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RESEARCH

Potential for Meaning Making in Mathematics Textbooks

A Multimodal Analysis of Subtraction in Swedish Year 1

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Textbooks are a common teaching tool widely used in children's mathematical education. Comparative studies of textbooks have focused on different aspects, such as content, mathematical symbols and so on. However, a multimodal approach to textbook research—that is, studying how writing, images, mathematical symbols, etc. interact—is sparse. This study analyses 40 exercises from 17 Swedish Year 1 (children 7–8 years) textbooks using a multimodal approach with a focus on subtraction as an arithmetic operation. The aim was to describe and analyse how subtraction in Swedish Year 1 mathematics textbooks can be understood using a multimodal approach. The results show that it is sometimes possible to solve an exercise without focusing on the mathematical content that the exercise is designed to offer. Writing, images, mathematical symbols, speech and moving images are used differently within the same textbook and between textbooks. The results also show that there are considerable similarities between the exercises in printed and digital textbooks, with some exceptions. The examples in the study indicate that three different approaches are needed when working with these exercises, which implies great complexity in children's meaning making in their work with mathematics textbooks. This could negatively impact children's access to beneficial learning situations. Therefore, this study could contribute to a larger awareness of the complexity in question, which, by extension, may contribute to the development of beneficial learning situations in mathematics education, especially regarding subtraction.

Keywords: meaning potential; modes; designs for learning; multimodality; mathematics textbooks; digital textbooks; printed textbooks; primary school; early years; subtraction

Introduction

In today's society, we constantly encounter information in the form of different sign systems, whether in books or on television, the Internet, billboards or smart phones. Reading not only entails interpreting written text, but also, for example, images and sound (Kress, 2003). In addition, over the past six decades, expectations related to reading and writing ability have shifted towards visual and multimodal literacy skills (Kress, 2003). O'Halloran (2005) describes mathematics as multimodal in nature. To learn, understand and use mathematics, one must be able to make meaning from different resources, such as mathematical symbols, writing and images. Individuals interpret these resources and thereby create meaning in different ways, forming an overall understanding of the subject. Therefore, multimodal studies like this are important where all different resources for meaning making or *modes* (Kress, 2011) of textbooks are concerned: writing, images, mathematical symbols and, in digital textbooks, speech and moving images. Meaning making is understood as a process whereby individuals continuously create meaning from their environments with the help of different modes (e.g., Kress, 2010; Selander & Kress, 2010).

Over 75 percent of children in compulsory education worldwide are taught mathematics with textbooks. In Sweden, that number increases to over 90 percent (Mullis, Martin, Foy & Arora, 2012). This indicates that mathematics could be considered a textbook controlled subject (Johansson, 2006; Taflin, 2007). Research on textbooks and how they are used in general has been conducted (e.g., Fan, Zhu & Miao, 2013), but research from a multimodal perspective is sparse. The mathematical content of this study is subtraction. First, the understanding of subtraction can be considered a central part of Year 1 content. Second, subtraction is one of the four operations of arithmetic that children can find hard to understand (Foxman & Beishuizen, 2002; Fuson, 1992; Skolverket, 2010). Therefore, this study will ultimately contribute to research on mathematics textbooks from a multimodal approach with a focus on the content of subtraction.

The aim of this study is to describe and analyse how subtraction in Swedish Year 1 (children 7–8 years) mathematics textbooks can be understood from a multimodal approach. This opens up the possibility of studying each resource in the textbook at the same time, but also these resources in combination. The research questions concern

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how subtraction is presented in printed and digital textbooks from different modes: 'Which modes are used?', 'How do different modes interact with each other?' and 'What meanings are the exercises designed to offer?'

Textbooks can be understood as teaching tools intended to support children's meaning making and, by extension, their learning. Using textbooks can mean more or less work for the learner, depending on the textbooks' design regarding the use of different modes (Bezemer & Kress, 2010) and how teachers plan and implement textbook use in their teaching (Pansell, 2018). Sometimes, more work must be done by textbook designers, and sometimes the learner must do more work. Mathematics textbooks are designed to be used to solve exercises and could therefore be understood as textbooks with which more work is done by the learner. When making meaning, children must distinguish between various forms of information in the textbook, which could be a difficult task. When children have a difficult time understanding a textbook, they are likely to miss a learning opportunity (Weinberg & Wiesner, 2011). The teacher is of course of great importance in such work but is not the focus of this study. No matter how committed and engaged the teacher is, there will be times when the child must work with the textbook without the support of a teacher. More knowledge about textbooks' content, structure and potential for meaning making is needed and could, by extension, provide information about the possibilities and constraints of textbooks. This could, in turn, contribute to the design of beneficial learning situations.

Mathematics Textbooks, Subtraction and Multimodality

Existing research on mathematics textbooks often focuses on textbook analysis or textbook comparisons (Fan, Zhu & Miao, 2013). Regarding primary school and the topic of subtraction, several studies have focused on how subtraction is presented. These are often comparative studies in which textbooks from different countries are analysed (e.g., Carter, Li & Ferrucci, 1997; Charalambous, Delaney, Hsu & Mesa, 2010; Fuson, Stiegler & Bartsch, 1988; Mayer, Sims & Tajika, 1995) and studies focusing on components of subtraction, such as word problems (Despina & Harikleia, 2014), computation (Engvall, 2013; Reys, Reys & Koyama, 1996) or instructions (Zhou & Peverly, 2005).

