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Kristina Holmberg
Lecturer
Halmstad University
Sweden

Lisbeth Ranagården
Lecturer
Halmstad University
Sweden

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Athens Institute for Education and Research
8 Valaoritou Street, Kolonaki, 10671 Athens, Greece
Tel: + 30 210 3634210 Fax: + 30 210 3634209 Email: info@atiner.gr
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Kristina Holmberg
Lecturer
Halmstad University
Sweden

Lisbeth Ranagården
Lecturer
Halmstad University
Sweden

Abstract

The public and academic debate about mathematics education has been intensified during the last decade. In relation to this, it is important to investigate what ideas concerning mathematics education are expressed by teachers and students. The aim of this article is to study repertoires and discourses related to mathematics education articulated by teachers and students in elementary school. The article is part of a larger project about mathematical education. Data consists of group conversations with 120 students and 8 teachers in two elementary schools in Sweden. The math project was supported by the National Agency for Education 2010-2012. All together 17 hours of video and audio documentation were produced. The theoretical framework is built on poststructuralist and social constructionist theory and two approaches to discourse analysis are applied; the micro oriented discursive psychology and discourse theory as formulated by Laclau and Mouffe. Findings show that the math book is central in the construction of the "good" mathematics education and can be seen as an ideological dilemma. On the one hand, the book becomes a symbol for security and support and is articulated as something associated with traditional and abstract mathematics education. The book becomes the home of mathematics, with power effects in the classroom activities. The book decides who is smart and who is not; it decides who needs help and when to wait for help. On the other hand, the 'good' mathematics education is excluding the math book. It is practical and built on students' participation and delight at the same time as it is structured around the norms of the book. The results are discussed in relation to quality in mathematics education.

Keywords: mathematics, education, discourse, ideological dilemma
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Introduction

During the last decade mathematics education in Sweden has been a subject to an intensive debate. All together, reports from PISA and TIMSS revealing worsening student results, rising status for school questions in political debates, and millions of Swedish crowns investigated to improve results in mathematics, has transformed mathematics education into a central public issue. Also, the number of international scientific publications in mathematical education has tripled since year 2002 (SummonTM search, 2014), indicating a growing international interest among researchers. According to Ryve (2011), the number of articles studying discourses related to mathematical education has increased, and he points out the importance of conducting studies in mathematics education using well-formulated theoretical perspectives. In accordance to this, our article is using a discourse analytical approach (Potter & Wetherell, 1987; Potter, 1996; Holmberg, 2010) to investigate the field of mathematics education. The aim of this article is to study repertoires and discourses related to mathematics education articulated by teachers and students in elementary school.

Theory and Method

Two approaches to discourse analysis are used, both founded in poststructuralist and social constructionist theory (Potter & Wetherell, 1987; Potter, 1996; Laclau & Mouffe, 1985). In discursive psychology, the sensitivity to various accounts of reality, and how knowledge is made persuasive is argued for (Potter & Wetherell, 1987; Potter, 1996). The preference is that knowledge continuously is being constructed by actors in an ever on-going rhetoric battle. Discursive psychology emphasises the rhetoric and how different acts of speech can become convincing in the social arena. Another analytical aspect is the researchers' creation of hypothesis related to possible consequences that different utterances in a conversation might have (Potter, 1996). By paying attention to this, the analysis can be further extended and the strategies that legitimize actions may become visible. This conversation analysis is a way to identify the rhetorical resources and the repertoires used in talk.

These repertoires are also important when discourses are the main interest, as they are in discourse theory formulated by Laclau and Mouffe (1985). Central in this theory is the logic of equivalence and difference applied to identify and demarcate discourses that are utilized in conversations. Discourse maps emerges and become visible to the researcher by building chains of equivalence. But discourse theory might as well be used complementary with discursive psychology (Ericsson, 2006; Holmberg, 2010). The discourse analytical posture is that everything always can be different, and that there always are alternative stories to tell (Burr, 1995).

This article is part of a larger project where elementary teachers' and students' discussions about mathematical education are investigated. Data consists of group conversations with 120 students and 8 teachers in two elementary schools in Sweden. All participants were interviewed twice, in the beginning and in the end of a math project that was supported by the National Agency for Education 2010-2012. All together 17 hours of video and audio documented empirical material were produced.

Focus of analysis is excerpts emanating from group discussions with teachers and students. The quotations are chosen to represent different repertoires, which also helps to organize the results. In the empirical material, a large amount of utterances present similar examples as the chosen excerpts and repertoires. A reduction of the number of quotations has been made in accordance with the theoretical perspective (Potter, 1996). Therefore, all identified repertoires are represented by only one or two excerpts. Some of the quotes are also possible to conform in more than one repertoire, which is not considered as a problem in a discourse analytical approach.

