinks for a while). Ahh, one number in *each* box, *now* I know.

So, when he wrote “11” not in one box but in two separate boxes, the written calculation used all the boxes, and the student was satisfied.

(3) *dashed numbers* indicate that they should be filled in.

(4) *not all tasks in an exercise can have the same answer*

A student is figuring out the answer of a task in an exercise (Figure 3). The first answers were the same, and the student says: It cannot always be two so I think it is eight this time.

(5) *tasks at the beginning of an exercise are easier than the rest*. Students expressed that the first tasks are easier to solve and that it gets harder further down in the exercise.

What is considered successful when working with mathematics textbooks

The data also reveals norms for how a successful student working with the mathematics textbook acts, norms considered mathematically sophisticated, which are:

(1) *Solving all tasks on the page without skipping some of them*. This was expressed when some of the students questioned when I told them to solve some of the tasks and not the whole page.

(2) *Quickly understand how to solve the exercises*. It was expressed as good if the student understood what to do with the exercise immediately, perhaps without reading the instructions. So, working fast is something that is considered successful.

(3) *Solving the tasks with mental calculation* is something that is expressed as good. This is often followed by answering in mathematical symbols on an empty line.

(4) *Not using the images*. Students expressed that it is desirable to solve the tasks without using the images for support.

Me: Can you use the image to do the calculation?

Student: Yes, but you don't need that if you are good at math.

This approach was also shown in action when some students used the image to solve the exercise. When they worked with the exercise, I saw them using the images, but when I asked how they went along with the exercise, they did not mention the image. First, when they were specifically asked if they used the image, the students said they did.

Concluding remarks

The results showed norms about aids and clues in the task designs that support students' calculation, and norms about what is considered successful when working with mathematics textbooks. The aids mentioned were finger-counting, drawing an image, to ask a friend or the teacher or to use a number line. These are all considered resources and modes supporting the calculation. The clues given in the task design were to read the instruction and/or guide boxes, that the number of empty pre-drawn boxes indicate how long the answer should be, dashed numbers, that not all tasks in an exercise can have the same answer and that tasks at the beginning of an exercise are more accessible than the rest. Things considered as successful when working with mathematics textbooks were to solve all tasks on the page without skipping some of them, quickly understand how to solve the exercises, solve the tasks with mental calculation and not to use the images. This approach was considered mathematically sophisticated (Yackel & Cobb, 1996) by the students.

In further research, it would be interesting to study sociomathematical norms linked to digital textbooks. Partly because there is potential for more modes to be used and partly because students can interact with the textbook. Also, it is sometimes possible to manipulate the tasks during the work with the digital textbook and get feedback during or after the work. More knowledge about this could provide essential knowledge supportive for students' learning in mathematics.

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