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Changes in beliefs of teachers on a PD course after reflecting on students' learning results

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In this paper, we discuss results of a qualitative part of a research project aiming to investigate the impact of a professional development course with a specific focus on reflecting of students' learning results on teachers' beliefs towards teaching and learning of mathematics. We refer briefly to some aspects of teachers' professional development. Afterwards, we discuss teachers' beliefs as the main theoretical construct for our research. Data for this paper about teachers' beliefs were collected by semi-structured interviews with three teachers after the professional development course. Results show that teachers report in interviews changes referring to teaching and learning of mathematics from a transmission-oriented view to a more constructivist-oriented view.

Keywords: Beliefs, belief change, professional development, reflecting students' learning results.

Introduction

There is a consensus that university studies and internships are not enough to prepare future teachers for all challenges in their professional career (Mayr & Neuweg, 2009). For this reason, professional development (PD) is understood as being a key factor for innovating and reforming mathematics teaching in school (Garet et al., 2001). However, every change seems to be dependent on specific characteristics of PD: Desimone (2009) summed up five key features of high quality teacher PD. She described that PD will be effective, if a PD course is content-focused, enables active learning, is coherent, has a critical duration and if teachers take part in a PD course collectively. In addition, Franke et al. (1998) reported that reflecting students' learning results makes teachers' learning sustainable. Reflecting students' learning results means, that teachers collect in distance phases of a PD course students' results when working in a specific learning environment or working on a specific task developed in the PD course. Afterwards these students' learning results were the basis of the next face-to-face meeting in the PD course.

Although research identified several features of PD, in most cases the effectiveness is not clear (Yoon et al., 2007). In addition, it is not clear how they influence teachers' learning. For example, Franke et al. (1998) could show that a mix of several characteristics including reflecting students' learning results is effective for teachers' learning, but they did not focus on reflecting students' learning results as a single variable. In a qualitative design, for example also Strahan (2003) found that teachers reflecting on students' learning results increased students' achievement on elementary school level. In addition, Schorr (2000) showed that students' achievement increases when teachers completed a PD including the analysis of students' problem solving processes. Like a conclusion, Little et al. (2003) state that reflecting students' learning results has the potential to bring students more explicitly into deliberations of teachers. However, more research is needed to understand how teachers learn from reflecting students' learning results and whether it impacts on teachers' professional competence including particularly teachers' beliefs.

To investigate the efficiency of reflecting students' learning results in PD courses on the teachers' knowledge, beliefs or motivation, the study as a whole considers two PD courses with a quasi-

experimental setting. Content, teacher trainer and learning time were mostly the same in both courses. However, we integrated reflecting students' learning results in the first PD course, but not in the second. In this paper we will not refer to quantitative results of our research that we reported elsewhere (e. g. Hahn, & Eichler, 2016). We further do not refer to differences between the effects of the two PD groups, but we emphasize results of a qualitative interview study including three teachers of the PD course with reflecting students' learning results. In these interviews, we primarily refer to the teachers' beliefs concerning the teaching and learning of mathematics.

Beliefs about teaching and learning of mathematics

Beliefs can be defined as “psychologically held understandings, premises, or propositions about the world that are thought to be true. [...] Beliefs might be thought of as lenses that affect one's view of some aspect of the world or as dispositions toward action.” (Philipp, 2007, p. 259).

For our research a crucial question is whether beliefs could be viewed to be stable or changeable. Partly, researchers use stability as a part of their definition of beliefs (Fives & Buehl, 2012; Liljedahl, Oesterle, & Bernèche, 2012). In contradiction to that, there are studies which demonstrate belief change by a special intervention. For example, Decker, Kunter, and Voss (2015) reported changes referring to teaching and learning of preservice teachers and teacher trainees. Liljedahl et al. (2012) analyzed related literature and conclude that there is a different meaning of stability in research studies. As a result, they propose to avoid stability in the definition of beliefs. For them, belief change is a natural process that requires a sufficient extent of time. For this reason, in this research study beliefs are described as changeable.