In the results of this article the "good" mathematics education should be understood as a discursive construction. To clarify this, quotation marks are used consistently thoroughly when we want to point at a concept as a local and temporal articulation.

The Math Book

In the following, five repertoires that in varied ways highlight the math book related to mathematics education are presented.

The Book as a Symbol for Security and Support

Teacher

> For me it would have been very difficult to put the math book aside… probably I would not trust myself… that I would bring everything in… then I would probably take a peak to see that I got all parts and stuff… and things

This utterance is handling teachers' trust in their own skills and their confidence in the math book. According to this teacher, the math book is defining the content of the mathematics education. It becomes a checklist used to support the teacher who thereby can keeping track of different mathematical topics. The large confidence in the math book enhances the authors' influence in mathematics teaching, where no considerations concerning the interests from the student group can be taken into account. In this perspective, the teachers' knowledge about mathematics and learning becomes insignificant. The teachers' task is merely to ensure that students do the tasks in the math book.

Thus, mathematics education is hegemonized by the **math book**, where the teacher becomes positioned as a communicator of a given content rather than as a responsible leader of different learning goals.

The **"good" mathematics education** is formulated as equal with the content of the math book.

The Book Associated with Traditional and Abstract Mathematical Education

Teacher

> I think that we have way too much written math… if we make it practical the kids can follow but when we come inside again and are working in the math books it is completely gone… I would like to work more with practical mathematics and diminish the abstract

The problem raised by this teacher concerns the translation between practical and abstract mathematics. Learning is described as successful when it comes to practical mathematics, but the same content managed in a more abstract way, seems to imply difficulties for student learning.

The statement also reveals an ambition for change, where the teacher would like practical mathematics to claim more space in mathematics education. Also, this account says that mathematics education provided at the present time is more abstract. This rhetoric is based on the idea that teaching should focus on activities that are successful for student learning, a convincing argument. On the other hand, what is not working will not be problematized and in the next step developed. As a result, the transformation from concrete to abstract is not considered a knowledge that needs to be a part of teaching and student learning.

The **math book** is constructed as abstract and insufficient.

The dominating way of teaching of mathematics emanates from the book. No desire to exclude the math book is expressed. Instead, the proposal is that the amount of teaching based on the book will decrease. The **"good" mathematics education** is constructed as a combination of a successful practical mathematics and a math book oriented problematic and abstract mathematics.

The issue is handling the difficulty of getting the abstract and practical mathematics intertwined.

The Book as the Home of Mathematics

Teachers

> Kate: […] there are not so many kids who think math is something useful, it is for the school… it becomes so abstract and then it's another thing when you make it practical…
>
> Doris: Oh no, it's not math anymore… if one has not worked in the math book one has not worked with mathematics…

According to this quote the students often constructs mathematics as a school issue and not to everyday life or life outside school. Mathematics is tied to the math book while practical mathematics is not articulated as mathematics.

> *Students 9-11 years old*
> Shirley: what is mathematics… tell us some different things so we can understand what you mean. (7 sec) thus… (2 sec) I don't know really…
> Leo: no, me neither…
> Shirley: me neither… (laughs a little bit)
> Hamish: (turns straight toward the camera and says very seriously an in a firm voice) no… mm… aha… plus, times… minus… (beats his hands together on the table in front of him and looks very proud)
> Shirley: mm.. it's… (4 sec)
> Hamish: I don't know… (mumbles something inaudible)
> Shirley: thus, it is the things that are in the math book, type…

Here, school mathematics is constructed as equated with the content offered by math books. Hypothetically, this is problematic because math skills are difficult to use in everyday life unless students can make connections to the world outside the math book. All pauses in the conversation also suggest that the question of what mathematics is, has urged the students to reflect. They have no quick answers, which may indicate that they have not discussed this earlier. As well, the question is not easy to answer. If teachers mostly use mathematical concepts when students are working with the math book, consequently math will be associated with the book. The teaching of mathematics that students in the conversation has been part of may be characterized as very practical mathematics, but if there is a lack of mathematical concepts in the discussion between teachers and students in these situations, the students can't be expected to make connections to mathematics.

In this perspective the **math book** becomes constructed as the creator of the boundaries of what mathematics can be. The mathematics is in math books, which in turn are in schools. Links to life outside school and to people's everyday lives are not made.

