Reading strategies in mathematics: a Swedish example

Cecilia Segerby
Malmö University, Sweden

Recent research shows that the dominant practice in mathematics education in Sweden involves students working individually from a textbook. However, to read mathematical texts involves comprehending the global meaning from the page and this requires specific reading skills. In this study, the reading strategies of six 10-year old students, with different levels of mathematical achievement, are identified. The analysis is based on Palinscar and Brown's reciprocal activities prediction, clarification and summarisation and Halliday's Systemic Functional Linguistics (SFL). In this small study, high achieving students more often described that they used appropriate reading strategies.

Keywords: mathematics textbooks, reading strategies, primary school

Introduction

In Sweden, mathematics students spend a large portion of their time working individually with textbooks, with little involvement from teachers except to answer questions about an exercise (Johansson, 2006). Consequently, the textbook influences how students learn and apply mathematical concepts (Bryant et al., 2008). However, mathematics textbooks are generally written in a short dense style with few contextual clues to help decode, for example, the meaning of specialised words (Adams, 2003). As multimodal texts, textbooks require students to synthesise complex meaning-making systems, through identifying the separate meanings and purposes of, for example, charts and written texts, and recognising how these separate purposes combine (Carter and Dean, 2006). Consequently, special reading skills are needed (Carter and Dean, 2006). However, not all students possess these skills and some struggle to gain anything from their textbooks except the location of the exercises (Weinberg and Wiesner, 2011).

To comprehend a mathematics textbook requires students to activate their prior-knowledge, comprehend vocabulary, symbols, and visual images and use strategies to monitor their reading (Carter and Dean, 2006). Identifying the main idea in a particular paragraph or section helps students to make connections between their prior-knowledge and the new information being learnt (Carter and Dean, 2006). As well, understanding the specialist mathematics vocabulary and the concepts behind them support making links to new knowledge (Lee, 2006). However, some mathematical words having different meanings in conversational language (Adams, 2003; Lee, 2006), such as odd and volume, and this may hinder rather than support appropriate connections being made.

Symbols, such as those for mathematical operations, can efficiently tell the learner what to do (Adams, 2003). However, Österholm's (2006) study with Year 12 and university students showed that students concentrated on the operative meaning and not on the semantic role of the symbols. By focussing on the numbers without connecting them to the textual meaning, many students were led to using the wrong mathematical operations.

Visual images are thought to make concepts easier to learn and more accessible. If students cannot make a connection between written text and visuals, they might fail to construct the intended meaning from the illustrations (Noonan, 1990). In textbooks, visual material or graphics can be categorised as decorative, related but non-essential, or essential. Decorative material makes the page more attractive, but serves no instructional purpose. Related, but non-essential, material repeats ideas already provided in words and can provide another entry point into understanding the textbook. Essential graphic material can be graphs and tables that is referred to, but not repeated in the text. This graphic material must be 'read' along with the rest of the text and cannot be ignored (Noonan, 1990).

Previous research on students' reading strategies in mathematics have mostly concentrated on investigating the result after implementing different reading strategies, such as Borasi et al.'s (1998) study. However, given that so many Swedish students are expected to work individually in their textbook, it is surprising to find that apart from Österholm's (2006) study there is no information about the reading strategies that they use in classrooms. As a result, the aim of this pilot study is to identify the reading strategies that Year 3 students use. The two research questions were: "What kind of reading strategies do Year 3 students use when they approach a page in a Year 4 mathematics textbook?" and "What kind of comprehension problems do students indicate that they have when reading this page?"

Systemic functional linguistics (SFL) is used as a methodological tool in combination with the reciprocal activities of prediction, clarification and summarisation (Palinscar and Brown, 1984) to view the students' different reading strategies. In an earlier study (Ebbelind and Segerby, 2014 forthcoming), SFL was used to identify the potential difficulties that students face when interpreting a textbook page. SFL provides information about how textbook context, classroom context and social context can have an impact on students' reading strategies. However, because SFL is used to analyse texts, it could not be used by itself to describe specific reading strategies. Consequently, Palinscar and Brown's (1984) reciprocal strategies are used to describe the strategies, but these are linked to SFL. In this way, a more complete understanding of the connection between the textbook page and how it is likely to be interpreted can be made.

