

Original Paper

When Students' and Teachers' Views on Good Mathematics Teaching Limit Co-teaching in Mathematics

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Abstract

The empirical material in this paper is from a Swedish upper secondary school where the mathematics lessons over the last two years have been co-taught. Co-teaching implies that two teachers are most often present in the classrooms during the mathematics lessons. Despite this additional support, students' performance in mathematics remained low and this is why a professional development program was initiated. The aim of the professional development program was to find new ways to increase the number of approved students. At the start of this professional development program, classroom observations and a questionnaire were conducted with teachers and students. The results indicate that teachers' and students' views on good mathematics teaching became a limitation for the design of the co-taught lessons. Thus, to increase the number of approved students, teachers' and students' views on good mathematics teaching ought to be the focus of the professional development program.

Keywords

co-teaching, mathematics, professional development, teachers' views, students' views

1. Introduction

This paper is based on empirical material from a professional development program at a Swedish upper secondary school. All the mathematics teachers at the school were involved in a one-year professional development program where the author of this paper acted as organiser and facilitator. According to Liljedal (2014), research on the professional development of mathematics teachers can be sorted into studies focused on knowledge and/or beliefs, on the method used in the professional development program or on the effectiveness of the professional development program. Furthermore, research on professional development generally focuses on change of some kind. As the core of professional

development is teachers developing their teaching for the benefit of students' learning, some kind of change is always present in professional development programs (Sowder, 2011; Avalos, 2011). The aim with the professional development program at the school in this study was to increase the number of approved students in mathematics. The majority of the students at the school are involved in vocational programs with one obligatory mathematics course. Many of the students fail this course even though its content is almost identical to the final mathematics course at lower secondary school. Thus, even though the students have passed a similar mathematics course at lower secondary school, many of them have problems with the mathematics course at upper secondary school. To improve students' learning, co-teaching in mathematics was implemented at the school two years ago. Co-teaching implies that most often two mathematics teachers are present in the classrooms during the mathematics lessons. However, despite this many student still have problems with the obligatory mathematics course why the aim of the professional development program was to find new ways to increase the number of approved students.

Knowledge *of* practice was chosen as approach for the professional development program at the school. This approach has become increasingly prominent in recent years as it has shown to promote teachers to develop their teaching for the benefit of students' learning (Avalos, 2011; Sowder 2007). The approach implies teachers' using their own classrooms to investigate learning, knowledge and theories (Cochran-Smith & Lytle, 1999). A challenge with a knowledge *of* practice approach is that teachers sometimes reinterpret new guidelines and their own teaching in ways that enable them to avoid changes (Morgan, 2009). Thus, the first step of the professional development program was to investigate and describe the ongoing mathematics teaching at the school. As mentioned, the ongoing mathematics teaching at the school was conducted through co-teaching. Co-teaching has evolved from inclusive educational practices and even though it has been used since the 1960's (Cook & Friend, 1995) it has increased in later years (Roos, 2019). However, at the school focused on in this paper the initiative for co-teaching was not mainly inclusion but to increase the number of approved students in mathematics. The first step in the professional development program was to investigate and describe the ongoing mathematics teaching. Classroom observations of mathematics lessons were made by the researcher. The observed mathematics lessons were most often co-taught by two mathematics teachers. Also, a questionnaire was conducted with teachers and students. One part of this questionnaire focused on connections between teachers' teaching and students' learning as well as on how a mathematics lesson ought to be designed to promote students' learning. The issue to be elaborated on in this paper is possible connections between teachers' and students' answers on the questionnaire and the design of the observed co-taught mathematics lessons. More explicit the paper will focus on the following research questions:

- What are the teachers' and students' views on how a mathematics lesson ought to be designed to promote students' learning?

- How can the observed co-teaching be understood in relation to teachers' and students' views on how a mathematics lesson ought to be designed to promote students' learning?

In the professional development program, the aim with investigating these questions was to understand the present to be able to promote changes that hopefully would increase the number of approved students in mathematics in the future. However, in this paper the aim with investigating these questions is to increase knowledge of the conditions for co-teaching in mathematics since this is a field rarely investigated (Magiera, Zigmond, & Practice, 2005).