Mathematics education produced in the two excerpts above is based on the math book. No utterances can be tied to a rhetoric concerning the **"good" mathematics education** made by the teachers and students. Instead the quotes are interesting because they capture a repertoire that defines mathematics as the math book.

The Book Decides Who is Smart and Who is Not

> *Teacher*
> …and then I relate this to the math book… is it because I should be on page 323 when the others are at 248… so, it's the book that is important or is it the fact that mathematics is a way of seeing reality and… I use the numbers to count… not as a way to see how far I've come in the math book

This teacher is talking about mathematics teaching and the competition that the students often end up in, about who has advanced the furthest. In the quotation, the math book is created as a forum for the contest in which students with simple means can see how far they have come related to other students. Based on a rhetoric that revolves around the idea that those who find it easy with maths also are most advanced in math books, the book as a forum for contests becomes a way to measure how good you are. According to this, the teacher reflects on whether it's the math book or mathematics itself that is important.

The **math book** is constructed as limiting for the students learning in mathematics. The aspect that working in the math book easily goes to competitions is highlighted as problematic.

The **"good" mathematics education** is depicted as a teaching, which takes a broader look at mathematics than the math book can offer. Here a more philosophical approach is put forward that deals with mathematics as a perspective on reality.

The Book Decides Who Needs Help and When to Wait for Help

Students 7-8 years old

Manuel: sometimes it's a little… sometimes math is really hard…

Kristina: and what is it that…

Manuel: it's like when it's something we don't know, then I think it's hard, then you have to wait… well if you are really tired…

Fred: then you have to wait and wait until your brain knows…

Manuel: aah… (Sighs and lets his whole body collapse)

Kristina: okay, if I understand… if it is something that is awkward in the math book or when you're counting then you have to sit there and then you have to think about it yourself…

Manuel: yes, but sometimes it is enough to raise your hand and the teacher will come…

Kristina: yes…

This quote points out the individual work being done when the student sit alone and count in the math book. What seems to be frustrating for this student is that when he cannot solve a math task, he is supposed to wait. Either waiting means an individual effort where he himself should come up with a solution, or it means that he should raise his hand and wait for the teacher's assistance. Teaching in this conversation seems to be designed as individual work where students work on their own with their math books. This leads to a situation where the structure and progression of the book have a strong influence on whether a student needs help or not.

In the excerpt, waiting becomes a dominating part of what the students describes as problematic with mathematics education.

In the above conversation the **math book** is construed as a problem because it is used as a starting point for students' individual learning. If

students have problems they should find out strategies on their own to solve the problems.

The quote above shows a construction of teaching that could be considered a contrast to **"good" mathematics education**. Waiting is described as a hassle and overall this indicates that the students would be happy to alter this practice. The **"good" mathematics education** could herby be described as an education where students do not have to wait and instead could be active and work with mathematics continuously.

The Practical

In the following, two repertoires that in varied ways highlight the practical mathematics in relation to mathematics education are presented.

Practical Mathematics as Built on Students' Participation and Delight

The students have just described a math game they usually do. It's a game that trains mental arithmetic and it's about succeeding with as many of the linked assignments as possible. When the students fail, which means that she no longer knows which number is the answer, she should sit down. At the end there is only one winning student left. After the description of the game the following conversation takes place:

> *Students 12-14 years old*
> Kristina: But what do you think of the game then…
> Mary, Amy and Felice: It's fun…
> Kristina: it's fun, but it's not difficult then…
> Felice: yes it is…
> Amy: or it's much more fun to do math then…
> Ethel: because you get more, thus you take in more…
> Amy: you do not learn as much if you just sit and work in a book… and only do the instructions…
> Ethel: no, then there will be no fun…
> Amy: just sitting and becoming completely brainwashed…
> Kristina: but what's the funny part… it sounds… I think it sounds really hard… what's the fun…
> Marion: you have to think very much…
> Amy: it's a challenge…
> Marion: aah…
> Kristina: okey…
> Marion: you have to keep track of it all the time, it's challenging that it's more difficult… it's no fun if it's too easy… if it's a bit difficult then it's fun…
> Kristina: but it's not embarrassing when one can't…
> Amy: noo…
> Mary and Marion: noo…

> Amy: noo, there are not many that can do it…
> Mary: you've got to stand up for what you are…
> Marion: it's a pretty high level anyway, she says it very quickly so it's no wonder if you're out for the difficulty…
> Mary: yes it's difficult and it can be a little stressful, one can say…
> Ethel: they say high numbers…
> Kristina: yes that's right, it goes pretty fast…
> Mary: and high numbers…
> Amy: they say (talking fast) two times three divided by four, plus five, divided by three, very quickly and you just ba… ugh… de-de-de-de (wiggling her head sounding like a machine)
> Marion: and she did't cope… it's very… you have to think… then you train a lot of math…

According to this conversation the game is challenging, making the students think intensely. This teaching exercises the students´ ability to keep multiple devices at mind, to remember and to do mathematical calculations. They believe it's difficult and that few succeed, but nevertheless the game is experienced as enjoyable and fun. Here, thinking is tied to mathematics and it seems that it creates meaningfulness to the students. They make clear that they exercise very much mathematics in this form of teaching.