A further crucial question concerns the definition of the belief object that should be changed by PD. Beliefs can refer to a special subdomain of mathematics (Eichler & Erens, 2015), to mathematics itself, teaching and learning of mathematics or an overachieving orientation that is independent from a subdomain (Staub & Stern, 2002). Beliefs referring to teaching and learning of mathematics can be divided into two paradigms: the transmission-oriented and the constructivist-oriented view of learning (Fives, Lacatena, and Gerard, 2015). Transmission-oriented beliefs of teaching imply that knowledge is directly transmitted from teacher to the learners and learners absorb all information. In this case, learners are passive recipients. For this reason, teachers' role is to prepare all information for students to enable an effective storing and an optimal recall. In contradiction, the constructivist-oriented view of learning reflects the active role of learners as constructors of their own knowledge structures. In this case, students learn new information based on their existing knowledge and beliefs to enable an integration of information in their mental networks (Decker et al., 2015; Staub & Stern, 2002). For this reason, teachers take a role as constructor of learning environments that enable students to learn self-directed. Voss, Kleickmann, Kunter, and Hachfeld (2013) proposed evidence that these two dimensions are not the endpoints of a continuum. Instead of this, the authors proposed to understand these two dimensions as two distinct, negative correlated dimensions. These dimensions can be assessed on different scales. For this reason, it is possible that teachers have a high extent of both views on teaching and learning of mathematics.

Based on the definition of beliefs and the two main aspects of beliefs for our research, we primarily focus on the following research question:

Which influence show the PD course with reflecting on students' learning results on teachers' beliefs referring to teaching and learning of mathematics out of teachers' perspective?

Methods

We regard three groups of teachers in our study as a whole. Two groups of teachers were enrolled in a PD course that focused on problem solving and modelling in secondary school. An ongoing task for both PD courses was to develop tasks that meet different criteria of problem solving and modelling. The first group further was asked to give these tasks to their students and to collect the results of students' work that we call results of students' learning. These results of students' learning were the basis of the next face-to-face phase of the PD course. Teachers of second group were asked to improve problem solving tasks and a third group of teachers did not get any intervention.

We conducted pre- and posttests to measure the efficiency of the mentioned specific aspect of teachers' PD, i.e. reflecting students' learning results. Further we conducted interviews with the teachers. In this paper we regard three teachers of the first group who took part in the interview session voluntarily. The interviews took place about one month after the last meeting of the PD course. In semi-structured interviews the teachers were asked to report about their changes towards beliefs of teaching and learning of mathematics. All teachers are teachers of upper secondary schools and at the age of 40 to 50 and were women. These teachers could be representative for the whole group, because it consists of 21 teachers at the mentioned age. In addition, seventeen of these teachers were women.

We analyzed the interviews with a coding method including deductive and inductive codes (Mayring, 2015). The deductive codes were based on existing research referring to teaching and learning of mathematics considering the transmission-oriented and the constructivist-oriented beliefs. According to both types of beliefs, we created codes for teachers' answers. In this context, we distinguish between teachers' beliefs before and after the professional development course. The distinction is based on hints in teachers' statements which enables us to match beliefs to the appropriate point in time. In addition, we analyzed the role of "reflecting students' learning results" for teachers' learning during the PD course.

Results

The results section is structured into three parts. At first, we want to show how teachers' statements are coded according to beliefs about teaching and learning of mathematics. Second, we sum up beliefs of the three teachers. And third, the effects of "reflecting students' learning results" are considered.

In the interviews teachers were asked to report about their beliefs before and after taking part in the professional development course. In particular, they should consider changes in their statements. For example, Mrs. B states:

Mrs. B: [...] it has changed that the tasks are different. Students should argue more and I do not have to work off stacks of tasks. I can work off all facets more determined and I do not have to say that I must work off a model and then practice, practice, practice
.....

Mrs. B reported about changes in her beliefs about teaching and learning mathematics. We interpreted her statement as follows: At the end of her statement, she mentioned that she now does not have to introduce a mathematical model followed by many exercises in the lessons. Furthermore, she reported

on working off stacks of tasks before the PD course. Both parts of the statement are coded as transmission-oriented beliefs, because she emphasized practicing as repetition of information or procedures which is represented in stacks of tasks. In addition, the mentioned parts of the statement were coded as beliefs at the beginning of PD course, since she reported about changes during the PD (see table 1). In the first part of her statement, she considered a change in tasks and argumentation in her classroom. She also mentioned that she can work off the mathematical ideas more determined. These parts of the statement were coded as constructivist-oriented beliefs, because Mrs. B reported a student centered teaching style where students are asked to argue about mathematical concepts and to talk about mathematical problems with each other (see student-oriented perspective in teaching in table 2). In addition, these parts of the statement were coded as beliefs after taking part in the PD course, because in the whole statement Mrs. B reported about changes. In conclusion, the statement of Mrs. B shows a belief change from a transmission-oriented view to a constructivist-oriented view of teaching.

The three teachers showed similarities in reporting aspects of a transmission orientation and a constructivists orientation. A code that seemed to be crucial for all three teachers, but was not included in the quotation of Mrs. B, was expressed by Mrs. C:

Mrs. C: Students should do more and I have to restrain myself a little bit more.

