Exercise design in mathematics textbooks: the case of subtraction

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Mathematics textbooks are teaching tools used by most students studying mathematics worldwide. In this descriptive textbook analysis, all Swedish mathematics textbooks for year 1, both digital and printed, were mapped out according to the resources used for communication. For delimitation, a focus on subtraction as an arithmetic operation was chosen. The result shows large differences between the 17 textbook series, concerning both the type of subtraction exercises offered and the use of different resources for communication and learning, such as writing, images, and mathematical symbols. Digital textbooks were largely similar to the printed textbooks, except for one tablet-based textbook. Altogether, the study shows that the choice of mathematics textbooks affects how subtraction is presented to students and, by extension, the learning situations students encounter when working with mathematics textbooks.

Textbooks are frequently used in mathematics education. Most students learn mathematics using textbooks. Mathematics textbooks are used by more than 75 % of students in compulsory schools worldwide and more than 90 % of students in Sweden (Mullis et al., 2012). In the final report of a large Swedish national in-service training program, *Matematiklyftet* (The mathematics lift), individual work with textbooks was described as common in the 35 elementary and upper secondary classrooms studied (Österholm et al., 2016). Together, this indicates that textbooks frame mathematics teaching and the learning situations that students encounter.

This study is a descriptive textbook analysis that aims to map out exercise design in Swedish year 1 mathematics textbooks. This is based on a desire to gain knowledge about all textbooks in a specific market. I study resources for communication and chose the arithmetic operation

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of subtraction as a delimiter to make the study feasible. I provide overall knowledge of exercise design of subtraction exercises that Swedish year 1 students encounter when working with the mathematics textbook. The study is part of a thesis project (Norberg, 2020) about students' meaning-making when working with mathematics textbooks, which is my main interest. The other studies consist of (a) a textbook analysis aimed at providing in-depth knowledge of what the mathematics textbook offers as a teaching tool (Norberg, 2019) and (b) video observations of 18 students working with mathematics textbooks.

Fan et al. (2013) concluded, in a systematic literature review, that research on mathematics textbooks often focuses on single textbooks, one textbook series, or a few textbook series from different countries, and not on all textbook series in a certain market or country. Mapping all textbooks in a certain market has implications for what is offered to the students in that market, which must be identified to ultimately understand students' work with textbooks, making this type of research desirable. In addition, research on digital textbooks is an unexplored area (Fan et al., 2013). Digital textbooks offer more resources for communication and learning, such as moving images and speech, and thereby furnish other opportunities for learning. Moreover, there is a need for empirical research focusing on mathematical language (Dyrvold, 2016; Österholm & Bergqvist, 2013). This study meets these needs, as I studied all textbook series for Swedish year 1, printed as well as digital. I focused on all resources for communication and learning: writing, images, and mathematical symbols, as well as speech and moving images for digital textbooks. To eventually understand students' work with mathematics textbooks, this study provides overall knowledge about what mathematics textbooks in Swedish year 1 offer.

As mentioned earlier, to make this study feasible, I chose specific mathematical content – that is, subtraction. I made this choice for two reasons. One, subtraction, together with addition, often constitutes the the bulk of textbook content for year 1, and it constitutes central content of the curriculum (Skolverket, 2019). Two, subtraction is considered an operation of arithmetic that has been found to be difficult for students, regardless of the local conditions and settings (Foxman & Beishuizen, 2002; Fuson, 1992; Skolverket, 2010). I documented the number of subtraction exercises and which resources for communication are used, and I pursued knowledge on the ways and the extent to which textbook series differ, or whether subtraction as an arithmetic operation presented in textbooks is relatively equivalent, notwithstanding the specific choice of textbook series. Charalambous et al. (2010) suggested the possibility of a country-specific *textbook signature* and emphasized the need for further research, which provided support for this study. This information may be useful for teachers, as well as textbook publishers, authors, and researchers, to support their understanding of what mathematics textbooks can offer Swedish year 1 students.

There are approximately 20 textbook series from which to choose on the Swedish market for year 1 (7–8 years). Each individual teacher is responsible for making this choice, because there has been no governmental regulation of textbooks in Sweden since 1991 (Skolverket, 2006). In addition, mathematics textbooks represent a significant part of the annual funding used for teaching materials, because mathematics textbooks are materials that get consumed during the school year.

The aim of this study is to map out Swedish year 1 mathematics textbooks, focusing on exercise design. To this end, the study focuses on resources for communication will be focused and the content subtraction is chosen as a delimiter. It is worth noting that the object of study is the mathematics textbook, and not subtraction as an arithmetic operation. The following research questions clarify the aim.

1. To what extent do different subtraction exercises exist?
2. To what extent are different resources for communication used to represent subtraction exercises?
3. Are there differences between textbook series regarding the properties involved in the former research questions? If so, in what way?

Subtraction situations describe ways of understanding subtraction as an arithmetic operation and derive from Fuson's (1992) work. The study derives from the assumption that all resources for communication and learning are important when working with textbooks. The resources for communication that this study considers are writing, images, mathematical symbols, moving images, and speech.

