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# EVALUATION OF A LARGE SCALE PROFESSIONAL DEVELOPMENT PROGRAM

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*This paper reports on a part of an evaluation of the professional development program (PDP) Boost for Mathematics in Sweden. Around 200 mathematics lessons were observed, and the teachers were interviewed after each lesson. The findings indicate that the PDP has had a significant impact on the teachers' knowledge about the mathematical competencies as they are presented in the national curriculum documents, and that the teaching practice had improved and now gives the students better possibilities to develop the competencies. The results also show that these improvements are still present one year after the program had ended.*

## INTRODUCTION

There is an international trend towards competencies (reform mathematics), and several professional development programs (PDPs) have been performed (e.g., Boesen et al., 2014). In Sweden, Boost for Mathematics (Sw: Matematiklyftet) was a professional development program carried out in the years 2012-2016. It was a large scale program, and about 80 % of all Swedish mathematics teachers in compulsory and upper secondary school (school years 1-12) have participated, a total of 33,580 mathematics teachers. The two-folded aim was to develop the teaching culture and the professional development culture at schools. Four didactical perspectives guided the professional development program: 1) Teaching for the development of mathematical competencies, 2) Formative assessment, 3) Routines and interactions in the classroom, and 4) Classroom norms and socio-mathematical norms. The result of this PDP has been evaluated (Österholm et al., 2016). The evaluation was extensive, for example, including around 200 lesson observations, interviews with teachers and principals, observations of collaborative meetings, and document analyses. In this paper, we report on one part of this evaluation.

Research studies on large scale professional development programs mainly use teachers' self-reports as empirical data; "One limitation of the large-scale studies we reviewed is that they relied primarily on self-report data of teachers' changing classroom instruction." (Goldsmith et al., 2014, p. 24). In view of this large literature review, the evaluation presented here contributes to what is known in an important way, since the conclusions are based on observational data of changes in classroom instruction in a large scale professional development program.

In this paper, we focus on how the teaching culture developed regarding the first didactical perspective, that is, *teaching for the development of mathematical*

*competencies*. The mathematical competencies here refer to the abilities the students are supposed to develop, according to the national curriculum, and include, among other aspects, problem solving and communication.

In this paper, we aim to answer the following research questions:

RQ1: To what extent has teachers' knowledge improved concerning mathematical competencies when they participated in the PDP Boost for Mathematics?

RQ2: To what extent has the teaching practice improved concerning teaching for the development of mathematical competencies, when teachers participated in the PDP Boost for Mathematics?

The paper is arranged as follows. First, we describe the professional development program and the theoretical framework underpinning the evaluation. Thereafter, we outline the method, followed by results from the analyses. Finally, we discuss the implications for large scale PDPs in relation to implementation of reforms.

## **DESCRIPTION OF THE PDP BOOST FOR MATHEMATICS**

The professional development program *Boost for Mathematics* conforms to research findings concerning quality of large scale in-service programs (see Boesen et al., 2014). The main part of the program was supervised teacher collaboration and discussions, where web-based support material was used, which was developed by researchers and teacher educators at Swedish teacher colleges. As it is important that principals and school leaders are a part of a PDP (e.g., see Zehetmeier, 2015), professional development for them was also part of Boost for Mathematics.

The support material for teachers consists of different modules that for compulsory school cover a specific mathematical content area (e.g., algebra or geometry), while the modules for upper secondary school cover a specific educational area, such as problem solving or teaching in accordance with the mathematical competencies. The quality of the material was monitored by appointed mathematics education researchers. The material is hosted by the Swedish National Agency for Education, and is still available for anyone to utilize, also after the program has officially ended.

The modules contain didactical support material; scholarly texts, research articles in mathematics education, video, and audio, together with instructions for lesson activities and questions for collegial discussions. The modules framed, in a four-step model, how the PDP should be conducted at the schools; 1) individual preparation, 2) collegial preparation, 3) lesson activity, and 4) collegial follow-up discussion. The four-step model was developed in order to reach the program goals that the teachers to a higher degree should reflect on their decision-making in their mathematics teaching, as well as developing a wider range of teaching methods and teaching approaches, to be able to adapt to students' different needs.

There are also results from other evaluations of Boost for Mathematics. A large survey with participating schools and teachers show that the PDP mainly has been

implemented as intended (Ramböll, 2016). This survey also shows that the teachers in general are satisfied with the program.