Thus, multimodal research on textbooks is scant, and multimodal studies focusing on subtraction as an arithmetic operation have not been found. Dowling (e.g., 1996, 2013) conducted extensive research on mathematics textbooks focusing on how different modes affect the learner from a sociological and class perspective. Herbel-Eisenmann (2007) used a discourse analytic framework derived from Halliday's systemic functional linguistic (SFL) to study language in a middle school textbook. A conclusion drawn is that textbook authors must be more aware of language choice when selecting expressions (Herbel-Eisenmann, 2007). Herbel-Eisenmann (2007) also stresses 'how powerful the hegemony of traditional forms of discourse in mathematics curriculum materials can be' (p. 361), which indicates a need for more research on mathematics textbooks.

O'Keeffe and O'Donoghue (2015) studied writing in lower-level Irish secondary school mathematics textbooks. They concluded that the language analysis employed should be complemented by other textbook analyses to create knowledge that is as full as possible, as textbooks are complex to analyse. Lepik, Grevholm and Viholainen (2015) state in a survey study of 400 Estonian, Finnish and Norwegian teachers' use of mathematics textbooks that children do not get the opportunity to discover textbooks' full potential as multifaceted teaching tools. This could imply that a multimodal approach to textbook analysis would provide a way to achieve this aim, as such an analysis considers all resources for meaning making. The multimodal approach helps us observe all communication resources in a textbook, both individually and together, which enables us to understand the meaning that the mathematics textbook is designed to offer.

An Indonesian study (Nugroho, 2010) focused on how modes were used in Year 1 Singaporean textbooks and how they assisted in explaining mathematical concepts. Nugroho (2010) studied writing, images and mathematical symbols and found that these modes complement each other. The researcher claimed that these modes are essential, especially for younger learners, and emphasised that the images mode could help convert abstract phenomena into something more concrete. This can be compared with Sutherland, Winter and Harris (2001), who studied images in primary school textbooks in five countries and sought similarities and differences in how multiplication was presented. They claimed that images sometimes draw attention to less relevant information, leading children to focus on these parts of the book rather than the mathematical content being taught.

Mathematics textbooks 'are tools with constraints and weaknesses', Johansson concludes in her study of three Swedish teachers' use of textbooks in Years 8 and 9 (2006, p. 28). This is supported by a Swedish study of Year 4 textbooks (Segerby, 2017) emphasising the challenge of reading mathematics textbooks and highlighting their multimodal complexity. A study conducted not on textbooks, but on mathematical tasks from Programme for international student assessment (PISA) and from national tests in mathematics, analysed solutions statistically to investigate the potential meanings of various modes (Dyrvold, 2016). Dyrvold (2016) investigated how difficult the tasks were to read and solve and focused on writing, mathematical symbols and images. The results showed no relationship between the number of modes and how demanding the task was, but the combination of modes and images mode was part of this. Österholm (2008) studied writing in mathematics textbooks used in a Swedish upper secondary and university context. He concluded that students seemed to develop non-desirable reading strategies and that it would be developmentally beneficial for students to have more variety in their experience of texts. Österholm (2006) also compared mathematical and historical texts with and without mathematical symbols. He found a difference between students reading mathematical texts that only consisted of a writing mode and students reading texts that consisted of both writing and mathematical symbols and concluded that more research on this topic is required.

Conceptual Framework

This study derives from a multimodal design for learning approach (Selander & Kress, 2010) where meaning making is central. Meaning making is defined as activities in which individuals understand their environment and is linked to communication and learning (e.g., Jewitt, Bezemer & O'Halloran, 2016, Kress, 2010). However, this textbook analysis focuses on the potential for meaning making, not meaning making itself. A multimodal analysis of textbooks must relate to a content aspect, Danielsson and Selander (2016) argue, which in this study consists of subtraction. In this section, a description of how a multimodal approach was used in this study will be given, followed by an explanation of how subtraction can be theoretically understood.

A multimodal approach

This study focuses on mathematical textbooks as multimodal teaching tools and their potential for meaning making. A multimodal approach could broaden the scope of how mathematics can be represented, according to Björklund Boistrup (2017). The multimodal approach highlights the fact that communication is always made from several modes (Jewitt, 2011). A mode is understood as 'a socially shaped and culturally given resource for meaning making' (Kress, 2011, p. 54). The modes studied in this textbook analysis are images, writing, mathematical symbols, moving images and speech.

Modes carry potential for meaning making, and meaning making occurs in communication (e.g., Kress, 2011). This textbook analysis does not study communication, but the potential for enabling communication between child and textbook. The textbook is therefore seen as a communicating teaching tool. This study strives to contribute to the knowledge of potential for meaning making, which forms the basis for children's meaning making in their work with mathematics textbooks.

Communication can occur between individuals or between an individual and an object, such as a textbook. When an individual encounters and interprets a textbook, meaning is made through representations of some kind—for instance, by showing with the body or by writing mathematical symbols. For example, a child reads a task in her textbook, counts on her fingers and writes down the answer '5'. In this case, meaning is made using gestures and mathematical symbols. The individual is represented here as a child but could also be the teacher, as the encounter between the teacher and the textbook also constitutes meaning making. However, this aspect will not be included in this study. Morgan (2006) emphasized that a multimodal approach could a resource for making rational descriptions of mathematical representations and structuring the interpretation of the function of representations. This study will focus on the former.