1.1 Co-Teaching

Co-teaching in mathematics takes place in both primary and secondary school (Scruggs, Mastropieri, & Mcduffie, 2007) and can be conducted very differently (examples below), both when it comes to the categories of teachers that work together and how the teaching in the classroom is organized (Cook & Friend, 1995). Despite these differences, co-teaching can be understood as “two or more professionals delivering substantive instruction to a diverse, or blended, group of students in a single physical space” (Cook & Friend, 1995, p. 1). The most common form of co-teaching is when one subject teacher and one special education teacher work together in an inclusive classroom (Scruggs, Mastropieri, & Mcduffie, 2007). Thus, the co-teaching model at the upper secondary school in this study with two mathematics teachers co-teaching is less common. No matter what categories of teachers that collaborate, Cook and Friend (1995) have found five different organizations of co-teaching; one teach-one support, station teaching, alternative teaching, parallel teaching and team teaching. One teach-one support implies a classroom where the lessons are conducted in whole class and one teacher leads the lessons and the other teacher offers individual support to students. In station teaching the content of the lesson is divided into two segments presented in separate stations in the classroom between which the students rotate. The two teachers have responsibility for one station each. In alternative teaching one teacher works with a large group of students while the other teacher works with a small group of students. The content in these groups may or may not be the same. In parallel teaching the class is divided in halves and the teachers teach the “same lesson” at the same time but to one of the groups each. Finally, team teaching implies that both teachers share the instruction in one classroom, thus the class is not split and both teachers are responsible for the instructions to the whole class.

A meta-synthesis of 32 qualitative studies on co-teaching (not specially focused on mathematics education) shows that the organization one teach-one support is the dominant organization of co-teaching with few examples of “truly collaborative models” (p. 411) and few visible changes of classroom instructional practices. Further, the meta-synthesis shows that many teachers involved in co-teaching believe that co-teaching has a positive effect on students learning and on the professional development of the teachers. According to the meta-synthesis administrative support, volunteerism, compatibility of co-teachers, joint planning time and teacher training are important factors for successful co-teaching (Scruggs, Mastropieri, & Mcduffie, 2007). Even Cook and Friend (1995)

emphasize that co-teaching ideally includes collaboration in all facets of the educational process including designing intervention strategies, evaluating student progress, assess students learning and evaluating the effectiveness of the co-teaching process.

1.2 The School

The upper secondary school focused on in this paper is located in a medium-sized Swedish town. The school offers several vocational tracks and one academic track (all tracks are three years). The grades required to be accepted at the school are quite low compared to the average on a national level (Swedish National Agency for Education, 2019). However, the grades required to be accepted at the school are similar to other schools offering mainly vocational tracks. For the students at the vocational tracks, one mathematics course is obligatory. For the students at the academic track, two mathematics courses are obligatory. In Sweden, the grades A-F are used where A implies excellent and F implies fail. The students at the vocational tracks must have at least grade E on their obligatory mathematics course to get their certificate. Students at the academic track must have at least grade E to be qualified for any further studies at university. The grades among the students who took the first obligatory mathematics course (thus students from both vocational and academic tracks) the year before the professional development program was initiated were distributed as follows (Table 1).

Table 1. Distribution of Grades the Previous Term

Grade	A	B	C	D	E	F
Number of students	5	13	44	43	106	36

There are several possible explanations for the low grades, for example lack of substantial pre-knowledge, less good mathematics education at the upper secondary school, students having poor self-esteem, bad motivation, fixed mindsets, etc. However, whatever the explanation might be, the problem remains that the most common grade is an E and that several students fail the obligatory mathematics course. As mentioned, in an attempt to reverse this trend, co-teaching in mathematics was implemented at the school two years before the professional development program was initiated. Based on organizational matters, the headmasters decide which pair of teachers that co-teach. During the two years the most mathematics lessons have been co-taught by two mathematics teachers. If needed, there are special education mathematics teachers available at the school. However, despite this addition of co-teaching in mathematics the low exit grades remains (Table 1). These low grades were the starting point for a professional development program aiming at increasing the number of approved students in the mathematics course.