Systemic Functional Linguistics (SFL)

Halliday described the relationship between people's linguistic interactions and the kinds of meaning that can be realised. Halliday argued that texts are developed through the context of situation which is surrounded by the context of culture (Halliday and Hasan, 1985). A situation is an instance of culture and culture lies behind the different types of situation that can occur (Halliday and Hasan, 1985). In this study, the context of culture is Swedish mathematics classrooms in which learning is expected to occur as a result of individual work in textbooks. The context of situation is the interaction between individual students and the textbook pages.

According to Halliday (Halliday and Hasan, 1985), a text is any instance of a living language that plays some part in the context of a specific situation. In this research the text in focus is the textbook pages but in relation to how students interpret the textbook. The text, therefore, is not just what is on the page but the interaction that occurs between it and the students as they try to make sense of it. Every text is about something and is constituted by the field, involves participants, constituted by the tenor, and is based on the text structure, constituted by the mode.

The field of the discourse describes the events that are taking place in the context of situation and are realised through naming aspects of the event. In relation to interpreting the textbook, it is about the content that is introduced on the page. Thus it was important to understand how the content of the page affect students' interactions with it.

Who is taking part, the status and roles of the participants, the authors of the page and the students, is constituted by the tenor (Halliday and Hasan, 1985). In this study, the authors of the textbook have a different role to that of the students and that of their teacher, who for a large part is invisible in the interaction, even if physically present in the classroom in which the interaction takes part. These roles were likely to affect the interaction.

The mode refers to the role that language plays and what the participants are expecting the language to do for them in that situation (Halliday and Hasan, 1985). It is about how coherence is achieved through synthesising the different modes such as text, symbols and illustration. Given that the textbook page combines illustrations with words and symbols, it was important to find out how the students integrated them together to gain meaning from the page.

In an earlier study (Ebbelind and Segerby, 2014 forthcoming), an analysis of a textbook page using SFL found that there were a number of potential difficulties for students in interpreting textbooks.

In this study SFL is combined with the reciprocal activities of prediction, clarification and summarisation (Palinscar and Brown, 1984) to identify students' reading strategies.

Reciprocal activities

Palinscar and Brown (1984) described four activities, which were considered to activate relevant background information, to help readers comprehend a written text.

Prediction concerns students predicting future content and drawing and testing inferences. It considers how students make sense of different components, words, picture, symbols, and so is about SFL's mode. However as it also refers to what is happening in the content of situation of the textbook page, there is a relationship with SFL's field.

Clarification requires students to engage in critical evaluation. It is connected with the coherence of words/phrases, symbols and visual representations and, like prediction, draws upon understandings both of the field and mode.

Questioning involves students composing questions on the content to see if they have understood it. However, in this study this reciprocal activity is not included as the study is not about students' learning but about the reading strategies that they use before any intervention is made.

Summarisation is related to identifying the major content and determining what the page is about. Thus, it is connected to SFL's field. It also connected to the mode as students will need to be able to extract meaning from synthesising the pictures with the words, symbols and pictures.

Method

Interviews, based on an interview guide, were used to ascertain what students considered as they approached the textbook page. The interviews were video- and audio-tape recorded. Table 1 shows the connections between the interview questions,

the reciprocal activities and Systemic Functional Linguistics (SFL). The questions focused on the field as they mostly referred to what was happening on the page.

Table 1. The questions related to reciprocal activities and SFL (System Functional Linguistics)

Questions:	**Reciprocal activities**	**SFL**
1. What is the first thing you look at on the page?	Prediction	Field
2. How can you find out what the page is about?	Prediction	Field
3. What is a digit and what is a number?	Clarification	Field
4. What is the function of the information box and what does it tell you?	Summarisation	Field and Mode
5. If you constructed a page in mathematics textbook, how would it look and why?	Summarisation	Field and Mode