Previous research

In this section, I present a literature review of research on mathematics textbooks. The first part, which bears on subtraction, is not intended to provide in-depth knowledge about subtraction, but to furnish an overall picture of the research field and show how specific mathematical content is studied. This choice relates to the fact that the object of study is not subtraction as an arithmetic operation, but rather the textbook as a teaching tool. The second part is intended to highlight research focusing on different resources for communication, because all of the resources for communication offer information that, together, comprise the exercises that the students then encounter. In this study, the term *textbook* should be understood as a student's textbook and not a teacher's guide.

The content of subtraction in mathematics textbooks

Generally, there is a relatively large amount of textbook research (cf. two recent special issues of ZDM, vol. 45 (5) and vol. 50 (5)). However, textbook research that focuses on primary school textbooks and subtraction as an arithmetic operation is largely limited to my research searches, and existing studies are mostly comparative. One example is the work of Charalambous et al. (2010), who studied the treatment of addition and subtraction of fractions and the presentation of these concepts in textbooks in Cyprus, Ireland, and Taiwan (for children aged 10–13 years). They concluded that there seem to be greater similarities between textbooks from the same country than there are between textbooks from different countries, and they suggest, as mentioned earlier, the possibility of a country-specific textbook signature. This could be compared to Remillard's et al. (2014) interventional study of the design of four U.S. teaching materials for years 1 and 2 (6–8 years). The results revealed substantially different types of opportunities in the curriculum design, which could explain the achievement results. The researchers called for further studies on the representation of opportunities to learn in mathematics curriculum materials. In another comparative study, Fuson et al. (1988) studied the way in which subtraction and addition were introduced in five different countries (China, Japan, Taiwan, the former Soviet Union, and the United States). Their study showed consistency between the first four countries, whereas the U.S. textbooks departed from the others in its subsequent introduction of the rules of arithmetic, which presented subtraction and more difficult subtraction exercises later than the textbooks from the other countries.

Subtraction linked to problem-solving was one of two objects of study in the work of Mayer et al. (1995). They studied three Japanese and four U.S. textbooks (12–13 years). In the Japanese textbooks, the authors found that over 80 % of the space was used to explain the method to solve problems, which can be compared with the U.S. textbooks, in which, on average, one-third of the space was used for the same purpose. The U.S. textbooks utilized almost 50 % of the space for student assignments, compared to 20 % in the Japanese textbooks. Almost one-fifth of the space in the U.S. textbooks was occupied by illustrations with a decorative purpose, which did not exist in the Japanese textbooks.

Reys et al. (1996) studied computations in addition and subtraction in Japanese primary school textbooks. They compared their results with those from U.S. textbooks and found that mental computation is presented earlier in Japan and that students are not trained to develop their own algorithms. This can be compared to Zhou and Peverly's (2005) study of a widely used Chinese textbook (6–7 years), in which the authors addressed the presentation of addition and subtraction concepts. There is no repetition of mathematical content in Japanese textbooks, as there is in Chinese textbooks (Reys et al., 1996; Zhou & Peverly, 2005). The authors of both studies stated that the goals concerning learning about computations might be the same in Japan, China, and the United States but that the methods used to achieve these goals differ greatly from country to country.

In a more recent study, Despina and Harikleia (2014) studied word problems connected to addition and subtraction in Greek textbooks (6–7 years). The results showed that most of the tasks involved two types of problems, one addition task and one subtraction task, both of which leave the result unknown. Other types of word problems that contained, for instance, a *compare* situation, barely existed in the textbooks.

In sum, most studies were comparative, and many showed results indicating that textbooks from different countries differed from each other. None of the studies examined all textbooks in a single specific market, and several of the studies demanded more research in this area, which reinforces the value of this study.

Resources for communication in mathematics textbooks

Various resources for communication are needed to represent mathematics (O'Halloran, 2005), and the different resources for communication used in mathematics textbooks together present an offer of mathematics content to the student. Textbook research focusing on different resources for communication is sparse (O'Halloran, 2005). In an empirical study of the annual Swedish national tests in mathematics (2003–2013) and the Programme for International Student Assessment (PISA) tests (2003, 2012), Dyrvold (2016) described how different resources for communication were connected to the relative difficulty of reading a task. The results showed

> that the number of different semiotic resources [resources for communication] in a mathematical task is not related to difficulty, but that difficulty is related to the particular combinations of semiotic resources [resources for communication] where pictorial images are one of the resources. (Dyrvold, 2016, p. 51)

This is in line with Segerby's (2017) interventional study on Swedish textbooks in year 4 (10–11 years). The results showed that the students must develop strategies and writing proficiency to work with textbooks. She explained that mathematics textbooks are challenging to read and highlighted, as did Dyrvold (2016), the combination of resources for communication in mathematics textbooks as a reason for this.

In another study focusing on different resources for communication, the researcher studied Palestinian elementary school geometry textbooks (Alshwaikh, 2016). One result indicated that the textbooks demanded more material processes than mental processes from the learner, leading to the conclusion that "this test was likely to encourage the learner of mathematics to be more scribbler than thinker" (Alshwaikh, 2016, p. 179). Alshwaikh also described methodological challenges in applying the analysis schedule to Arabic text. In a Swedish study, Grönlund et al. (2017) used a questionnaire to study 370 students and 30 teachers in a secondary school. They studied digital textbooks, with a focus on multiple resources for communication in the classroom. The results showed that teachers require knowledge about different resources for communication and new ways to think about and teach the use of digital tools (Grönlund et al., 2017).