2. Method

The initiative for the professional development program came from the headmasters and, based on this initiative, the author of this paper acted as organizer and facilitator. All 16 teachers in the professional development program are educated as upper secondary school mathematics teachers. The teachers (6 female and 10 male) had been teaching mathematics in upper secondary school between 5 and 20 years. Some of the teachers had further experiences of mathematics teaching at other grades and/or other countries. Some of the teachers taught only mathematics but most of them also taught one or two other subjects. The students selected for this paper are the 271 who started at the school the same term as the professional development program was initiated (both vocational and academic tracks). Of these students, 7 had grade A in mathematics in lower secondary school, 19 grade B, 29 grade C, 50 grade D, 145 grade E and 19 grade F (F indicate failing mathematics in lower secondary school). According to the headmasters, the distribution of the entrance grades of this cohort did not deviate from the usual. If comparing to Table 1 the entrance graded of these students were distributed similar as the exit grades of the students who took the mathematics course the previous year.

All requirements for information, approval, confidentiality, and appliance advocated by the Swedish Research Council (2017) were followed. According to these requirements, students older than 15 can decide by themselves if wanting to be involved in research or not. The students got information of the study from their mathematics teacher. Even though the students were older than 15, their parents were informed about the study and both students and parent were to agree about participation in the study. Not participating in the study did not influence the mathematics education of these students.

2.1 Observations

Before the start of the professional development program, all teachers were observed during at least one mathematics lesson. The intention was to get some insight into the ongoing mathematics teaching and the design of the co-teaching at the school. An observation template was used during these observations. This template included *expectations* (e.g., Are expectations on teachers/students expressed? Is the content motivated? If it is, how?); *content* (e.g., Is the content adapted to different students? What kind of tasks? Tasks from textbooks or other material?); *design of lesson* (e.g., Structure? Who talks when? Who asks and who answers questions?) and the *co-teaching* (e.g., How is the teaching organized between the teachers? Do the teachers have different roles? If they have, which roles?). During the observations the researcher was sitting at the back of the classroom making notes in the template based on its questions. After each observation a summary of the lesson was also written.

2.2 Questionnaire

Before the start of the professional development program, a questionnaire was conducted with teachers and students. The questionnaire was digital, anonymous and almost identical to teachers and students. The students conducted the questionnaire during a lesson that was selected by their mentor teacher. Thus, the lesson was not a mathematics lesson but a lesson that the students have each week with their mentor teacher. The teachers conducted the questionnaire at a time they themselves decided. The

questionnaire covered a large area of questions whereof only some will be focused on in this paper. These are the questions that are connected to the research questions in this paper, thus questions related to teachers' and students' views on how a mathematics lesson ought to be designed to promote students' learning. These questions were both questions presenting claims with fixed response options (e.g., working alone with tasks in the textbook is a good way to learn mathematics) and open questions (e.g., what would you say is the similarities and the differences between mathematics lessons in lower and upper secondary school?).

2.3 Analysis

The analysis made of the questionnaire focused on teachers' and students' views on how a mathematics lesson ought to be designed to promote students' learning. Then, this result were connected to the design of the observed mathematics lessons. Even though the observed lessons were on different mathematical topics and were co-taught by different teachers to different students, the lessons were very similar in their design. Based on these similarities, the observed lessons will be presented as a typology. A typology is based on the common features (Atkinson, 1990; Hammersley & Atkinson, 2007) from all of the observations. Thus, the typology presented here is an analytic construction based on repeating patterns from all the observed lessons. The questionnaire was compiled digitally with one result for the teachers and one for the students. When analysing these questionnaires, it became apparent that the views on mathematics teaching, students' learning as well as the views on how a mathematics lesson ought to be designed to promote students' learning were very similar for teachers and students. In the results, these similarities will be elaborated on in relation the typology of the observed co-taught mathematics lessons.

3. Result

First in this section, the typology lesson will be presented and after this the results from the questionnaires. The two sections with results from the questionnaires will focus on the first research question—"What are the teachers' and students' views on how a mathematics lesson ought to be designed to promote students' learning?"

3.1 The Observed Lessons—Presented as a Typology

Approximately 20 students sit in single desks arranged in rows with the board at the front. When the lesson starts, one teacher is standing at the board and the other is seated at a desk next to the students. The teacher at the front starts to introduce today's topic by saying "today we will continue with...". After this, the teacher writes and solves some tasks on the board. Now and then the teacher asks a question to the students. Approximately three or four different students answer these questions. During this part of the lesson some of the students listen to the teacher, some copy what the teacher is writing on the board in their note books and some students seem to be occupied with something else than mathematics. After about ten or fifteen minutes the students are to work on tasks in their mathematics textbook. Now the teacher who sits in a desk rises. The rest of the lesson the two teachers walk around

in the classroom helping students who raise their hands. Sometimes the students talk to each other but it is relatively quiet in the classroom. When no students are raising their hands, the two teachers either talk to each other or to students who are not working on the tasks trying to get them started.