To understand textbooks as teaching tools for meaning making from a theoretical perspective, Bezemer and Kress (2010) concluded that 'Text designed for readers to engage with aspects of the world cannot be fully understood without due attention to all modes operating in the text' (p. 25). In a multimodal context, each mode provides part of the potential for meaning making (e.g., Kress, 2011). In this study, part of the potential is found in the images in the exercises, while part is found in the writing and mathematical symbols. In the digital versions speech and sometimes moving images is added to this. All modes are seen as resources with affordances and constraints. From this perspective, different modes do not offer exactly the same meaning in communication. Furthermore, this is contextual and differs from situation to situation.

It is important to emphasise that this study does not focus on all meaning potentials. Textbooks can be considered teaching tools designed to offer a specific potential for meaning making to solve exercises in such a way that the content the exercise was designed to offer is discovered. This potential for meaning making is this study's focus. The meaning individuals actually discover in their encounter with textbooks will therefore not be studied, but will be the subject of a forthcoming study.

How subtraction can be understood

In the literature, several researchers have described different subtraction situations. For instance, Carpenter and Moser (1983) described subtraction as *separating, part-part-whole, comparison* or *joining* situations. Riley, Greeno and Heller (1983) used the concepts *change, equalize, combine* and *compare* with subgroups. In this article, the analysis of subtraction situations derives from Fuson's (1992) research. Based on work by Carpenter and Moser and Riley Greeno and Heller, Fuson described a categorization which is used in this study. She described three different situations: *change take from, compare* and *equalize*. The former two are considered basic operations, and the *equalize* situation is produced by a combination of these two. A *change take from* situation is described as a unary operation in which one number is operated on to produce a new unique number: 'Amal has four apples and eats two of them. How many apples are left?' A *compare* situation is described as a binary operation in which two numbers are operated on: 'Amal has four apples and Casper has two apples. How many more apples has Amal got?' Another difference between the two situations is that *change take from* could be understood as an active situation in which the quantities change, whereas *compare* can be understood as a static situation because the quantities remain the same. *Equalize* situations could be understood as active binary operations in which two numbers are operated on by taking away or adding something: 'Amal has four apples and Casper has two apples. How many apples does Amal need to give away to have as many as Casper?' or 'How many apples does Casper need to get to have as many as Amal?' The operations performed mathematically are the same in the three examples above, but the underlying mathematical idea differs. It is important for children to comprehend this to obtain critical knowledge about subtraction as an arithmetic operation.

Concerning subtraction in Swedish Year 1 textbooks, most exercises do not address a specific subtraction situation (Norberg & Boström, submitted). The study shows that if this is done, *change take from* situations are by far the most common. Some of the studied textbooks only offer *change take from* situations, while others offer *change take from* and *compare* situations equally. This implies that the choice of textbook affects the student's ability to experience various subtraction situations.

Method

With a multimodal approach comes an awareness of various modes, which guides the method of analysis. The method of analysis aims to make modes visible, as well as drawing attention to the potential for meaning making when working with mathematics textbooks. It must also illuminate the mathematical content being studied: subtraction. The analysis proceeds from Danielsson and Selander's (2014, 2016) Model for Working with multimodal texts in education, which was operationalized to fit this study's purpose. A perspective on subtraction deriving from Fuson (1992) was added to this model.

Exercises from various Swedish Year 1 mathematics textbooks on the Swedish market were chosen based on the following selection criteria. First, publishers were first chosen from an Internet search using the Swedish keywords for 'textbooks', 'publishers' and 'elementary school'. Second, the Swedish Textbook Authors' Association was contacted, and publishers who publish textbooks were identified. Third, this information was then checked with a reference group from a primary school, leading to the identification of six publishers. All textbooks produced from 2011–2017 were chosen. The year 2011 was chosen because it was when the most recent Swedish curriculum was published. Five textbook series had complete digital textbooks, and four of these also had a printed textbook, while one was available only in a digital version formatted for tablets. Altogether, 17 textbook series were studied: 12 in printed format, four in printed and computer-based formats and one in tablet format.

First, all pages containing subtraction in all textbooks (approximately 1,700 pages) were studied to gain an understanding of how subtraction is presented in Swedish Year 1 textbooks overall. The results from this survey are presented in a quantitative study (Norberg & Boström, submitted). Second, two to four subtraction exercises from each textbook were chosen for deeper analysis, totalling 40 exercises. The criteria for inclusion were that the exercises should derive from a subtraction situation, show breadth in the way that subtraction was presented and derive from the quantitative study's results. The breadth was addressed according to subtraction situation and the way modes were used in the exercise. Some exercises are presented in the results section below with the publishers' permission. These exercises were chosen to give the reader examples of the variation of exercises that exist. The first exercise is an example that can be a bit problematic. The second exercise is an example that works well, and the third exercise is an example that shows the printed and digital versions of the same exercise. Together, these three examples were also chosen to illustrate both two subtraction situations.