Six Year 3 students (10 years old) were interviewed individually about how they approached page 12, in the widely-used, Swedish, Year 4 mathematics textbook *Matte Direkt Borgen* (Falck, Picetti and Sundin, 2011), which was about digits, numbers and place value. The page is similar to many other pages in Swedish textbooks in its layout. At the top of the page is a heading "Siffror och tal" (digits and numbers) and then there is an information box that describes the content, followed by five exercises. The text in the information box states: "When we write numbers, we use one or more digits. Our number system contains the digits: 0 1 2 3 4 5 6 7 8 9". This is followed by "The digits in a number have different values" and an illustration showing the different values of the digits of number 2345 (2 in 2345 is worth 2000, digit 3 is worth 300, etc.)". The information box also contains an illustration of a boy holding a board with the number 2345. A speech bubble says "How much is digit four worth here?", the boy's hand points at digit five which is the units digit. The girl answers "Forty!" and her left hand is raised, showing five fingers.

Each exercise on the page has three questions, except the fifth exercise. The first exercise is "How many digits are there in this number?" The two following exercises have the question "How much is the digit worth in this number?" The fourth exercise is "Write a number with four different digits" and the fifth and last exercise on the page is "Moa has one note worth a thousand kroner and another note worth fifty kroner. Can she buy the coat?" Connected to the exercise is an illustration of a coat with a price tag of 1498 kroner.

The teacher was asked to choose two students, considered as high achievers in mathematics (A1 and A2), two as middle achievers (B1 and B2) and two as low achievers (C1 and C2). It seemed valuable to see if the reading strategies of students with different achievement levels in mathematics could be compared. Teachers' use of subjective assessments to identify students' achievement levels can be problematic. However, for a small pilot study, such an approach seemed appropriate.

Results and Discussion

Prediction

The first two interview questions were about the first thing that the student looked at on the page and how they found out what the page was about. They were thus about predicting and connected to SFL's field, as they focused on what was happening on the page.

Four (A2, B1, B2, C2) of the six students first looked at the picture of the coat in the bottom right corner of the page, connected to exercise 5. A1 looked at the

heading "Siffror och tal" (Digits and numbers) and C1 focused on the "strange numbers" (2345) on the board, held by the boy in the information box. As the pictures caught almost all the students' eyes, they seemed to have an important role. However, the pictures repeated the ideas expressed in the written text so they are related, but non-essential material (Noonan, 1990). However, it is not clear that the students recognised that the pictures were duplicating written material, as their initial viewing of the page did not suggest that they saw the pictures as being connected to the written text, as can be seen in the answers to the following question.

The students gave different answers as to how they could find out what the page was about:

> A1: Look at the headline in order to know that to do and then in the information box.
>
> A2: Look around in the text (pointed at headline, information box, text in the tasks)

Both of the high-achieving students (A1 and A2) looked at the main heading and at the information box. On this page, the heading is important because it identified the main idea that there was a relationship between digits and numbers (siffor och tal). The high achieving students stated that they had come to understand the value of the heading, by themselves, as they could not remember being explicitly taught about it during their mathematics lessons.

Three students (B1, B2 and C2) focused on the numbers (symbols), a similar strategy to those of the older students in Österholm's study (2006).

> B1: Maybe it is about how much money you will get back (pointed at the picture in the information box). I do not know how to find out what the page is about.
>
> B2: I see what it costs (points at the coat) and that they put numbers under each other (pointed at the information box) digits under each other. I think that it is about training to set up numbers (operations).
>
> C2: If there is a lot of numbers like on this page I start to look at the numbers in the first task.

C1 did not seem to know how to figure out what the page was about except that it was about mathematics.

> C1: I think that it is about maths and if there is some maths.

The predicting strategies that the students used were closely connected to the pictures but it did not seem that they understood that the pictures were replicating information also provided in the text. Only the high achieving students used the heading and information box to find out what the page was about. Yet this information can help students activate their prior knowledge in order to learn new knowledge.

Clarification

In relationship to this textbook page, clarification was linked to students' definitions of the important mathematical words, digit and number. The students were asked to read the page and identify if there were any words they did not understand. None of the students said they had found any words that they did not understand. I then asked them to describe what a digit and what a number (Siffor och tal) were, as these two words made up the heading.