Learning in mathematics is also discussed in a comparison between the math game and the math book. According to the students the math book is about instructions that don't support learning the way the game does. It seems like the desirable in a demanding game also promotes learning at a larger extent.

The **math book** is construed as limiting related to what a math game can offer. Working in the book just involves following instructions, which are not perceived as pleasurable.

The **"good" mathematics education** is produced as a practical mathematics that also focuses on developing student mathematical abilities, such as students' mathematical thinking. This teaching is also fun and challenging for students.

For a while the teachers have been talking about practical mathematics where the students pretend to shop at Ullared [a very famous Swedish shopping centre with low prices] and working with the Idefix-house [a mini-house used for math tasks]

> *Teachers*
> One last question… do you know that it's good to work like this…
>
> What you can see is the joy…. the children are on pretty quick with ideas and then the imagination starts… we can se that they

> feel good when they're so so involved… and somewhere along the way they lose the joy of math but here it seems as also the slightly older kids like this and are engaged…

According to this teacher, working with practical examples in mathematics education provides motivation and joy for the students. By involving the students and allowing them to create their own math tasks, they can use their imagination, which seems to contribute to motivation. This type of mathematics teaching also has a therapeutic function in the sense that the students get to feel good.

In the quotation, a parallel is drawn to a kind of normality where pupils through their education lose the joy of facing mathematics. Despite this statement, a line is drawn between the joy-killing education and their own joyful education. The specific mathematics advocated by the teacher, offers an education in which students, even though they get older, can continue to have involvement with mathematics.

Hypothetically, on the one hand, it is possible to provide the "normal education" with content, based on how the teacher describes the opposite, "the practical teaching". Practical mathematics teaching is articulated as something that creates the following chain of equivalence: *Joy – Interest – Motivation – Students can use their imagination – Students feel good – Participation – Involvement.* On the other hand, based on the logic of difference, the following chain of equivalence can be created to describe the "normal mathematics education": *Not joy – Disinterest – Not motivation – nonparticipation.* The normal education of mathematics is also articulated by being a contrast to the *practical mathematics* and can thus be constructed as *abstract mathematics* and the *math book mathematics.*

Based on the analysis made above, the **math book** is construed as a contrast to the mathematics teaching advocated by the teachers in the conversation, and the math book becomes completely excluded from a concrete everyday mathematics.

The **"good" mathematics education** is portrayed as a practical activity where students, starting from themselves and their interests, may shape the tasks that they should work with. This teaching becomes democratic by student influences, and this teaching creates delight and joy for the students. Finally, this teaching has a therapeutic dimension as it makes the students to feel good. The effects of such an education seems to create motivation among both younger and older students, something that the normal mathematics education falls down on, according to the analysis.

Practical Mathematics as Also Constructed Around the Norms of the Book

This example is really about mathematics content in a book in civics. The argument about how numbers and dimensions of the books should be handled in the teaching is the same as in mathematics teaching. It's also what the conversation revolves around when one of the teachers starts to talk about a math example in the book:

> *Teacher*
> Yes I'm a teacher in civics and we've talked about the Viking Age and been out on the schoolyard and measured how large Viking ships were… it was a totally different experience than just seeing a number in a book… one want to experience that, what one has learned is useful to know… also that the knowledge they have learned can be useful in another context…

According to this teacher, working practically with mathematics gives other experiences than the abstractions found in the book. Usability aspects are also important. Students want to be aware of the practical utility of mathematics, and that lesson stuff also can be used in other contexts such as in the schoolyard. The mathematics in the example is about concrete dimensions of ships, as part of the teaching in Civics. According to the teacher it is the students' perception of size that is important.

Such reasoning has implications for the usefulness of the book as it in itself fails to provide students with experiences that they can achieve by translating mathematical abstractions into something concrete in reality. Also, by concretize through practical examples mathematical utility and usability becomes clear to students, which creates motivation.