Framework for analysis

To understand how textbooks are structured, Danielsson and Selander's (2014) model was used. With this model, the text as multimodal was made visible, providing possibilities to detect difficulties in the texts. The analysis model is relatively extensive, and Danielsson and Selander (2014) emphasised that the model does not need to be used as a whole. Different parts of the model can be used for different texts depending on subject matter and purpose. In this analysis, the first two parts of the model were found to be relevant. These are (1) *General structure – setting* and (2) *Interaction between textual parts.* This is because an exercise's structure and the interaction between different modes are essential to determining the potential for meaning making an early-year mathematical exercise can offer. In (1), thematic orientation and sequencing are central. This part of the analysis can be seen as a comprehensive analysis and describes how the text invites reading, what content is offered and how it encourages certain activities. Here, the type of text, how the text is organized, how the text should be read and the role of images for the potential for meaning making is in focus. Part (2) focuses on the text's various modes and how they work together. The relationship between congruence in writing and other modes is studied, as is congruence between concepts, descriptions and explanations. Congruence refers to whether the modes correspond to each other or if concepts, descriptions and explanations are congruent. If, for instance, the different modes contain contradictory information, incongruence exists. The multimodal analysis was complemented by a focus on the subtractive aspect of the exercises. This part of the analysis studied the subtraction situations on which the exercises focused and how the different modes contributed to the potential for meaning making according to the mathematical content. To operationalise the analysis method, the following questions were formulated:

- *Which modes are used?*
- *How are the modes used, and how do they interact?*
- *How should the exercise be read to solve it?*
- *Which subtraction situation is the exercise designed to offer?*
- *Which mode or modes carry information about what mathematical content is focused on?*

Each question was asked, and the answers were summarised. Information found in each mode and the potential for meaning making according to the subtraction content that the exercise was designed to offer was sought. If the text, for instance, said 'Take away' or 'Compare' or the image showed apples and apple cores, then it was possible to tell what kind of subtraction situation that the exercise was designed to offer. With these questions, a focus on different aspects of multimodality from a mathematics educational perspective was possible. This created an instrument for understanding the textbooks in a new way.

Results and Analysis

The aim of this study was to describe and analyse how subtraction in Swedish Year 1 mathematics textbooks can be understood using a multimodal approach. In this section, three examples of analysed exercises will be presented to illustrate the contribution of a multimodal approach to mathematics textbooks. The presentation structure follows the analysis questions above. After that, some general results will be given based on the analysis of 40 exercises taken from 17 textbook series to broaden the scope of the potential for meaning making in subtraction in Swedish Year 1 textbooks.

Example 1: Ducks

The first example (see **Figure 1**) shows the first page of the textbook that contains subtraction. This page introduces the operation of subtraction, and the child is supposed to read the upper part of the page to understand the concept.

To understand this page as a multimodal teaching tool, it will be examined from the top to the bottom. The first, question was *Which modes are used?* The modes used on this page are writing, mathematical symbols and images. The second question was *How are the modes used and how do they interact?* The heading reads 'Subtraction 0 to 5'. The blue square below this shows the subtraction symbol, and 'minus' is written below the symbol. This example shows incongruence, as there is no explanation that 'subtraction' and 'minus' mean the same thing. Furthermore, how the child should understand what 'Subtraction 0 to 5' means is not explained. The bird next to the blue square explains that the subtraction symbol (–) 'means there will be fewer'. This is misleading for the child, as subtraction could also mean that two amounts should be compared, which is something about which the child does not receive information. In the next section on the page, there is an explanation of what subtraction means in three different modes. The heading reads, 'Image', 'Maths story' and 'Maths' language'. The writing relates a short story: '4 birds sat in a tree. One bird flew away. Then there were only 3 birds left'. This writing is supposed to guide the child to understand the image showing four birds in a tree, one of which is about to fly away. This is shown through the bird spreading its wings and the two lines under the bird signalling movement. This little episode is also shown in mathematical symbols: '4 – 1 = 3'. In this section, there is congruence between writing, images and mathematical symbols. This part of the page can be understood as a guide box. However, as it does not imply any calculation, the child may not pay much attention to it if the child works with the textbook alone.

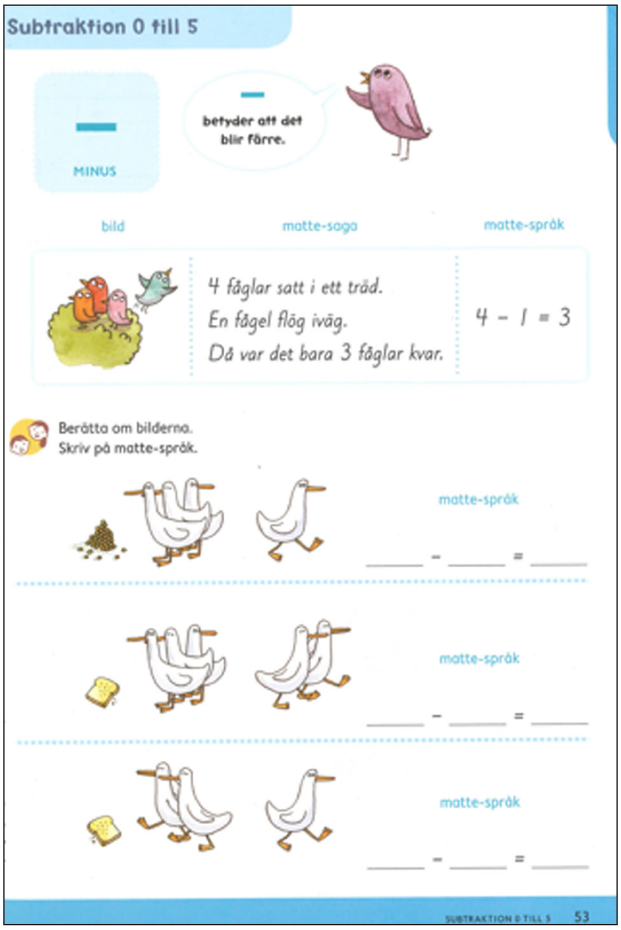

Figure 1: Ducks, subtraction as *change take from*. Kavén & Persson (2011). *Mattedetektiverna. 1A*, p. 53. Illustrator: Nilsson Thore, Maria.

