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► **To cite this version:**

Cecilia Segerby. Writing in mathematics lessons in Sweden. CERME 9 - Ninth Congress of the European Society for Research in Mathematics Education, Charles University in Prague, Faculty of Education; ERME, Feb 2015, Prague, Czech Republic. pp.1490-1496. hal-01287787

HAL Id: hal-01287787

<https://hal.science/hal-01287787>

Submitted on 14 Mar 2016

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Writing in mathematics lessons in Sweden

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Previous research has shown benefits for both the students and the teachers in letting students write in different ways in mathematics. Consequently, communicating their understanding is emphasised in the current Swedish curriculum. In this paper, Swedish students' perceptions are examined of their writing during mathematics lessons and their assumptions about the purpose of keeping notes. The results come from a questionnaire answered by 136 randomly selected students in Years 3, 4 and 5 and show that writing is not extensively used during mathematics lessons with calculations being the dominant kind of writing. As well, half of the students considered their notes to be worthless.

Keywords: Mathematics education, primary school, communication, writing.

INTRODUCTION

Research has previously shown advantages from having students write more than numbers and symbols during mathematics lessons. This is because writing helps clarify and organize students' ideas, which then contributes to making sense of mathematics; in this way, students' thoughts become visible and provide opportunities for reflection (Freitag, 1997). In contrast to orally communicating ideas, writing allows students to develop a deeper understanding of concepts (Johanning, 2000). Consequently, writing contributes to documenting students' knowledge and experiences to others. Writing can also be an effective communicative tool as both students and teachers become aware of the student's understanding, feelings and misconceptions about the content being learnt (Meaney, Trinick, & Fairhall, 2012).

There has been some research which has documented the kind of notes the students write during their mathematics education. Britton, Burgess, Martin, McLeod and Rosen (1975) examined the writing in mathematics of students between the ages of 11 to

18 years and found three categories: transactional, expressive and poetic. Transactional writing focuses on the final product as its purpose is to inform, advise, persuade and/or instruct. These authors found this to be the most common writing. Expressive writing is more personal and has been called "thinking aloud on paper", like a diary. Less than ten percent of the writing collected in Britton and colleagues (1975) research was of this kind. The last category, poetic writing, encourages imagination such as constructing your own exercises, drama and poetry and was about twenty percent of the collected writing.

Meaney, Trinick, & Fairhall (2012) examined the writing in mathematics lessons of students in Years 1 to 11. They divided what Britton and colleagues (1975) categorised as transactional writing into three different genres: description, explanation and justification. Descriptions were of mathematical situations or objects, such as definitions. Explanations showed how mathematical phenomena and events came to be, often through a series of steps showing the working out of a problem. Justifications involved providing information about why something is done and included reflections. In their study, Meaney and colleagues found that calculations were the students' privileged of writing.

The current Swedish curriculum (Skolverket, 2011) emphasises developing students' communication skills in mathematics to support their understanding. However, there is limited research on the kinds of students' notes used in mathematics lessons and it cannot be found previous research in Sweden on students' opinion about their writing in mathematics.

The aim of this paper is to examine students' perceptions of the writing they do in Year 3 (when they are about nine years old), 4 (when they are about ten years old) and 5 (when they are about eleven years old) during their mathematical lessons. The research questions for the study reported in this paper are:

- What kinds of writing do Year 3, 4 and 5 students perceive that they write down during their mathematics lessons?
- What do these students consider to be the functions of that writing?

A questionnaire study was conducted with 136 students. The result of this study will be the baseline for an intervention study. Before discussing the methodology, next section discusses research connected to writing in mathematics education.

WRITING IN MATHEMATICS IN YEARS 3, 4 AND 5

Writing in mathematics is often considered as useful for developing students' vocabulary knowledge. For example, Lundberg and Sterner (2006) stress the fact that students should have possibilities to build up a dictionary in mathematics. These authors considered some vocabulary to be difficult to comprehend as there are terms (concepts and words) that only can be found in mathematics. Some words, such as *odd*, can have a different mathematical meaning to their meaning in natural language (Lee, 2006). Having different meanings for the same word can be confusing for students. This may be the case in Year 4 in Sweden as it is at this point that mathematical textbooks are considered to become more challenging with many new concepts and the quantity and complexity of the text increasing, thus putting higher demands on students' reading skills (Myndigheten för skolutveckling, 2008).