The evaluation of the professional development program *Boost for Mathematics* that will be reported on in this paper took place in the years 2014-2016. A project group of four researchers (the authors of this paper) developed tools for collection of empirical data (interviews, observations and questionnaires) and for analysis of development concerning the four didactical perspectives mentioned above. Eight specialists in relevant areas (mathematics education, assessment, statistical analyses, and evaluation) supported the project group in critical phases of the evaluation. Sixteen project assistants carried out the collection and preparation of data, together with some initial analyses. The main analyses and the reporting of the evaluation to the Swedish National Agency of Education (Österholm et al., 2016) was done by the project group.

## ANALYTICAL FRAMEWORK

The framework guiding our analyses regarding teaching for the development of competencies takes its departure in the descriptions in the Swedish national curriculum documents for mathematics. Five competencies (Sw: *förmågor*) are common for school years 1-12: 1) problem solving, 2) conceptual understanding, 3) procedural competency, 4) mathematical reasoning, 5) mathematical communication. Two additional competencies exist only for upper secondary school (years 10-12): 1) mathematical modelling, and 2) the relevance for using mathematics.

For each of the competencies, we constructed a tool that could be used to analyze whether a teaching activity could give the students the opportunity to develop that specific competency. The tool, based on Lithner et al. (2010), looked at two aspects: A cognitive aspect (to identify, interpret and so on), and a productive aspect (to carry out, use, choose and so on). Here we describe this tool in detail for only one competency; problem solving, as an example.

Problem solving is defined as follows: “Mathematical problems are, in contrast to pure routine tasks, situations or tasks where the students don’t directly know how the problem should be solved” (Swedish National Agency of Education, 2016).

For the competency of problem solving, we framed the cognitive aspect as 1) being able to identify different components of a problem, to see alternative solution possibilities, and to understand methods, tools and goals of problem solving, 2) being able to evaluate and assess solutions, strategies and methods, and 3) to judge the plausibility of the result in relation to the problem. We subsequently framed the productive aspect as 1) being able to use mathematics to solve problems arising in mathematics and other contexts, 2) being able to use and adapt problem solving strategies and methods, and 3) being able to formulate and specify different types of mathematical problems.

## METHOD

This paper focuses on the development of the teaching culture in the participating schools. We analyze changes in the classroom practice and in teachers' knowledge, when it comes to teaching for the development of the mathematical competencies.

### Sample

35 Swedish schools that participated in the professional development program were randomly chosen for the evaluation. At each school, three mathematics teachers were randomly selected, that is, a total of 105 teachers were selected. Half of the schools were visited *before* and *during* the PDP, and the other half were visited *during* and *after* the PDP. Since the same type of data was collected at all schools, and we had data from *before*, *during* and *after* the professional development program, we could examine *changes* in a direct way. Each school was visited twice, with a one-year interval, collecting data from the same teachers. If a teacher had left the school between the visits, a new teacher at the same school was randomly selected.

The structure with two visits offered the possibility to explore changes in a direct manner. We could not visit all schools in all three stages (before, during and after the PDP) due to time limitations. However, all schools did not start the PDP the same year. In spring 2015, we visited the first half of the schools *before* the PDP, and the second half *during* the PDP. At the second visit, in spring 2016, the first half was visited *during* the PDP and the second half *after* the PDP. This made it possible to perform two different types of analyses; the *same teachers* are analyzed two different years and *different teachers* are analyzed the same year.

### Data collection and data processing

For each teacher, we observed a mathematics lesson with audio recording of the teacher's voice. The recordings were supplemented with copies or photographs of curriculum materials used during the lesson, and notes on what was written on the whiteboard and on what tasks the students were working with. After the lesson, a structured interview was conducted with the teacher. Each interview took about 75 minutes. The same interview guide was used at both visits.

The interview questions covered a range of issues for all four didactical perspectives. The following questions were used for the analysis presented in this paper:

1. What did you want the students to learn during the lesson?
2. The national curriculum documents describe different mathematical competencies. How do you think the competencies affect your planning of lessons in general?
3. For each competency, describe the core of the competency and give one example of how you have worked during a lesson to give the students the opportunity to develop this specific competency.
4. Sometimes learning goals are divided in content goals and competency goals. What is your view on this division?

5. Do you use learning goals directly from the national curriculum document? If so, from what part of the document?

All interviews were transcribed and the lessons were described and divided into activities based on the working methods we could observe (e.g., teacher presentation, whole class discussion, group discussion, or individual work).