The next section on this page starts with a small picture of two children talking to each other. It is explained in the beginning of the book that this is a symbol for working in pairs, so the image is used as an instruction. The writing reads, 'Tell about the images. Write in maths' language'. The images show three situations involving ducks grouped in different ways, as well as some grain, two slices of bread and breadcrumbs. Mathematical symbols are used to write the answers. In this section, there is congruence between the modes. To perform the calculation, the child must pay attention to the writing and images in this section. At the bottom of the page, the writing says, 'Subtraction 0 to 5', and the purpose of this text is to tell what chapter the page belongs to. Therefore, to summarise this page, *writing* is used for the headings, explanatory text, exercise instructions and chapter labelling. *Images* are used for decoration, for instruction and to convey mathematical information related to the calculations, and *mathematical symbols* are used for explanation and to write down the answers. This information is necessary to identify for discovering the potential for meaning making that the exercise is designed to offer.

The third question was *How should the exercise be read to solve it?* Here, the images carry the necessary mathematical information. This is supported by the subtraction symbol and the information in the upper part of the page. The child must interpret the images as small episodes or events and write the answers in mathematical symbols. In the first task, for example, the child must interpret the image as follows: 'First there were four ducks, and then one walked away. How many are left?' This leads to the calculation '4 – 1 = 3'. Based on the image's appearance, another possible interpretation could be 'There are two groups of ducks, one group with three ducks and one group with one. What is the difference between the two groups?' This leads to the calculation '3 – 1 = 2'. In this case, the child would use the image as a resource for calculation, not as an event. Both solutions are of course mathematically correct, but if the child is supposed to be taught subtraction as *change take from*, the interpretation of the image is important. To interpret the image in this way, the child must notice the ducks' legs and the direction in which they point. The child cannot look at the ducks' bills, as some of the remaining birds are looking at the ones that are leaving. According to the third task, the interpretation of the image could be understood as '3 – 2 – 1 = 0'. This is because all the ducks look as if they are walking away, as their legs are moving, which is not the case in the first two tasks. Finally, the breadcrumbs and slices of bread could mislead the child, as these parts of the images are not supposed to convey meaning besides decoration. The approach necessary to solve the exercises on this page is divided. In in the first part, the potential for meaning making involves perceiving the modes in the form of a guide box explaining how to understand the content to come, but the second part involves perceiving the modes as part of an episode that can be interpreted.

The fourth and fifth questions were: *Which subtraction situation is the exercise designed to offer?* and *Which mode or modes carry information about what mathematical content is focused on?* The subtraction situation that the exercise is designed to offer is subtraction as *change take from*, where one amount is decreased. This is seen in the writing mode in the use of 'fewer', 'flew away' and 'left' and in the images mode with the picture of the four birds in a tree with one about to fly away and the ducks in the lower part of the page. However, it could be difficult to perceive the ducks' movement in these images.

This exercise demonstrates that there is sometimes incongruence between the modes in the tasks and that more information may be included than is necessary.

Example 2: Dots and stars

In this example (see **Figure 2**), the entire page consists of tasks, and the first task is used as an example of how to solve them. The modes used are writing, mathematical symbols and images. The writing takes the form of instructions: 'Put X over those you take away. Calculate and write.' The mathematical symbols show what calculation to perform, and they are also used to provide an answer for the exercise. Images are used as resources for calculation and, in the first task, as instruction. There is congruence between the modes, as they do not give contradictory information. The potential for meaning making in this exercise could be considered clearer than the 'Ducks' example in several ways. On one hand, this depends on the fact that the whole page consists of the same potential for meaning making needed to solve the exercise as designed. On the other hand, because the images in this exercise do not need to be interpreted the same way as those in the 'Ducks' example.

To solve this exercise, the child must interpret the image as a resource for calculation. The dots and stars are

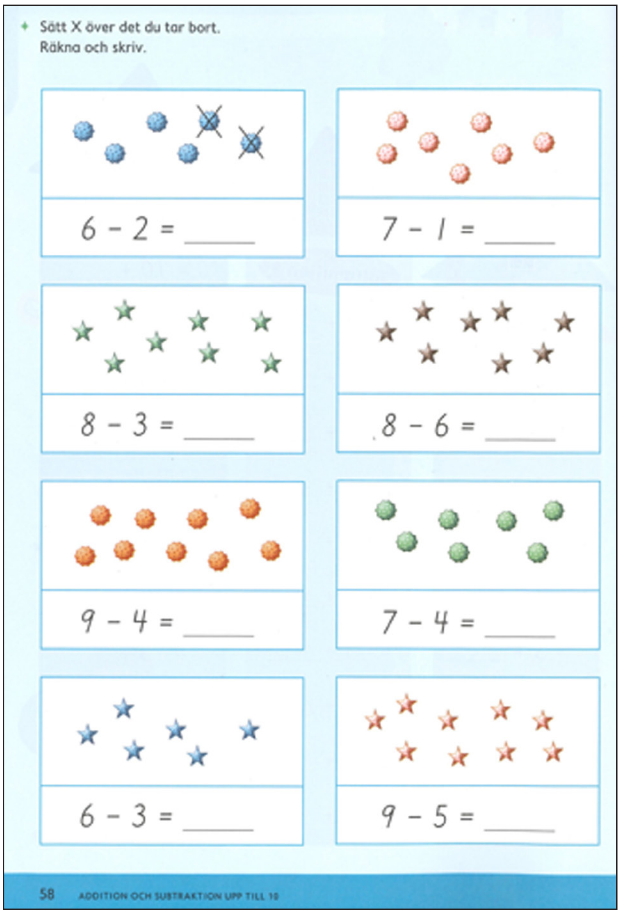

Figure 2: Dots and stars, subtraction as *change take from*. Kavén & Persson (2011). *Mattedetektiverna. 1A*, p. 58. Illustrator: Nilsson Thore, Maria.