The importance of understanding the vocabulary in mathematics is also shown in Vilenius-Touhima, Aunola and Nurmi's (2008) study with students in Year 4 and in Möllehed's (2001) study in Years 4 to 9 where a relationship appeared between students' mathematics problem solving performance and understanding the mathematical vocabulary in the exercises. Yet, according to Misono and Takeda's (2012) study in a fifth-grade class in Japan many of the students did not use mathematical terms and they found it difficult to write descriptions about mathematical operations. As a consequence these authors suggested that teachers need to train the students to describe each step using mathematical terms and not only let the students write down why they were able to get the correct answer by only using numbers.

In Sweden, Ebbelind and Segerby (2015) and Segerby (2014) found that few of the exercises in the textbook require the students to describe, explain and evaluate their understanding, so there are limited opportunities to develop this skill in the textbook. This is problematic since working in the textbook is the dominant practice in mathematics in Sweden (Johansson, 2006; Myndigheten för skolutveckling, 2008).

It has also been suggested that teachers should provide students with instructions about how to structure mathematical arguments, such as justifications and explanations, and to construct narratives, which support mathematical thinking (Meaney et al., 2012). In the research by Hensberry and Jacobbe (2012) with seven students, aged between 5 and 11, a problem solving model was used to structure students' writing, which led to improvements in problem solving achievement.

Another positive aspect of keeping notes in mathematics was found in Johannings' (2000) research about problem solving in groups. It indicated that writing helped students to find their mistakes and understand, remember and solve the problem better, when they first wrote in isolation before they met and discussed the problem in groups. However, this study was conducted among Years 7 and 8 students and it is not clear how relevant the results are for younger students.

There are several benefits of letting students write different kinds of texts in mathematics, but it is also essential that teachers explain the aim for the writing and for whom they write so they understand the purpose of doing that (Meaney et al., 2012; Morgan, 1998). In next section, the method for the reported study is described.

METHOD

To examine students' perceptions of their writing in mathematics, a quantitative study was conducted with 300 randomly selected students from Years 3, 4 and 5 (100 in each Year) throughout Sweden during spring 2012. A total of 136 students responded; 50 students from Year 3, 40 students from Year 4 and 46 from Year 5. When randomly selected samples are used, every unit in the target population has the same possibility to participate and it is reasonable to generalize the result. In this study, the selection of the students was

Britton et al.'s categories	Questions in the questionnaire
Transactional involving informing, such as calculations	1a, 1b, 1c, 1e, 1g, 3a, 3b, 3c, 3e, 3f, 4a, 4b, 4c, 4e
Expressive, such as evaluation	1d, 1f, 3d and 3e, 4d
Poetics, such as original mathematical exercises (stories)	2

Table 1: Categories connected to the questions in the questionnaire

done by the Swedish Tax Agency, who has information on all Swedish residents. By using this approach 136 different classroom contexts from across Sweden could be examined to reveal the context of culture involving writing in mathematics. Context of culture refers to what occurs outside language, such as the events and conditions of the world (Halliday & Matthiessen, 2004). For example, context of culture can involve how the mathematic education is designed in Sweden such as the reliance on the textbook and how that affects the teacher's and the student's roles.

As mentioned earlier, it is considered that mathematics becomes more difficult in Year 4 with texts becoming longer and many new concepts being introduced (Myndigheten för skolverket, 2008). This is why it was decided to investigate the writing in Years 3, 4 and 5 to see if there were differences in the writing.

Pre-testing the questions in the questionnaire is crucial to its success. Therefore, a pilot study was conducted involving 15 students in Year 3 to examine how the youngest students were likely to reply to the questions. The students answered the questionnaire individually before talking in groups of three or four students. This led to that question four was reformulated from "How does your understanding in mathematics being accessed?" to "How does your mathematics teacher find out about your understanding in mathematics?" With other questions, the numbers of alternative responses were expanded.

The questionnaire contains four questions and all of them, except for question 2, contain closed-response answers where the students could choose one or more alternatives. In question 2 the students could only choose one alternative since it involves students making decision of how often they write down mathematical exercises (stories) of their own. The alternatives in the questions contain limited amounts of texts in respect to the youngest students' reading ability in this study.

Questions 1 and 2 of the questionnaire examine the first research question concerning what the students perceive that they write down during their mathematics lessons, while questions 3 and 4 examine the second research question involving what the students consider to be the functions of keeping these notes in mathematics.