### Method of analysis

Two result variables were constructed concerning the didactical perspective *Teaching for the development of mathematical competencies*. The first variable describes to what extent each teacher plans and reflects in line with the didactical perspective. The second variable describes to what extent the teaching of each teacher is in line with the didactical perspective.

The analysis focused on three aspects: What knowledge do the teachers have regarding the competencies? What understanding do the teachers have for how classroom activities can give students opportunities to develop the competencies? What competencies are the students given the opportunity to develop?

Several assessments were made for each aspect. The two first aspects were analyzed using 19 assessments of the interviews to form the first result variable. The second aspect was analyzed using 10-14 assessments (two for each of the 5 competencies in grades 1-9 and 7 competencies in grades 10-12) of each activity in the lesson observations to form the second result variable. The final score for each of the two result variables was calculated as an average of all assessments.

All assessments were described very carefully to ensure the quality of the analysis. One assessment will here be presented in detail, but all assessments were done using similar tables and descriptions.

**Example:** Assess to what degree the teacher shows knowledge and will to let problem solving affect the planning of lessons.

Value	Definition	Example
0	The teacher never spontaneously talks about the competencies in relation to the planning of lessons, and gives only short answers to direct questions.	<i>The students should of course develop their problem solving ability during the lessons.</i>
0.5	The teacher stresses the importance of the impact of the competencies on the planning of lessons, but only in general terms.	<i>I give the students many problems to help the students develop their problem solving ability.</i>
1	The teacher exemplifies how the competencies affect the planning of the lessons. The teacher mentions both the cognitive and the productive aspect.	<i>When we work with problem solving in the class we always discuss both different ways of attacking a problem and ways to specify the problem at hand.</i>

Table 1. Assessment of teacher knowledge in relation to the planning of lessons.

This assessment is connected to the second aspect above, and was based on the answers to two different interview questions, one concerning how the competencies in general affect the planning of lessons and what the core of each competency is. The second question concerned learning goals, and to what extent the teacher used learning goals directly from the national curriculum documents, since the competencies are described in those documents. The value of the assessment was decided using Table 1.

We were able to analyze the change in both result variables, since we had data collected with a one-year interval from each teacher. Half of the schools were visited *before* the PDP and *during* the PDP, while the others were visited *during* the PDP and *after* the PDP. Statistical analyses through t-tests were used to identify significant differences, using  $p < 0.05$  as the limit for statistical significance. Two types of differences were analyzed, which increases the reliability of the results. In the first analysis, we compared the same group of teachers at different times, when they were at different stages of the PDP. In the second analysis, we compared two groups of teachers at the same time, but when the groups were at different stages of the PDP.

## RESULTS

As a result of the professional development program *Boost for Mathematics*, the teachers plan and reflect to a higher degree in line with the competencies, see figure 1.

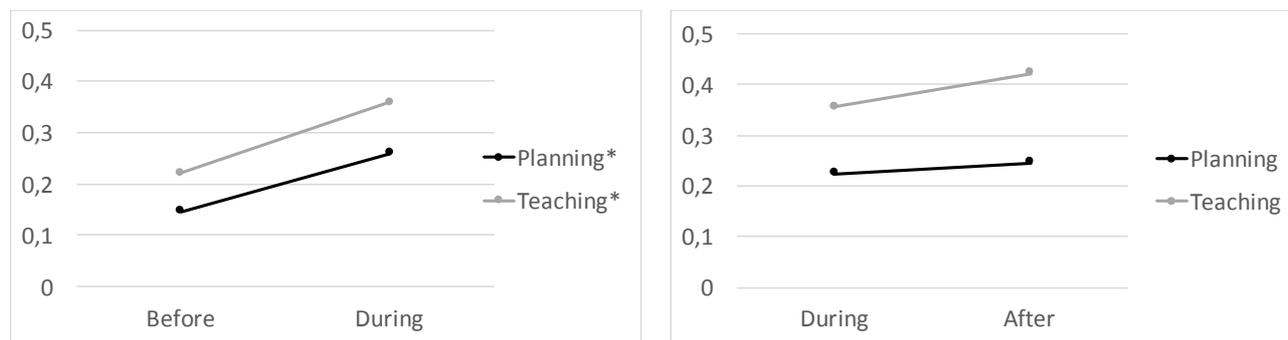


Figure 1. *Changes in teachers' planning and reflection on the one hand and teaching activities on the other hand, during different stages of the PDP (before, during, and after). \* marks changes that are statistically significant ( $p < 0.05$ ).*

Figure 1 also shows that the teaching had changed during the PDP. The teachers work more in line with the didactical perspective *Teaching for the development of mathematical competences*. Furthermore, the right side diagram shows that there is no drop in how teachers work or plan one year after the PDP. This indicates that the effects of the program are stable.