Three students described a digit and number appropriately (A2, B1 and C1). The rest thought that digit and number were the same thing and related to two-digit

numbers, such as 22. Four students defined numbers as mathematics tasks (A1, A2, B1 and C2). For example, B1 said "*such as 21 – 5 =*", indicating a task based on an operation. In Sweden, the word "tal", number, is often used colloquially in mathematics classrooms to mean a task, such as "This week you are going to solve twenty numbers (tasks) in the textbook" and "Can you solve the number 5 x 3=". It is perhaps not surprising that some students, independent of level of achievement, could not define digit correctly and did not realise that they did not understand. The information on the page did not seem to help them to learn the correct meaning. Yet, for students to comprehend a page, understanding the meaning of the mathematical words is essential (Adams, 2003; Carter and Dean, 2006; Lee, 2006).

Summarisation

The interview questions about summarisation focused on students' thoughts about the information box and how a textbook page should be constructed. This strategy is related to SFL's field, about the naming of objects, and the mode, about the text's coherence and the connection between the pictures and the text.

All of the students thought that the information box was important. Two of them could not explain why (B1 and C2), while the others stated that it explained what to do. It is interesting to note that they did not see it as providing information about what they were to learn about the topic but rather what they had to do. When the students were asked to identify what the information box told them, the two high achieving students (A1 and A2) read both the text and looked at the picture in the information box and said that it was about numbers, digits and place value. They found it hard to connect the picture of the boy with the sign to the textual information, possibly because the words and the hand signals of both the boy and the girl do not match. The two high achieving students tried unsuccessfully to explain what the picture was meant to convey and became frustrated. This suggests that for these students the different modes, the pictures and the words, were not producing a coherent text (Halliday and Hasan, 1985) from which the students could construct meaningful mathematics. The lack of coherence seemed to affect other students in other ways.

B1 only read the speech bubbles and said that the digit 4 meant 40. B2 read the three first lines in the box and said, "You only use 1 to 9 to write every number. I have never thought about that." C1 looked at the picture where the number 2345 has been split into its composite values and said, "5 is not as much as 40, 40 is not as much as 300." C2 responded similarly to B2 and only read the first three sentences in the information box. She stated:

> 1 has less value than 2 and 6 has more value than 3, 9 has a very giant value compared with 0. Because 0 is nothing but 9 is really high.

C2 only referred to digits and their value and did not seem to understand that the information box was about place value (talvärde), where the digits gain their value from the position that they occupy in the number.

When the students were asked to describe how they would construct a textbook page, all of the students suggested that the page would contain multiplications tasks, which was the area they had currently worked on. Three of the students (A1, A2 and C2) also suggested addition tasks and B1 suggested some subtraction tasks.

C1 and B2 thought that at the beginning the tasks should be easy and at the end become harder. B2 suggested that there should be reading tasks at the bottom of

the page. However, only one of the students (B1) suggested that a description of what to do should be included. Nothing was said about what they should learn.

Four of the students wanted pictures on the page but for different purposes. One purpose was to be a decoration (Noonan, 1990) such as an animal at the bottom of the page (B1) and a car in the beginning of the page student (C2).

Another purpose was as a repetition of the idea being expressed in the text (A2 and C1), which would make it related but non-essential information (Noonan, 1990). C1 said that pictures can help you to solve the tasks if you cannot read. On the other hand A2 stated that he thought that some pictures were confusing. He pointed at a picture on the next page in the textbook and said, "Like this picture, with the dragon. I do not understand it and I do not like it". In the picture, the number 2908 was written in large digits above a dragon's head and the number 6890 was written in small digits underneath the dragon. The purpose of that page was to order numbers. However, it was clear that rather than supporting the student's understanding, like the picture of the boy with the board, the picture caused confusion and frustration.

In summary, it would seem that the purpose of an information box and how to read it is not clear to all the students. Two students could not explain the purpose of the information box. Only the high achieving students used both the pictures and the text to understand the textbook page. The other students focused on different parts of the information box and did not seem to be able to connect the parts into a coherent whole. Valuable information was missed such as the description of numbers and digits and the relationship between them. Children's confusion over the role of pictures was evident in their suggestions for how a page should be constructed, with some just wanting decorative pictures. Only two of them wanted to have pictures that were related but non-essential to the text.