In order to answer the research questions the categories by Britton and colleagues (1975), *transactional, expressive and poetic*, are used to structure the questions in the questionnaire to visualize the students' different kinds of writing (see Table 1).

However, what differs between previous studies (Britton et al., 1975; Meaney et al., 2012) and this study is that it does not examine examples of students' texts. Instead it focuses on students' opinions and feelings about what they write down during mathematics lessons and what the purpose of keeping those notes are. This approach has previously not been used in Swedish mathematics education research.

In the next section each of the questions responses are presented and discussed.

RESULTS AND ANALYSIS

Question 1: "What do you write down during mathematics lessons?"

The results are presented in Table 2 and in the text that follows they are interpreted regarding the categories of transactional and expressive writing.

Transactional writing: The most common kind of writing, which the students perceived that they did, was writing calculations. This is a similar result to that of Britton and colleagues (1975) which was conducted 40 years ago in USA and suggests that writing in mathematics may have not developed much since then, at least from the perspective of how students refer to it.

What do you write down during mathematics lessons?	Year 3	Year 4	Year 5	Total
a) My operations (calculation)	100%	100%	100%	100%
b) Knowledge goals for the different areas in mathematics	10%	5%	4%	7%
c) Mathematical words with explanations	22%	5%	26%	18%
d) Thoughts about what I think is easy and/or difficult in mathematics (evaluation)	10%	2%	2%	5%
e) How to solve mathematical problems	30%	18%	37%	29%
f) Thoughts as preparation for group exercises in mathematics, such as problem solving exercises	12%	4%	9%	9%
g) Results from practical exercises	12%	11%	11%	12%

Table 2: Summary of results from question 1

The second most common kind of writing was keeping notes on different strategies connected to problem solving. Although this kind of mathematical writing has been connected to improve problem solving (Hensberry & Jacobbe, 2012; Johanning, 2000), only 29 percent of the students considered that they had been involved in producing this kind of writing.

Less than 20 percent of students had written definitions of mathematical words. In Year 4, only 5 percent of the students considered that they had written definitions in their mathematics lessons. Given that previous research has suggested that this is important for students in making sense of what they are learning (Lee, 2006; Lundberg & Sterner, 2006), there is some concern that so few students recognise this as part of the writing that they do in mathematics. As a correlation has been found between Year 4 students' knowledge of mathematical vocabulary and the problem solving performance (Möllerhed, 2001; Vilenius-Touhima et al., 2008), this result suggests that an intervention study would be most beneficial for students in this Year level. The students, independently of the Year, considered that they rarely wrote about the knowledge goals that they were to achieve in different areas.

Expressive writing: Research has also shown benefits by letting the students write down thoughts as preparation for group exercises (Johanning, 2000), but very few students had done this in this study. Evaluation is another kind of expressive writing and as discussed in the part about the responses to question 4, evaluation in mathematics was said to be done by teachers. This would explain why students rarely wrote their own evaluations of their mathematics learning.

Question 2: "I create own exercises (stories) in mathematics"

This question is the only one in the questionnaire that examines the poetic writing. There is a summary of results in Table 3.

This table shows that in Year 3 approximately 70 percent of the students consider that they sometimes or often create exercises of their own but that number decreases to approximately 30 percent in both Years 4 and 5. The poetic writing seems to occur rather often in Year 3 but is barely used in Year 4 and 5. This kind of writing can contribute to reveal the students' understanding and misconceptions about the content being taught (Meaney et al., 2012) so this

I create exercises (stories) in mathematics by myself	Never	Rarely	Sometimes	Often
Year 3	8%	26%	56%	10%
Year 4	29%	42%	22%	7%
Year 5	33%	33%	27%	7%
Total	23%	33%	36%	8%

Table 3: Summary of results from question 2

What do you use your notes in mathematics for?	Year 3	Year 4	Year 5	Totally
a) To correct my calculations	28%	38%	24%	29%
b) To practice and look at before tests	8%	15%	28%	17%
c) To look up explanations for different mathematical words	4%	7%	4%	5%
d) To follow my development in mathematics	20%	13%	9%	14%
e) To communicate with the teacher	4%	0%	2%	2%
f) As a help when I solve different exercises	24%	30%	19%	24%
g) Nothing (for my learning in mathematics)	48%	40%	52%	47%

Table 4: Summary of results from question 3

kind of exercises seems to be relevant regardless the students’ age.