Carter et al. (1997) conducted a study on four Chinese and six U.S. textbooks (12–13 years) regarding addition and subtraction, with a focus on the presentation of integer addition and subtraction. All Chinese textbooks used a combination of writing, images, and mathematical symbols to introduce content, whereas the U.S. textbooks more frequently used images and mathematical symbols. The researchers concluded that writing is used more often in Chinese textbooks than in U.S. textbooks.

Altogether, in studies focusing on different resources for communication, researchers have stated that mathematics textbooks are challenging to read. In this study, an entire country's textbooks, printed as well as digital, are mapped out to gain more knowledge about textbooks as teaching tools, focusing on exercise design. Doing so provides information about what students are offered when working with mathematics textbooks, which provides important information necessary to, by extension, understand students' work with mathematics textbooks.

Conceptual framework

The aim of this study was to map out all textbooks in a specific market, namely Swedish mathematics textbooks for year 1, with a focus on resources for communication used in the exercises and to the extent to which they occur. The studied resources for communication were writing, images, mathematical symbols, moving images, and speech. I made a delimitation to subtraction as an arithmetic operation. I did this to understand which kinds of exercises Swedish year 1 students may encounter in their work with mathematics textbooks. In this section, I describe how to understand subtraction as an arithmetic operation.

Different ways of understanding subtraction

It is possible to describe subtraction as an arithmetic operation in various ways. The concepts used to describe subtraction situations in this article derive from Fuson's (1992) extensive research on the four operations of arithmetic. Fuson's (1992) categorization of subtraction refers to earlier work in the area, by Carpenter and Moser (1983) and by Riley et al. (1983). Carpenter and Moser (1983) described subtraction as *separating*, *part-part-whole*, *comparison* or *joining* situations. Riley et al. (1983) used the concepts *change*, *equalize*, *combine* and *compare* with associated subgroups. More recently, Bartolini Bussi et al. (2011) described subtraction and addition operations through nine problems and used the concepts *combine*, *change* and *compare* to describe the nine different situations.

All of these categorizations of subtraction are similar to those described by Fuson, but they subdivide the subtraction situations into more subcategories, for example, into different variants of comparison situations. As the material being categorized based on subtraction situations consists of a considerable data of more than 2,000 units of analysis, Fuson's approach was chosen, because her categorization was most appropriate, as it contained the fewest categories, thereby making the textbook analysis more transparent.

Fuson (1992) described three situations: *change take from*, *compare* and *equalize*. The former two are considered basic operations, and the third is produced by a combination of these two. Change take from is described as a unary active operation, in which one number is operated on to produce a new unique number: "Alice has three marbles and gives one away; how many marbles are left?" A compare situation is described as a binary static operation, in which two numbers are operated on and the quantities remain the same: "Alice has three marbles, and Noh has one marble. How many more marbles does Alice have?" Equalize situations can be understood as active binary operations, in which two numbers are operated on by taking away or adding something: "Alice has three marbles, and Noh has one marble. How many marbles does Alice need to give away to have as many as Noh?" Through an exercise, a student cannot discover an equalize situation if the method of calculation is not explicitly presented in the instructions for the exercise, as it appears in the learner's calculation when taking away or adding.

A descriptive textbook analysis

In this descriptive textbook analysis, I aimed to map all Swedish textbooks for year 1, with a delimitation of subtraction as an arithmetic operation, which means that this study provides general knowledge about exercise design in Swedish year 1 textbooks. In this section, I present the following: the study design; the selection and implementation; the data collection, with a particular focus on the large number of units of analysis and the challenges associated with comparing printed and digital textbooks; and the method of analysis, focusing on subtraction situations and resources for communication.

Table 1. *Description of the studied textbook series*

Publisher	Year	Textbook	Total number of pages	Pages containing subtraction	Exercises
Natur & kultur	2015	Eldorado	288	82	108
Studentlitteratur	2012	Favoritmatematik	410	153	199
Studentlitteratur	2012	Favoritmatematik, digital		153	211
Sanoma	2014	Koll på matematik	286	51	72
Gleerups	2012	Lyckotal	272	49	67
Liber	2011	Mattedetektiverna	200	25	39
Sanoma	2011	Matte direkt safari	286	93	170
Studentlitteratur	2011	Mattekul	212	50	79
Studentlitteratur	2013	Mera favoritmatematik	410	184	232
Studentlitteratur	2013	Mera favoritmatematik, digital		184	243
Majema	2016	Mitt i prick	304	95	109
Gleerups	2016	Mondo	318	55	76
Liber	2013	Nya matematikboken	240	98	128
Gleerups	2012	Nya Mästerkatten	288	55	75
Natur & kultur	2015	Pixel	256	54	77
Gleerups	2014	Prima	262	48	67
Gleerups	2014	Prima, digital		49	68
Natur & kultur	2015	Qnoddarnas värld, tablet		37	37
Natur & kultur	2016	Singma	582	97	107
Liber	2017	Uppdrag matte	364	35	53
		Total:	4990	1647	2217