3.2 Questionnaires

As mentioned, the two sections below with results from the questionnaires will focus on the first research question—“What are the teachers’ and students’ views on how a mathematics lesson ought to be designed to promote students’ learning?” The explicit questions from the questionnaire are provided in the results below.

Questionnaire teachers

13 teachers (of 16) answered the questionnaire. Thus, there was a drop-out of three teachers. All teachers who answered the questionnaire emphasize that a good teacher is needed for students to learn mathematics. But what is then a good mathematics teacher? All of the teachers agreed *a lot* or *quite a lot* with the claim that teachers presenting solutions of tasks (not tasks solved by students but new tasks) on the board is a good way for students to learn mathematics. Further, all but one of the teachers agreed *a lot* or *quite a lot* with the claim that students working individually in their textbook is a good way for students to learn mathematics. All of the teachers agreed *a lot* or *quite a lot* with the claim that getting tasks individually explained by a teacher is a good way for students to learn mathematics. The teachers agreed more strongly with these three claims than they did with two other claims focused on group activities and on problem solving as a good ways for students to learn mathematics.

Questionnaire students

263 students (of approximately 270[1]) answered the questionnaire. 250 of them *agreed strongly* with the claim that a good mathematics teacher is important for their possibilities to learn mathematics. Who is then a good mathematics teacher according to the students? 231 of the students agreed *a lot* or *quite a lot* with the claim that teachers presenting solutions of tasks (not tasks solved by students but new tasks) on the board is a good way for students to learn. 238 of the students agreed *a lot* or *quite a lot* with the claim that students working individually in their textbook are a good way to learn mathematics. (Unfortunately, the students were not given the claim about teachers explaining individually is a good way for students to learn mathematics.) Similar as the teachers, the students agreed more strongly with these two claims than they did in other claims focused on group activities and on problem solving as a good way for students to learn mathematics. The students were also asked about similarities and differences between the mathematics lessons in upper secondary school and lower secondary school. This question was asked since the students at the time for the questionnaire had just started upper secondary school. Thus, their main experiences of mathematics education at the time for the questionnaire was from lower secondary school. However, they had had enough of mathematics lessons at upper secondary school to be able to judge similarities and differences between that mathematics education and their previous experiences. Even though this was an open-ended question, the students were very unanimous when describing the mathematics lessons at these two levels (lower

secondary-upper secondary) as very similar. In free wordings they described the design of the mathematics lessons and the content in the lessons as very similar, for example:

The design of the lessons is the same.

I think that the most in upper secondary school is very similar to lower secondary school.

The design is the same, introduction by the teacher at the board and then own work in the text book.

The only thing that some of the students wrote as being different was that they expressed that the teachers at upper secondary school were better on explaining how to solve mathematics tasks than the teachers at lower secondary school, for example.

Better introductions by the teacher, better teachers, the teachers show more interest in each student at upper secondary school and the teachers are better.

Regarding the level of difficulty some students wrote that the mathematics at upper secondary school was harder than the mathematics in lower secondary school while other students wrote the opposite. The students also got a question about their grade in mathematics at lower secondary school where a majority (79%) wrote having grade D-F (the lowest grades).

3.3 Connections between Observations and Questionnaires

This section will focus on the second research question—“How can the observed co-teaching be understood in relation to teachers’ and students’ views on how a mathematics lesson ought to be designed to promote students’ learning?”. Thus, in this section the observed co-taught mathematics lessons that above was presented as a typology lesson will be connected to teachers’ and students’ views on how a mathematics lesson ought to be designed to promote students’ learning.

Of course, there were individual differences in the observed lessons but, all observed mathematics lesson was conducted in whole class where one teacher led the lesson and the other offered individual support to students. Thus, all the observed lessons—despite being co-taught by different teachers to different students—was designed as *one teach-one support* (Cook & Friend, 1995). The lessons started with the teacher leading the lesson introducing today's topic by counting some tasks on the board and after that the students worked on tasks in their mathematics textbook.