supposed to be used as counters. The child should cross out the right number, then count the ones that remain and write the correct mathematical symbol on the empty line. Compared with the previous example, this exercise is plainer, as the whole page is composed of the same kind of exercise, and the images do not include any decorative elements. The child must focus on the mathematical symbols, except in the first task, where the counters have already been crossed out. The image supports the mathematical symbols and can be used as a resource for calculation, but it is nevertheless possible to solve the tasks without using the images, and the child should, if using the images, begin reading in the mathematical symbols mode. The approach needed to solve this exercise involves understanding the image as a resource for calculation, except in the first task, where the image is used as an instruction showing a sequence of events. The child is supposed to use the images to perform the calculation. This differs from the former example, where the child instead should understand the tasks as episodes that should be interpreted. This indicates a clearly different potential for meaning making, as the images in this example are designed to be used to perform a calculation that has not been done, whereas the former example requires the child to interpret a calculation that has already been done. These examples show that different approaches are needed to solve subtraction exercises encountered in mathematics textbooks.

Regarding the subtraction situation that the exercise is designed to offer, the writing and image in the first task inform the reader that this is a *change take from* situation. This is accomplished using the words 'take away' and the image of the first task, where two of the dots are crossed out. To solve the tasks as a *change take from* exercise, both images and mathematical symbols are necessary.

This exercise provides an example of the fact that a certain order exists in how the exercise should be read to discover the mathematical content of the exercise.

Example 3: Polly and Milton 1 and 2

The examples shown here derive from the printed (see **Figure 3**) and digital (see **Figure 4**) versions of the same textbook. In the exercise in the printed book, the modes used are writing, images and mathematical symbols. In the digital book, these are complemented by speech. The chosen pages show the heading 'SUBTRACTION, COMPARE'. The majority of this page consists of a guide box in the shape of a blue square with an explanation of subtraction as a *compare* situation, and at the end of the page, there is a task to solve. The writing reads, 'Subtraction, compare. We use subtraction (minus) when we compare and look at the difference. Polly has 5 caramels. Milton has 3 caramels. How many more caramels has Polly got? In maths' language, we write: 5 – 3 = 2. Minuend, minus sign, subtrahend, equals difference (difference).' After this is a task with an image, mathematical symbols and the writing 'Compare. How many more caramels has Polly got?'

To solve the exercise, mathematical symbols are used to write the answer. In both the printed and digital versions, writing, images and mathematical symbols are used for explanation and instruction. The images mode and the mathematical symbols mode are also used as resources for solving the task. There is congruence between the modes in the printed textbook, but the speech mode in the form of text to speech (TTS) creates incongruence in the digital version. The option to have the exercise read aloud in the digital version could be useful for the child, as this would provide support for interpreting the exercise. However, to do so, the TTS needs to be congruent with the other modes. In this exercise, the speech and the writing are incongruent because the voice of the TTS sounds monotonic, some writing is spoken incorrectly, and some is not read aloud at all. In TTS, the writing in the blue box reads, 'Subtraction, Compare. We use subtraction left parenthesis minus right parenthesis when we compare and look at the difference. Polly has 5 caramels. Picture. Milton has 3 caramels. Picture. How many more caramels has Polly got? Picture'. The parentheses are read aloud, which could interfere with the child's understanding of the text. At the end of the explanation, when different mathematical terms are explained, the TTS only says, 'Picture', which means that important information is left out. This indicates that the speech mode, which could be helpful when interpreting the task, does not work in this example. In fact, the speech mode makes it harder

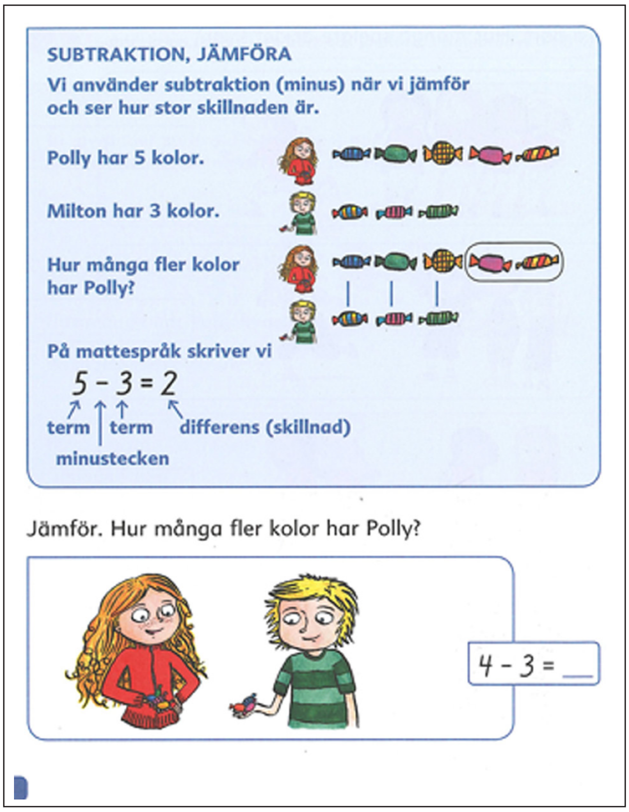

Figure 3: Polly and Milton 1, subtraction as *compare*. Brorsson. (2014a). *Prima matematik 1A*. Illustrator: Kristiansson, Johanna.