Selection and implementation

This study maps all Swedish mathematics textbooks for year 1, both printed and digital, from 2011–2017. This material forms a large data set. First, I carried out an Internet search with the keywords *textbooks*, *publishers* and *elementary school* to find active publishers in Sweden. Second, I contacted the Swedish Textbook authors' association, and to ensure that no publisher was omitted, I also questioned a reference group of active teachers. Third, I searched all publishers' websites in December 2017, focusing on *mathematics*, *years 1–3* and *textbooks*. I selected all textbook series for year 1 that were published in 2011 or later, resulting in a total of 17 series. The year 2011 was chosen based on the release of the current curriculum (Skolverket, 2011). All studied textbooks are shown in table 1.

Data collection

I analysed all pages that contained subtraction as an arithmetic operation (approximately 1,700 pages). The number of units of analysis, however, was greater than this number because it represented the number of exercises. This was because mathematics textbooks seem to focus on exercises (Valverde et al., 2002). For a description of exercise and task, see figure 1 (with the publisher's permission). This resulted in a total of 2,217 units of analysis, because sometimes, there are two or more exercises on the same textbook page. In those cases, I assigned separate codes to the different exercises.

This means that an exercise consists of one or more tasks of the same kind. Problem-solving exercises, defined by Hiebert and Grouws (2002) as exercises in which students must struggle with important mathematics, such as occur in year 1 textbooks, were not part of this study's selection, because these exercises are designed to also offer content other than subtraction as an arithmetic operation. However, word problems were included in the selection. The chosen exercise examples are published with the publisher's permission.

A methodological choice on which I wish to comment concerns the use of exercises, rather than tasks, as the unit of analysis. I made this choice for three reasons: first, as mentioned earlier, mathematics textbooks appear to focus on exercises (Valverde et al., 2002); second, in a given exercise, a single type of mathematics content is practiced; and third, using tasks as the unit of analysis would have been too time consuming, given the large data set. This means that the study does not answer the question of how many subtraction tasks a given textbook series contains. This was a consequence of analysing such a large sample. Another methodological choice on which I wish to comment concerns the way that exercises in the digital textbooks should be coded for the

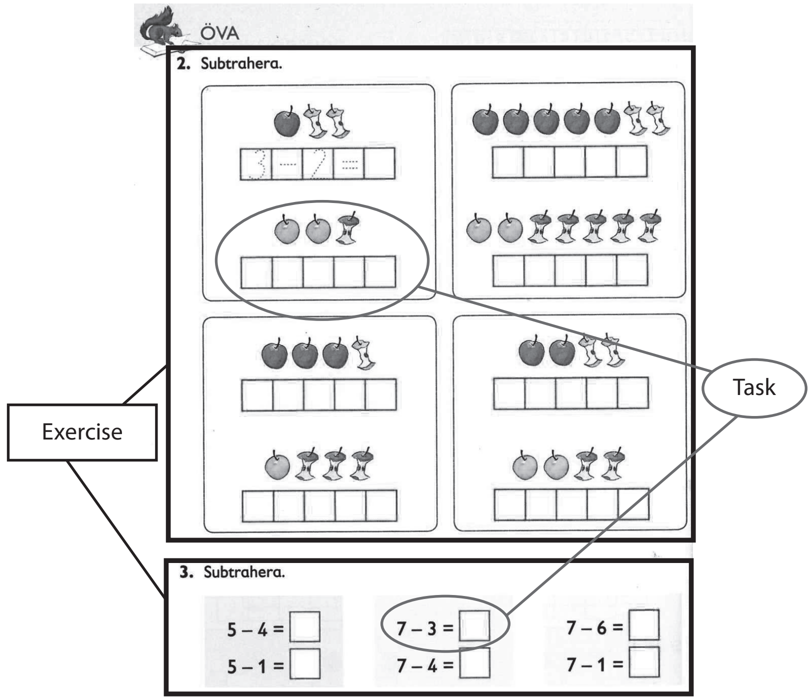

Figure 1. *Exercise and task (Favoritmatematik 1A. p.96; Ristola et al., 2012)*

purpose of comparison with the printed textbooks. The three digital textbooks for computers were coded in the same way as their printed versions, because they have the same structure. The only difference was that digital textbooks are read on a screen and have text-to-speech (TTS) capability. In the tablet textbook, each exercise consists of a unit of analysis, just like the printed ones. This caused some difficulties in comparing the tablet textbook to the other textbooks, because most of the exercises in the tablet textbook comprise more tasks than the exercises in the other textbooks do.

Framework for analysis

The framework for analysis was based on the aim to map out Swedish year 1 mathematics textbooks, focusing on exercise design. I focused on the extent to which subtraction exercises are used and which resources for communication are used. Therefore, the concepts of *subtraction* and of *resources for communication* became keywords. I compared Fuson's (1992) subtraction situations, subtraction as change take from and subtraction as compare, with the various resources for communication, writing, images, mathematical symbols, moving images, and speech, to form the basis of analysis in this study. I documented the textbooks one at a time, using one document for each textbook series.