Figure 2 shows a comparison between different groups of teachers the same year, but at different stages of the PDP. The patterns are the same as in figure 1, with significant differences between *before* and *during* the PDP, showing that the program has affected both the planning and the teaching. Figure 2 also shows that there are no significant differences between teachers one year *after* the PDP and teachers *during* the program.

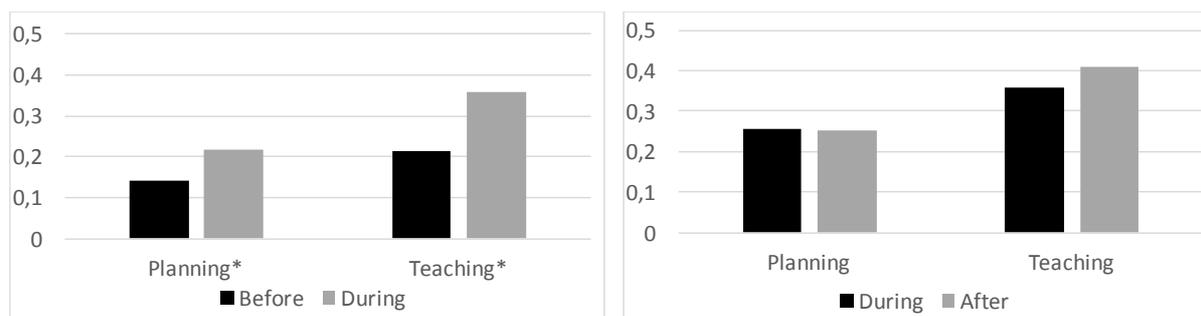


Figure 2. Differences between groups of teachers' that are at different stages of the PDP (before, during, and after) concerning their planning and reflection on the one hand and teaching activities on the other hand. \* marks differences that are statistically significant ( $p < 0.05$ ).

In total, the results in figure 1 are the same as in figure 2, showing the reliability of these results. The effect sizes of the significant differences between *before* and *during* the PDP are medium to large, with Cohen's  $d$  value of 0.56 for planning and 0.81 for teaching.

### What may the changes represent?

Here follow two examples of teacher changes, the first concerning the teacher's planning and reflections, and the second concerning activities in the classroom.

As one aspect of teachers' planning and reflections, we asked about the balance between content goals and competence goals. One teacher gave the following answer when interviewed before the PDP: "The competence goals are more of survival abilities. You practice them in all subjects. The content goals are the foundation the students should have." When the same question was asked to the same teacher during the PDP, the answer was: "The mathematical competencies are connected to the content areas I choose to focus on". In the first answer, the competence goals were clearly talked about as something outside the subject. In the second answer the teacher had changed to a balance between content goals and competence goals. The first answer was given the value 0 and the second answer was given the value 1.

At the lesson observed before the PDP, no competencies at all were discussed, and the students were not given the possibility to develop the reasoning competency. The lesson during the PDP could be seen as a contrast to the first. The teacher started by talking about the reasoning competency and what it could be. Later in the lesson, in a group assignment, the students were given the task to explain to a classmate what the equal sign stands for. The students were also to asked to present and argue for their explanations to the rest of the class. Discussions where the students have to argue for their descriptions, are seen as central for the reasoning competency.

## CONCLUSION AND DISCUSSION

After the change of the Swedish national curriculum documents in 2011, all schools in Sweden were given the opportunity to participate in the large professional

development program *Boost for Mathematics*. In this paper, we have shown that this large-scale PDP did in fact change the teaching culture concerning mathematical competencies. We argue that the reason for this change is that the teachers were given organized possibilities to develop their knowledge and abilities to teach in line with the new curriculum documents, as this result differs from previous change in curriculum documents in Sweden. For instance, Boesen et al. (2014) show in their study that the 1994 curriculum did not have the desired effect. The teaching did not change in any significant way, and was still focused on procedural knowledge. The competencies were present in the curriculum documents to a large extent, but they were not clearly conveyed (Bergqvist & Bergqvist, 2016). But, the large scale PD-program following the 2011 curriculum change made a difference (Österholm, et al. 2016).

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