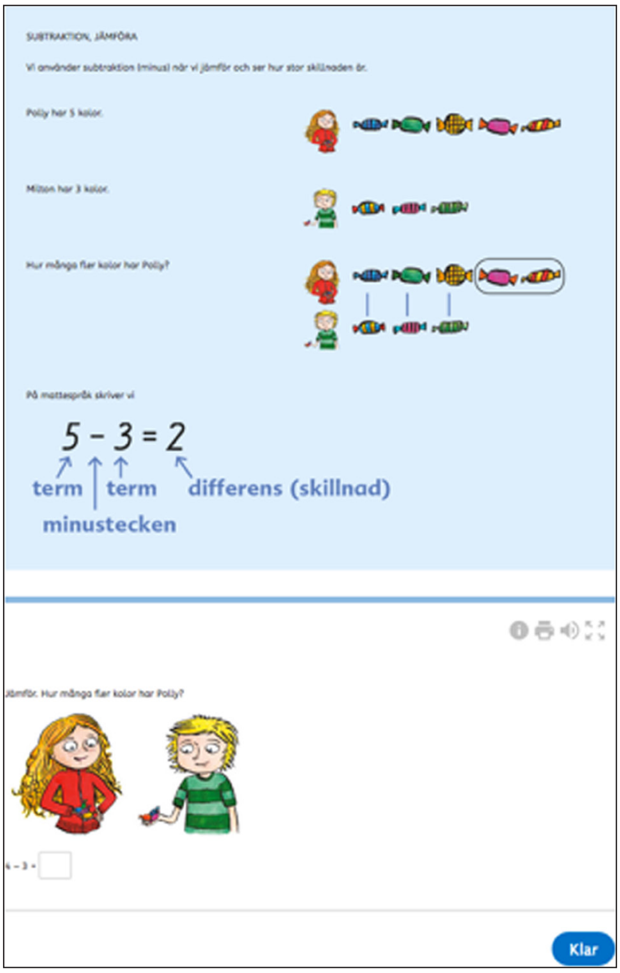

Figure 4: Polly and Milton 2, subtraction as *compare*. Brorsson. (2014b). *Prima matematik*. Digital textbook. Illustrator: Kristiansson, Johanna. Screen shot 170327.

to discover the potential for meaning making needed to solve the exercise as designed.

As this page introduces subtraction as a *compare* situation, the child must pay attention to the explanation in the blue square because it explains how to understand the exercises to come. The child is able to choose whether to use images or mathematical symbols, as both modes explain the mathematics needed to perform the calculation. However, to solve the task as a *compare* situation, the child must focus on the images mode. The approach needed to solve the exercise is divided. The potential for meaning making in the upper part of the page, the blue square, must be perceived as important information that explains the content to come. The images must be understood as an episode that should be interpreted, as the images first show Polly and Milton's candies, then the comparison of the two amounts. In the lower part of the page, the approach needed involves using the image as a resource for calculation, whether the child proceeds from the image or from the mathematical symbols.

These pages are designed to offer subtraction as *compare* situations in which two different amounts are compared. This is shown in the writing and speech in the words 'compare', 'difference' and 'How many more caramels has Polly got?' and in the images of the two amounts of caramels being compared. The comparison is strengthened by lines and rings drawn around the caramels that show the one-to-one correspondence and the difference between the two amounts.

Among other things, this exercise offers an example of the fact that the printed and the digital textbooks offer similar exercises and that improvements can occasionally be made in how modes are used in mathematics textbooks.

Summary

The modes used in the printed textbooks are writing, images and mathematics symbols, and in the digital textbooks, speech and sometimes moving images. The similarities between the exercises that are available in printed and digital formats are large, and the exercises in the digital textbooks look a lot like the exercises in the printed textbook, only on a screen. However, there are differences due to the possibility, for example, of having the writing read aloud in the digital textbooks, and sometimes short videos explain the concepts. The results show that improvements to these modes are sometimes needed. One type of digital textbook differs from the screen format, however: a tablet textbook. In this case, the layout benefits from a digital format, such that the exercises often show some kind of event in moving images, and the child can sometimes move objects, implying other postentials for meaning making than in other digital textbooks.

The modes are used differently and are sometimes congruent, sometimes not. To discover the mathematical content, different modes and different numbers of modes are used. The images mode is often involved, and sometimes more information is included than necessary. The results show that different modes can sometimes be considered unequally important for solving tasks and that, occasionally, the reading direction between different modes is important when solving exercises. The results also show that the approach needed to solve the exercise differs not only between exercises, but also within the same exercise, between textbooks and within the same textbook. In total, three different approaches are necessary to solve the exercises: an episode that should be interpreted, a resource for calculation and a guide box. This implies that the potential for children's meaning making in their work with textbooks is complex, and an awareness thereof is necessary.