The exercises were (a) first categorized for subtraction and whether a subtraction situation existed. An example of an exercise involving subtraction that does not address a specific subtraction situation may, for instance, say *subtract* in writing, and then, in mathematical symbols, denote $5-4=\_\_$ (see example in figure 1, lower exercise). That information does not express any specific subtraction situation, except for subtraction in general, and I therefore coded it as an exercise that does not express a subtraction situation. If a subtraction situation existed, I categorized the exercise by its type of subtraction situation, based on Fuson's (1992) subtraction categorization.

Next, (b) I documented the existence of resources for communication used in each exercise. I noted the number of resources for communication used in all exercises, because this is a useful approach to rendering principal descriptions of texts (Morgan, 2006). Then, (c) I documented the resource/resources showing the eventual subtraction situation that the exercise was designed to offer; (d) I also documented how the eventual subtraction situation was addressed. For instance, if the resource for communication that showed the subtraction situation was in writing, I documented the words that were used. If it was represented by an image, I documented the kind of image used. To qualify for coding in the moving images category, the subtraction situation had to be shown through moving images, and not through the narrator's speech (e.g. verbalizing the word *difference*) as still images were shown.

The following is an example of how this operated (see figure 1). This page consists of two exercises, and the writing says ”PRACTICE” and ”Subtract”: (a) the upper exercise shows a subtraction situation, but the lower one does not. The upper exercise was categorized as a change take from situation, as the images show apples and apple cores, implying that some of the apples have been eaten. Further, (b) the resources for communication used in the upper exercise consist of three different resources: writing, images, and mathematical symbols. Only two resources for communication were used in the lower exercise: writing and mathematical symbols. The lower exercise was not analysed further, because it did not contain a subtraction situation. In the upper exercise, (c) the images show which subtraction situation the exercises are designed to offer; (d) the images show episodes that are meant to be interpreted and can answer the following question: What has happened?

After this was complete, I compiled data from each textbook series into a document, which made it possible to view various textbook series individually as well as all together.

Findings

The analysis focused on mapping out Swedish year 1 mathematics textbooks, focusing on exercise design. I pursued this goal, focusing on resources for communication and subtraction as an arithmetic operation. First, the content of subtraction in Swedish year 1 textbooks is presented, describing the categories of subtraction that the exercises are designed to offer. This answers the first research question, about the extent of different subtraction exercises. Next, the way that resources for communication are used to represent subtraction is presented, answering the second research question, about the extent of different resources for communication. In these two sections, differences concerning subtraction exercises and resources for communication among textbook series are presented, thereby answering the third research question about the nature of the differences, if they exist. Last, in this section, I highlight the digital textbook series. Although they are in the minority, they comprise a larger number of resources for communication than the printed ones and are therefore of special interest. In all, this leads to mapping out Swedish year 1 mathematics textbooks, focusing on exercise design concerning subtraction and resources for communication.

Subtraction exercises in Swedish year 1 textbooks

Of the 2,217 analysed exercises, 63 % do not include a subtraction situation. Of the exercises that included a subtraction situation, 31 % involved a change take from situation, and 6 % involved a compare situation. The equalize category was not found in the data, as no exercises explicitly instruct the learner to use this category when calculating, which is the design necessary to make this category visible. Table 2 shows all textbook series, the number of subtraction exercises, and the distribution of subtraction offerings across the textbook series. To facilitate the interpretation of the tables, the five highest values in each category are marked grey in table 2–4.

In 12 of the textbook series, subtraction exercises that do not include a subtraction situation are the most common. Regarding the design of subtraction exercises, there are major differences between the textbook series, in terms of exercises that include subtraction situations. In only five textbook series – *Eldorado*, *Koll på matematik*, *Lyckotal*, *Pixel* and *Singma* – is it more common for a subtraction exercise to show a specific subtraction situation of any kind. The existence of subtraction exercises that do not address a subtraction situation varies significantly across the various textbook series, ranging from 39–92 %. Another major difference consists of the existence of exercises showing compare situations. Six of

Table 2. *Subtraction in Swedish year 1 textbooks*

Textbook	Total number of subtraction exercises	Change take from exercises (%)	Compare exercises (%)	No subtraction situation exercises (%)
Eldorado	108	27	27	46
Favoritmatematik	199	27	0	73
Favoritmatematik, digital	211	31	0	69
Koll på matematik	72	54	15	31
Lyckotal	67	37	16	46
Mattedetektiverna	39	41	5	54
Matte direkt safari	170	39	0	61
Mattekul	79	8	0	92
Mera favoritmatematik	232	23	0	77
Mera favoritmatematik, digital	243	26	0	74
Mitt i prick	109	33	3	64
Mondo	76	22	22	55
Nya matematikboken	128	33	10	57
Nya Mästerkatten	75	39	6	55
Pixel	77	36	23	40
Prima	67	28	9	63
Prima, digital	68	28	10	62
Qnoddarnas värld, tablet	37	35	0	65
Singma	107	51	9	39
Uppdrag matte	53	26	13	60
Total	2217	31	6	63

the textbook series – *Eldorado, Koll på matematik, Lyckotal, Mondo, Pixel* and *Uppdrag Matte* – show compare situations in 13–27 % of the subtraction exercises, and two of these show change take from and compare situations in the same proportion: *Eldorado* and *Mondo*. Six textbook series – *Mattedektiverna, Mitt i prick, Nya matematikboken, Nya mästerkatten, Prima* and *Singma* – show compare situations in 10 % or less of the subtraction exercises. Five of the 17 series – *Favoritmatematik, Matte direkt safari, Mattekul, Mera favoritmatematik* and Q*noddarnas värld* – do not cover compare situations at all.