The design of these lessons is according to the questionnaires in line with both teachers’ and students’ views of good mathematics lessons. Both teachers and students agreed *strongly* or *quite strongly* with the claim that teachers presenting examples of solutions of tasks on the board as well as with the claim students working individually in their textbooks are good ways to learn mathematics. Based on the questionnaire to both the teachers and the students, a good mathematics teacher is a teacher who teach mathematics by presenting examples of solutions of tasks on the board and then gives the students time to work individually in their textbooks. In the questionnaire the teachers also agreed *a lot* or *quite a lot* with the claim that getting tasks individually explained by a teacher is a good way to learn mathematics. This is in line with the observed lesson where one teacher led the lesson and the other offered individual support. Thus, the coherence is strong between the mathematics lessons observed and the

teachers' and students' views on good mathematics lessons. The observed co-taught lessons are according to the teachers and students answers in the questionnaire designed to promote students' learning of mathematics.

4. Discussion

As presented above, the observed co-taught lessons are in line with teachers' and students' views on how a mathematics lesson ought to be designed to promote students' learning. The teachers' and the students' views on how a mathematics lesson ought to be designed to promote students' learning confirm each other and the co-teaching at the school seems to have become "more of the same". The teachers have implemented one teach-one support (Cook & Friend, 1995) as their co-teaching model and, instead of one teacher explaining tasks individually for the students now two teachers do the same. There is however one problem with these lessons; based on the previous exit grades of the students at the school the students do not really seem to learn mathematics based on them. As mentioned in the introduction, it is important to investigate and describe the current state when working on professional development through the approach knowledge *of* teaching. However, at this school, both teachers and students expressed the ongoing design of the mathematics teaching as good, which may be why the change when implementing co-teaching was low. Based on the teachers' views on how a mathematics lesson ought to be designed to promote students' learning, when co-teaching was implemented very little, or nothing, was changed in the design of the mathematics lessons.

Based on the questionnaire to the students, they had prior experience of this design of mathematics lessons from lower secondary school. However, even though 79% of them had grade D-F (low grades—failed grades) in lower secondary school they still evaluated this kind of mathematics lessons as promoting students' learning. This may be due to these students never having experienced any other kind of mathematics lessons. Similar, the teachers have prior experience of this kind of teaching from upper secondary school where a majority of their students get low grades (last semester 75% of the students had grades D-F). Of course, these grades may be related to motivation, attitudes, pre-knowledge, etc., but nothing of that will change by more of the same kind on mathematics lessons. When co-teaching was introduced in a try to raise student achievement the organisation became *more of the same* where two teachers instead of one provide individual explanations to the students. This design of co-teaching is in line with the previous presented metasynthesis on co-teaching by Scruggs, Mastropieri and McDuffie (2007) showing that *one teach-one support* is the dominant design of co-teaching. Similar to the meta-synthesis the co-teaching at the school included few examples of collaborative and innovative models and few changes of classroom instructional practices.

Teachers and students view on how a mathematics lesson ought to be designed to promote students' learning confirm each other's and when co-teaching was introduced at the school the design of the mathematics lessons continued to be in line with the expected. Probably, even if using another design of co-teaching the classroom instructional practices would not change much. According to Hargreaves

and Fullan (2012), teacher collaboration can lead to improvement but then it has to be spontaneous, voluntary, unpredictable, and oriented towards development. The co-teaching at the school is quite the opposite, not spontaneous or voluntary and, rather than oriented towards development it is oriented towards consolidation of existing practice. This consolidation is supported by the views on of both the teachers and the students on how a mathematics lesson ought to be designed to promote students' learning. Based on the results presented in this paper teachers' and students' views on how a mathematics lesson ought to be designed to promote students' learning must first be focused on if wanting co-teaching to make a difference. Then, maybe co-teaching can be re-organised in a manner that will increase students learning of mathematics.

[1] 271 students started at the school this semester. However, the first weeks of the semester some new students started while others dropped out. This is the normal each year and based on this, the exact number of students at the week when the questionnaire was conducted is not known. Thus, the exact drop-out is not known but almost all students answered the questionnaire.

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