Discussion and Pedagogical Implications

This study has focused on how subtraction in primary school textbooks can be understood using a multimodal approach as a way of researching potential for meaning making. Different modes contribute different potentials for meaning making. For example, in 'Dots and stars', the writing mode conveys information about how to solve the task. The mathematical symbols mode is used to understand what calculation to perform, and the images mode is used as a resource for calculation. These modes complement each other. This is in line with the results of Nugroho's (2010) study. With this knowledge, teaching questions, such as 'What does the image tell you?' and 'What do the mathematical symbols tell you?' can support children's interpretations of textbooks.

The 'Ducks' example is an exercise in which more information is given than is needed. This could mislead children, as the images mode shows ducks walking and standing with their beaks pointing in different directions and with grain, slices of bread and breadcrumbs that could hamper the interpretation. This is supported by Sutherland, Winter and Harris (2008) and could be compared to Nugroho's claim that images concretise mathematical concepts for children. It is possible that the notion that images make it easier to interpret mathematics tasks may however constitute a simplification of the impact of images on children's interpretations.

The results of this study show that an incongruence sometimes appears between different modes, which could be confusing for the child. An example of this is given in the 'Polly and Milton' example between the speech and writing modes. If the potential for meaning making to solve the task with the images mode points in one direction, and the writing mode points in another, the task will be difficult for the child. Unnecessary energy could also be exerted in understanding what to do with the exercise instead of practicing, in this case, subtraction. This can be seen in the 'Ducks' example, in which there is incongruence in the writing mode in the use of 'subtraction' and 'minus'. This incongruence is especially important, as this is the concept that is to be taught, which could mislead the child. This result is supported by Dyrvold (2016), who claims that the combination of modes, particularly the images mode, is part of determining how demanding tasks are to read or solve. A conclusion to be drawn from this is that exercises sometimes contain contradictory information, and this could cause difficulties in the child's interpretation. As a result, the child needs support from a teacher to interpret the textbook. Special attention should be paid when the textbook page contains elements like guide boxes, as such elements otherwise might not receive attention from the child, as they do not require any calculation.

The results demonstrate that there could be a focus on how the exercise should be read in order to solve the tasks. This means that the child might need to begin reading in one particular mode. For instance, in the 'Dots and Stars' example, the child should proceed from the mathematical symbols mode to solve the tasks, whereas in the 'Ducks' example, the images mode is the starting point. In other examples, such as 'Polly and Milton', the child can choose between the images and mathematical symbols mode. To solve the task as designed, the child needs to know when to read in what way. This work could be energy-consuming for the child, and this supports the concept that mathematical textbooks require more work from the learner (Bezemer & Kress, 2010).

Regarding which mode or modes carry the mathematical content focused on in the exercise, the results show that different modes and different numbers of modes are used, and the images mode is often involved in the mathematical content design. The same modes could convey information for both solving the task and discovering the subtraction situation, but that might not be the case. A conclusion to be drawn from this is that the child might solve the tasks without noticing the subtraction situation that is intended to be taught. The child might also need help to identify which modes provide information for solving the task and which modes convey the mathematical content.

The examples in this study indicate three approaches needed to solve the exercises: as an episode that should be interpreted, as a resource for calculation, and as a guide box. In turn, examples of these are shown in the lower part of the 'Ducks' example, the 'Dots and stars' example and in the upper part of the 'Polly and Milton' example. To solve the tasks, the child must be aware that there are different ways of interpreting the tasks. When comparing two of the exercises, for example, in the 'Dots and stars' example, the images are designed to be used for calculation. In the lower part of the 'Ducks' example, the images are designed to be used as episodes that should be interpreted. Thus, then the intended way to interpret the former exercise would not be applicable to the latter. Another example of this is given in the upper part of the 'Ducks' example. This part is designed to be interpreted as a guide box. A child who does not read this as it is designed could lose the opportunity to identify a bearer of important information and pay little or no attention to it, as there are no tasks to solve on that part of the page. Modes are also used differently within the same textbook and between textbooks. One conclusion to be drawn from this is that different potentials are needed when working with subtraction exercises in primary school Year 1.

The results show considerable similarities between digital and printed exercises from textbooks available in printed and digital formats. What differs most between the digital and printed exercises is the possibility of having exercises read aloud and the fact that the former is in a digital format. According to how different modes are used, the results give examples of inadequacies in the use of speech, as in the 'Polly and Milton' example. This can imply that digital textbooks could be developed with better TTS. Another development opportunity related to digital textbooks is the possibility of showing processes—for instance, in a subtraction situation in which the moving images mode can be used to illustrate the situation. This would entail the child receiving support in interpreting the subtraction situation instead of trying to figure the process out by reading still images.

In summary, this study shows that writing, images and mathematical symbols are used differently in different exercises both within a textbook and between textbooks. The results also show that it is sometimes possible to solve an exercise without focusing on the mathematical content that the exercise is designed to offer. Three approaches are needed when working with the analysed exercises in this study: an episode that should be interpreted, a resource for calculation, and a guide box. This implies great complexity in the potential for meaning making in children's work with mathematics textbooks. This mode issue may deny children access to beneficial learning situations unless teachers, publishers and textbook authors are made more aware of how different modes and meaning potentials contribute differently to children's possible meaning making in subtraction exercises. Therefore, studies like this are of importance for the development of beneficial learning situations in mathematics education, as they emphasise awareness of the complexity of meaning making when working with mathematics textbooks. Teachers could invite children to participate in discussions that position the textbooks as multimodal texts and help them focus on those aspects, thereby facilitating children's meaning making and, by extension, learning.

Competing Interests

The author has no competing interests to declare.

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