Resources for communication in subtraction exercises

The resources for communication used in the printed textbooks include writing, images, and mathematical symbols, and speech and moving images are used in the digital textbooks. All resources for communication, except moving images, are frequently used in the textbooks for year 1 in the design of subtraction exercises. The answers to the tasks in the exercises are most often requested in the form of mathematical symbols.

In this section, I focus on the subtraction exercises including a subtraction situation. This is because subtraction situation exercises hold information regarding how subtraction as an arithmetic operation should be understood, which students are supposed to discover when working

Table 3. *Resources for communication in subtraction situation exercises*

Textbook	Number of subtraction situation exercises	Writing (%)	Speech (%)	Image (%)	Moving images (%)
Eldorado	58	91	-	41	-
Favoritmatematik	53	51	-	57	-
Favoritmatematik, digital	65	58	58	54	18
Koll på matematik	50	80	-	60	-
Lyckotal	36	61	-	58	-
Mattedetektiverna	18	44	-	72	-
Matte direkt safari	66	68	-	48	-
Mattekul	6	100	-	0	-
Mera favoritmatematik	54	50	-	54	-
Mera favoritmatematik, digital	63	43	43	56	19
Mitt i prick	39	85	-	13	-
Mondo	34	65	-	56	-
Nya matematikboken	55	58	-	58	-
Nya Mästerkatten	34	47	-	56	-
Pixel	46	87	-	46	-
Prima	25	60	-	72	-
Prima, digital	26	54	58	69	0
Qnoddarnas värld, tablet	13	46	46	85	77
Singma	68	87	-	56	-
Uppdrag matte	22	45	-	55	-
Total	831	65	10	54	4

with the exercises. These subtraction exercises thereby hold more information than subtraction exercises that do not include a specific subtraction situation. Subtraction situation exercises could therefore be understood as more interesting than subtraction exercises that do not include a specific subtraction situation.

Writing and images are the most common resources for communication when showing a subtraction situation (table 3). Here, it is important to note that sometimes more than one resource indicates a subtraction situation in an exercise. To form the subtraction situations, writing is used in 65 % of the exercises, and images appear in 54 % of the exercises. Speech is used in 49 % of the digital exercises containing subtraction situations, and moving images are used in 20 % of them. Mathematical symbols are not mentioned in this section because symbols cannot show a subtraction situation, only subtraction in general, which means that mathematical symbols must always be complemented by other resources for communication to represent a subtraction situation.

Additionally, regarding the use of different resources for communication to form subtraction situations, there are large differences among various textbook series. In four of the textbook series – *Koll på matematik*, *Matte direkt safari*, *Pixel* and *Singma* – writing is used 20–41 % more often than images, and that number increases to 50 % or more in three textbook series: *Eldorado*, *Mattekul* and *Mitt i prick*. There are reverse relationships in two textbook series, as images are used 28 % and 39 % more than writing in *Mattedetektiverna* and *Qnoddarnas värld*, respectively. In the remaining eight textbook series, the relationship between the use of writing and images is more equivalent, between 0–15 % either way. The use of speech is quite similar in all digital textbook series, but *Qnoddarnas värld* differs in use of moving images because this textbook series uses this resource in 77 % of the subtraction situation exercises, whereas the others use this resource modestly.

Following this general description, specific descriptions of the various subtraction situations will be given (table 4). According to a comparison of the two subtraction situations, resources for communication are used differently, especially in terms of the use of writing. Of the change take from exercises, 60 % use writing to form subtraction, compared to 88 % of compare exercises.

Four of the textbook series – *Eldorado*, *Mattekul*, *Mitt i prick* and *Singma* – use writing in more than 80 % of the change take from exercises. Nine textbook series – *Eldorado*, *Koll på matematik*, *Lyckotal*, *Mitt i prick*, *Mondo*, *Nya matematikboken*, *Pixel*, *Prima* and *Singma* – use writing in more than 80 % of the compare exercises. Only one textbook series – *Qnoddarnas värld* – uses images in more than 80 % of exercises when

Table 4. *Resources for communication in the different subtraction situation exercises*