Conclusion

The importance of the textbook in Swedish mathematics teaching means that understanding how children read a textbook page is valuable information. From this small study, it would seem that some students have been able to work out how to obtain more meaning from the page than their peers. A larger study is needed, to determine whether the suggestion of a correlation between mathematics achievement and an ability to decipher a textbook page found in this study can be seen in the wider population of Year 4 students.

Field: It was clear that not all students knew how to find out about the main ideas. Only some of the students could define "digit" and "number" appropriately. The context of culture of Swedish mathematics classrooms interfered with the students recognising that 'tal' did not mean exercise in this context of situation. Without being able to identify the main idea the students' relevant background information may not be activated, thus impeding their comprehension. It may also be that the students who were confused did not have relevant background information.

Tenor: From the students' perspective, the tasks on the page position them as doers that perform actions and not thinkers that reflect, describe or explain their thinking. This also had an impact on the field as their expectation as doers was that they would not read about what they should learn but what they would do in the exercises.

Mode: The pictures seemed to play an essential role because all the students looked at them first when they approached the page. However, the pictures did not always support the students' understanding but instead caused confusion. It was also

clear that many of the students were not able to integrate the pictures with the written text to create a coherent whole and thus could not make sense of the information that they were expected to learn.

The high achieving students had more successful reading strategies than the others students in the study. However, the study also showed that the high achieving students needed guidance in understanding the mathematical words connected to the main ideas. It is likely that not being able to locate and understand the main ideas expressed in the textbook will affect students' learning. However, a larger study is needed to investigate that further.

References

Adams, T.L. (2003) Reading mathematics: more than words can say. *The Reading Teacher*, 56(8), 786-795.

Borasi, R., Siegel, M., Fonzi, J. & Smith, C. (1998) Using transactional reading strategies to support sense-making and discussion in mathematics classrooms: An exploratory study. *Journal for Research in Mathematics Education*, 29(3), 275-305.

Bryant, B.R., Bryant, D.P., Kethley, C., Kim, S.A., Pool, C. & Seo, Y.J. (2008) Preventing mathematics difficulties in the primary grades: The critical features of instruction in textbooks as part of the equation. *Learning Disability Quarterly*, 21-35.

Carter, A.T. & Dean, O.E. (2006) Mathematics intervention for grades 5-11: Teaching mathematics, reading, or both? *Reading Psychology*, 27(2-3), 127-146.

Ebbelind, A. & Segerby, C. (2014, forthcoming) Systemic Functional Linguistics as a methodological tool in mathematics education. *Nordic Studies in Mathematics Education*.

Falck, P., Picetti, M. & Sundin, K. (2011) *Matte direkt. Borgen. 4 A /Pernilla Falck, Margareta Picetti, Kerstin Sundin*. Stockholm: Bonnier utbildning.

Halliday, M.A.K. & Hasan, R. (1985) *Language, context, and text: aspects of language in a social-semiotic perspective*. Oxford: Oxford University Press.

Johansson, M. (2006) Teaching mathematics with textbooks - a classroom and currricular perspective. *Doctoral dissertation*, Luleå University, Sweden.

Lee, C. (2006) *Language for learning mathematics*. Oxford: Open University press.

Noonan, J. (1990) Readability problems presented by mathematics text. *Early child development and care*, 54, 57-81.

Österholm, M. (2006) Kognitiva och metakognitiva perspektiv på läsförståelsen inom matematik [Cognitive and metacognitive perspectives on reading comprehension in mathematics]. *Unpublished Doctoral dissertation*, Linköping University, Sweden. Linköping: Uni Tryck.

Palinscar, A. & Brown, A.L. (1984) Reciprocal teaching of comprehension-fostering and comprehension-monitoring activities. *Cognition and Instruction*, 1(2), 117-175.

Weinberg, A. & Wiesner, E. (2011) Understanding mathematics textbooks through reader-oriented theory. *Educational Studies in Mathematics*, 76(1), 49-63.