The **(math) book** is construed as inadequate for student learning because its content is too abstract. Knowledge is in the math book, but this is not sufficient for student learning. Also, to get the experience, benefits and relevance related to mathematics need a concrete and practical mathematics.

In this example, **"good" mathematics education** is articulated as a combination of books and practical exercises. The book defines the mathematic content, but for learning to take place, teachers need to turn knowledge into something concrete.

Discussion

In the first part the repertoires are discussed and structured around three discourses. In the second part the ideological dilemma is discussed.

The Math Book and the "Good" Mathematics Education

The results show that the "good" mathematics education in various degrees relates to the math book. Three discourses are emerging from the results: *School mathematics, Balance* and *Mathematical ontology,* and is presented below.

School Mathematics

In *The book as a symbol for security and support* and in *The book as the home of mathematics* (3.1 and 3.3) a strong link between math book and math teaching occur. Here, school mathematics is created which reveals difficulties

to step outside school to bound with students everyday life. Also, when the definition of mathematics is limited to the math book the authors become a key players in education. The teachers' position is marginalized and the main task is to communicate a mathematical content that external actors decide.

Quality in this teaching is strongly linked to the math book and that all children should do the same things in the same order. It also embraces the idea that knowledge and exercises available in the math book are correct, so it can be used as a template for the optimized math content. The problem that emerges on the basis of such reasoning is the lack of considering students'. If the quality of this education should be developed it would primarily be directed to an improvement of the structure and format of the math book.

Balance

In the excerpts called 3.2, 3.5 and 4.2: *The book associated with traditional and abstract mathematical education, The book decides who needs help and when to wait for help* and *Practical mathematics as also structured around the norms of the book* combinations of activities including both the math book and practical exercises are produced. The content of the math book is articulated as something abstract and insufficient to help the teaching achieve good quality. Rather the activities with the math book need to be complemented by practical and concrete teaching. Such teaching is successful because it manages to give students experiences of mathematics, the students will discover how abstract mathematics can be used in reality. The teacher occupies a strong position as the responsibility to balance the content largely rests on the teacher. This education also requires a teacher that is updated with students' level of skills so that the content can be customized.

Quality in this teaching is strongly linked to the integration between the abstract and the concrete. It is about creating balance and not to do too much of one or the other. In line with this reasoning, quality is improved through intensified integration where it becomes even clearer that the abstract and concrete presuppose each other.

Mathematical Ontology

In 3.4 and 4.1: *The book decides who is smart and who is not* and *Practical mathematics as built on students' participation and delight* a mathematics education emerges that freed itself from the power of the math book when creating teaching content. Here, the reasoning is about mathematical skills, mathematical thinking and mathematical perspectives on reality. A mathematical ontology appears as a basis for teaching where students will discover the mathematical and practice on how to think mathematically. It is also interesting that challenging mathematics is portrayed as something positive and fun. This education also includes democratic aspects when students are given influence concerning the tasks. Perhaps the most surprising articulation is about the therapeutic dimension of this teaching, as the students are regarded as feeling good by doing mathematics this way. This teaching requires flexibility and creativity among both teachers and students.

Quality in this teaching stands out as a joint project for teachers and students. With the mathematical ontology as a starting point, greater creativity and more ideas can improve the quality.

The Ideological Dilemma

In several quotes the math book is described as somewhat problematic for the participants because of its power in teaching. The math book creates an educational content and forms a template where teachers can check the teaching content. At the same time a desire to work in a more concrete and practical way is expressed. Although the rhetoric revolves around the concrete and practical mathematics, the math book is there as the basis for the mathematical content, resulting in a dilemma for the teachers who not fully can work as they wish. The clearest example from the excerpts presented here is *The book as a symbol for security and support.* The dilemma appears to the teachers as an uncertainty about their own math skills and therefore, the book has to be used as a support, even if the teachers might prefer to free themselves.

If on the one hand, teachers completely rely their work on the math book, their own conviction that practical mathematics is preferable disappears. If on the other hand, the teacher only works with practical mathematics, the mathematical content would be lost as the teachers have no trust in their own math skills and therefore need the math book.

Conclusions

The results of this article point out the mathematics teaching in elementary school as a multifaceted and interesting area. In particular, the math book appears as central to the creation of teaching by all discourses emanating from the empirical material. The math book can be used as a base for teaching, for balancing teaching, or as the antithesis of the teaching advocated. Even in the ideological dilemma that emanates from the empirical data, the math book is central. Here the teacher is chained by the math book and is unable to free him-/herself in order to perform the desirable practical teaching.

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