Textbook	Subtraction as *Change take from*					Subtraction as *Compare*				
	Number of exercises	Writing (%)	Speech (%)	Image (%)	Moving images (%)	Number of exercises	Writing (%)	Speech (%)	Image (%)	Moving images (%)
Eldorado	29	83	-	48	-	29	100	-	34	-
Favoritmatematik	53	51	-	57	-	0	0	-	0	-
Favoritmatematik, digital	65	58	58	54	18	0	0	0	0	0
Koll på matematik	39	74	-	51	-	11	100	-	91	-
Lyckotal	25	44	-	68	-	11	100	-	36	-
Mattedetektiverna	16	50	-	69	-	3	0	-	100	-
Matte direkt safari	66	68	-	48	-	0	0	-	0	-
Mattekul	6	100	-	0	-	0	0	-	0	-
Mera favoritmatematik	54	50	-	54	-	0	0	-	0	-
Mera favoritmatematik, digital	63	43	43	56	19	0	0	0	0	0
Mitt i prick	36	83	-	14	-	3	100	-	0	-
Mondo	17	47	-	70	-	17	82	-	41	-
Nya matematikboken	42	45	-	67	-	13	100	-	31	-
Nya Mästerkatten	29	52	-	52	-	5	20	-	80	-
Pixel	28	79	-	61	-	18	100	-	78	-
Prima	19	53	-	74	-	6	83	-	67	-
Prima, digital	19	53	53	74	0	7	71	86	57	0
Qnoddarnas värld, tablet	13	46	46	85	77	0	0	0	0	0
Singma	58	84	-	55	-	10	100	-	60	-
Uppdrag matte	15	47	-	47	-	7	43	-	71	-
Total	691	60	12	55	5	140	88	4	53	0

forming change take from situations, and three – *Koll på matematik*, *Mattedetektiverna* and *Nya mästerkatten* – when forming compare situations. The use of speech and moving images follows the same pattern as subtraction situations in general, described earlier in this section.

Exercises and resources for communication in digital textbooks

Of the four digital textbooks, three use the shape of a printed textbook, although they are computer based. The fourth textbook, *Qnoddarnas värld*, differs in design and navigation because it is a tablet-based textbook. The three former textbooks are composed as spreads, often with several tasks and various exercises on the same spread, whereas the tablet textbook presents one task at a time. Another difference is that the tablet textbook is designed to sometimes offer a situation in which the student manipulates the tasks to solve them. For instance, this could be done by clicking on objects. Of all the 559 subtraction exercises, 70 % do not include a subtraction situation, and of the exercises that involve a subtraction situation, 29 % are derived from a change take from situation and 1 % from a compare situation.

Writing and speech are used to the same extent in all of the digital textbooks, except the tablet textbook. In the three computer-based textbooks, the student can choose to have the text read aloud through TTS by clicking on a button on the screen. In the latter, the reading starts automatically, but the exercise can be read out loud again if the student clicks on the icon marked with a question mark. It is, of course, possible to turn the tablet's sound off and thereby opt out of speech. It is worth pointing out that the quality of the TTS services varies. In one of the computer-based textbooks, the TTS is sometimes difficult to understand because the speech is monotone and uses strange phrasing. Additionally, mathematical symbols are sometimes not read aloud. Moving images are seldom used to form subtraction situations; only 6 % of the subtraction situation exercises use this resource. Two of the digital textbook series, *Favoritmatematik* and *Mera favoritmatematik*, sometimes use moving images to explain different types of content in the form of small lectures but do not use them in the exercises.

Summary and conclusions

The first research question concerned to what extent different subtraction exercises exist. The study shows that almost two thirds of the subtraction exercises do not include a subtraction situation. Additionally, 31 % of the subtraction exercises involve subtraction as change take from, and only 6 % involve subtraction as compare. This concludes that most of the subtraction exercises offer no specific subtraction situation but only subtraction in general, and that take away situations are much more common than comparison situations.

The second research question addressed to what extent different resources for communication are used to represent subtraction exercises. The study shows that when presenting subtraction exercises, writing, images, and mathematical symbols, as well as speech and moving images in digital textbooks, are used. All of them, except moving images, are frequently used in the textbooks for year 1 in the design of subtraction exercises. Writing and images are the most common ways to represent subtraction situations. To form the subtraction situations, writing is used in 65 % of the exercises, and images appear in 54 % of them. Speech is used in 49 % of the digital exercises containing subtraction situations, and moving images are used in 20 % of them. The answers to the exercises are usually in the form of mathematical symbols. This concludes that mathematical symbols are the most common form in which students should present answers; the other resources for communication used in mathematics textbooks are relatively evenly represented, except moving images.

The third research question focused on if, and if so, in what way, there are differences between textbook series regarding subtraction exercises and resources for communication. There are differences between the textbook series regarding both subtraction and resources for communication, and different textbooks offer different ways to understand subtraction. First, regarding subtraction. There is large variation between the different textbook series. For instance, some textbook series address both subtraction situations equally, and some only address change take from exercises. Second, regarding resources for communication. These results vary greatly between textbook series. Some textbook series are more writing based, and some are more image based. Some textbook series use writing and images equally. This concludes that (a) in some textbooks, students are given the opportunity to understand subtraction as both a take away and a compare situation, whereas in others, only as a take away situation. This means that students are given different opportunities to learn subtraction depending on the choice of textbook. Additionally, (b) various textbook series offer different kinds of readings, which implies that different working methods are required of the students depending on the choice of textbook.

Discussion

This study focused on exercise design in Swedish year 1 mathematics textbooks, with a delimitation to subtraction. This discussion will move between how subtraction and resources for communication form the exercises that the students encounter and how this differs between different textbook series. Overall, the discussion focuses on what is offered in Swedish year 1 mathematics textbooks in the content of subtraction, as well as challenges that might come along with this.