Question 3: “What do you use your notes in mathematics for?”

Table 4 shows the results in relation to the students’ responses to question 3 in the questionnaire. It is argued that the reported writing can be divided into transactional and expressive writing.

Transactional writing: The results show that approximately 30 percent of the students’ used their notes in mathematics to correct their calculations. Notes as a help to solve different exercises were used by approximately 25 percent of them. Less than 20 percent used notes as a preparation before tests. In question 4 (see Table 5) students considered that tests were the most common method that teachers used to determine their understanding. Therefore to find that very few students considered their notes as helpful to study for these tests suggest that students are not seeing writing in mathematics valuable for their learning. As well, very few students considered that they used their notes to communicate with the teacher. Given that it has been found that writing as a communication tool between the teacher and the students can contribute to exposing the students misconceptions, feelings and understanding (Meaney et al., 2012), and both the transactional and the

expressive writing are involved. This seems to be an area to focus on in an intervention study.

Expressive writing: It is also interesting to note that older students considered that they used their notes less for following their own development. This is related to responses to question 1 about determining whether what they were learning was difficult or easy. A higher percentage of students in Year 3 considered that they wrote about this in mathematics in comparison to students in Years 4 and 5.

Almost half of the students considered that their notes in mathematics lessons were not important for their understanding in mathematics. This suggests that the students are unclear about the aim of writing in mathematics. If students are unclear about the purpose of their writing, it may be that they do not perceive that they engage in different kinds of writing. The same might concern the use of explaining mathematical words. In question 1 approximately 20 percent considered that they wrote down explanation of mathematical words but according to the result of this question very few of the students used their notes as a dictionary. This might show that they know the words but it can also refer to students understanding of the usefulness in this kind of writing. Therefore it is essential that the aim for the writing is explicit

How does your mathematics teacher find out about your understanding in mathematics?	Year 3	Year 4	Year 5	Totally
a) Test and diagnoses	86%	90%	100%	90%
b) By the number of exercises I have done	28%	20%	17%	23%
c) Through the operations in my counting book/textbook	50%	38%	54%	48%
d) Through what I have written in my evaluation what I think is easy and difficult in mathematics	20%	18%	11%	16%
e) Other ways, such as homework	4%	5%	2%	4%

Table 5: Summary of results from question 4

articulated by the teacher (Meaney et al., 2012; Morgan, 1998).

Question 4: "How does your mathematics teacher find out about your understanding in mathematics?"

Transactional writing: The main sources for the teachers to evaluate the students' understandings are tests and diagnoses (90%). About 20% of the students also indicated that the teacher could work out how much they understood by counting the number of exercises they had done. Approximately 50% of students considered that the teachers looked at the calculations that they had done in their notebooks. The students' perceptions that the teachers focused on their calculations may contribute to them considering that writing mostly concerns doing calculations.

Expressive writing: Less than 20 percent of the students thought that their teachers used what they had written in their evaluations. This indicates that evaluation is not important for the students' development in mathematics. However, letting the students evaluate their learning visualize their thoughts (Freitag, 1997) and thereby provide opportunities to make the teacher aware of the students' understanding, misconceptions and feelings about the content being taught (Meaney et al., 2012).

CONCLUSION

According to the results of this study, it can be inferred that few classes in Years 3, 4 and 5 in Sweden use writing in mathematics extensively. Calculations are the dominant type of writing that appears, independently of the Year, and these notes are the main source for the teachers to evaluate understanding in mathematics.

However, in Year 3 it is more common for the students to use different kinds of writing connected to transactional, expressive and poetic functions, but that progressively decreases in Years 4 and 5. With older students the production and use of notes is less thought of as a way to follow their development in mathematics and to communicate with the teacher to expose misconceptions, feelings and understanding in mathematics. This is critical since Year 4 mathematics is considered to be more complex than in earlier Years and correlation between students' knowledge

of mathematical vocabulary and problem solving performance has been found.

Further research is suggested where different kinds of writing activities are implemented into a Year 4 class in mathematics to examine how these can contribute to developing communication skills and thereby support the students' mathematical understanding. The purpose for the writing then needs to be explicitly explained for the students so the notes can become valuable for them and not, as approximately half of the students in the reported study say to think, worthless for their understanding in mathematics.

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