First, the analysis shows differences, sometimes large, regarding to what extent the two subtraction situations are addressed in various textbook series. Some textbook series address both subtraction situations equally, generally speaking. However, other textbook series include no exercises involving compare situations. Despina and Harikleia (2014) also found this in Greek textbooks: Compare problems barely existed. This implies that students do not always encounter both subtraction situations in their mathematics textbooks, which might lead to a simplified understanding of what subtraction means. year 1, a year in which subtraction as an arithmetic operation is a central concept, could be considered a year when subtraction is still quite new for students and a year when many students are still exploring what subtraction means mathematically. Therefore, it is important that students encounter various kinds of subtraction situations so that they can understand subtraction. These opportunities are not only offered in textbooks, as a wide range of teaching tools exist, but textbooks are common teaching tools (Mullis et al., 2012) and play an important role in this work. Otherwise, the student could gain only a simplified understanding of subtraction. Therefore, it is important that students who are still exploring what subtraction means can discover both subtraction situations.

Second, most exercises do not address a specific subtraction situation. This could have various consequences for the learner. If the student already knows that subtraction could mean either taking away or comparing, these kinds of exercises could provide math skills training. However, if the student is still exploring the meaning of subtraction, the unaddressed exercises do not support exploration. These exercises could then imply that subtraction is just a numbers game and has no deeper mathematical content. This is supported by the work of Alshwaikh (2016), who concluded that the reader could develop "to be more scribbler than thinker" (p. 179).

Third, resources for communication are used differently when addressing subtractions. Writing is the most commonly used, followed by images. Large differences exist in the use of writing between the two subtraction situations. Writing is used in almost nine out of ten of the exercises showing subtraction as compare, but it is only used in six out of ten exercises showing subtraction as change take from. This could imply that it is more difficult to use images in comparisons than in situations where something is taken away or that it is more important to develop the use of various resources to show comparisons. There are also differences between the use of writing and images in various textbook series, especially when representing change take from exercises. Thus, an important issue regarding the students arises. In some of the textbook series, more of the content is presented in writing, and in other series, more is presented in images. There are different aspects of this. On the one hand, many students are not yet considered good readers; therefore, reading written words could be difficult for them. On the other hand, Dyrvold (2016) concluded that interpreting images is part of what makes reading mathematics textbooks difficult. This is important to consider when designing beneficial learning situations for students.

Another issue regarding resources for communication deals with moving images. This resource is rarely used to show subtraction as something being taken away and is never used when it comes to comparisons. The latter could be because subtraction as compare is considered a static operation (Fuson, 1992); therefore, moving images might not be the most useful resource to represent subtraction as compare. However, moving images would be an excellent resource to show subtraction as change take from because this situation is considered an active operation (Fuson, 1992). Therefore, it is clear that this area requires further attention in textbook development. The discussion reveals that mathematics textbooks could be developed as teaching tools with a greater focus on different resources for communication because various resources for communication are needed to represent mathematics (O'Halloran, 2005). As previously mentioned, this development could lead to a greater variety of methods to offer mathematical content in textbooks generally and in digital textbooks specifically. However, this requires teachers to possess the necessary knowledge, which Grönlund et al. (2017) proposed.

Implications

Mathematics textbooks for Swedish year 1 differ, sometimes significantly. The textbook series show differences concerning the extent of exercises that both do and do not include a subtraction situation, especially in terms of exercises showing compare situations. This could lead to a simplified understanding of the mathematical content. There are also differences regarding the use of different resources for communication to form subtraction situations, which implies that different readings are needed in different textbook series. A pedagogical implication from this is that teachers need to be aware that students are given different opportunities to learn subtraction and different working methods are required by the students depending on the choice of textbook. This is important so that they can make conscious and wise decisions when choosing textbooks. As this is an important and time-consuming task, appropriate conditions should be ensured for teachers.

Implications for textbook authors concern the awareness of how subtraction is presented in the textbook series, as well as that mathematics textbooks can be better developed. Focus could be directed to how subtraction is presented and if both subtraction situations are represented in textbooks. Another point of discussion is why the majority of the answers in the exercises are requested in the form of mathematical symbols. The question is raised of whether a greater variation in resources for communication used to respond to the exercises, for instance images, would mean a greater variety of learning situations for the students. Furthermore, digital textbooks are largely similar to printed textbooks, except for the tablet-based textbook, because it uses another format showing one task at a time and, to some extent, manipulative tasks. This means that textbooks in a printed format still dominate the textbook market and that digital textbooks often offer the same subtraction exercises as printed textbooks but on a screen. Additionally, digital textbooks seldom use moving images to show the mathematical content and could be developed as teaching tools.

Altogether, this study shows that a textbook signature (Charalambous et al., 2010) regarding subtraction in Swedish mathematics textbooks for year 1 does not exist. Subtraction is presented differently in different textbook series, and therefore, the choice of mathematics textbooks affects how subtraction is presented to students and, by extension, what learning situations students encounter when working with the mathematics textbook.

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