We interpret the statement as following: Mrs. C also reported changes in her beliefs. The whole statement was coded as constructivist-oriented belief, because she wanted the students to be more active in her classroom when they are learning mathematics. In addition, Mrs. C reports on restraining herself in lessons. This is in line with the constructivist view, because on this perspective, teachers are creators of learning environments and students shall learn self-directed. For this reason, it is necessary that teachers shall restrain themselves in lessons. This statement was coded as beliefs after taking part in PD course, since “more” indicates that she had other beliefs at the beginning of PD. In particular, the beliefs at the beginning compared to those reported in the statement included that Mrs. C was more in the center of the lesson and students were more passive which are in line with transmission-oriented beliefs.

The results of the analysis of the three teachers’ beliefs showed that they were transmission-oriented before they took part in the PD course. However, they seem to change their beliefs towards a constructivist-orientation during the PD course. The teachers also reported existing constructivist-beliefs they had at the beginning of PD course, but they stated changes towards more constructivist beliefs while they reduced the strength of transmission-oriented beliefs. Table 1 shows the results of coding for beliefs before teachers take part in the PD course:

	Mrs. A	Mrs. B	Mrs. C
repetition of information (practicing)	X	X	X
frontal teaching	X	X	X
exact instruction	X	X	
teacher is in center of lesson	X	X	X

Table 1: Predominant beliefs before taking part in PD course (mentioned by teachers)

Teachers reported in the interviews that they changed their beliefs referring to teaching and learning from a teacher-centered perspective to a more constructivist-oriented teaching perspective. The following table shows statements of teachers referring to beliefs of teaching and learning of mathematics after taking part in the PD course.

	Mrs. A	Mrs. B	Mrs. C
active role of students	X	X	X
knowledge construction	X		
teacher withdrawing in lessons	X	X	X
students' discussions are important	X		X
students should analyze own mistakes	X		X
tasks with a meaningful context within real life			X
cooperative learning (group work, ...)	X		X
student-oriented perspective in teaching		X	
pool of teaching methods		X	X

Table 2: Predominant beliefs after taking part in PD course (mentioned by teachers)

Both tables show different beliefs of teachers before and after the PD. These tables do not imply that all teachers had only teacher-centered beliefs at the beginning of the PD. They reported also that they had constructivist beliefs. For example, the statement of Mrs. C shows that she has more constructivist beliefs about teaching. This does not imply that she has not had constructivist-oriented beliefs at the beginning of the PD course. In her statement, Mrs. C only reported about more constructivist-oriented beliefs after taking part in PD. In addition, all the coded statements show that they also have transmission-oriented beliefs after PD course, but they report to think of teaching with more student-centered beliefs. Note, both tables only show predominant beliefs of teachers before and after PD. For this reason, peripheral beliefs about teaching and learning of mathematics are left out.

The results about beliefs show changes. For this reason, we want to know how reflection of students' learning results impact on teachers learning. In this context, Mrs. A and Mrs. C state:

Mrs. A: [...] I have learnt a lot about my students and I have also learnt a lot about myself and for this reason I have tested some things.

Mrs. C: I think it was good. The students' learning results show how other teachers proceed in teaching, which approach they use and how they describe. Within this action, you could take new ideas that I found in students' solutions. [...].

The statements of the three teachers show that "reflecting students learning results" were used to reflect the own practice of teaching. In this context, these teachers learnt about characteristics of their students and about themselves as teachers. As a consequence, Mrs. A tested some ideas contained in the PD course. In addition, the three teachers recognized other teaching styles when they reflected on students' learning results. For this reason, they also reflected about the practice of other teachers and their teaching approaches. In particular, they also reflected about their own practice compared to the

one of others to get new ideas (Mrs. C). These statements are typical for all three teachers. According to this, the reflection of teaching style could be understood as one factor that result in changes of beliefs about teaching and learning.

Discussion

The data from the interviews indicate that the three teachers changed their beliefs from a more transmission orientation to a more constructivist orientation of teaching and learning of mathematics. This is shown by statements of teachers after taking part in the PD course. The phrases in both tables consider the aspects of both beliefs about teaching and beliefs about learning. Based on the analysis in the results section, statements of table 1 refer to transmission-oriented beliefs and statements of table 2 to constructivist-oriented beliefs (e.g. Fives et al., 2015). In fact, teachers focused on constructivist-oriented beliefs, but they still expressed some transmission-oriented beliefs. This is in line with research findings of Voss et al. (2013), who supposed that both types of beliefs can co-exist. The statement of Mrs. C supports this assumption. Although she expressed transmission-oriented beliefs before the PD, she said that students should be more active, which indicates that she has had constructivist-oriented beliefs at the beginning of the PD.

Belief changes in teacher education are also shown in the study of Franke et al. (1998) for teachers on primary level who examined a student-centered framework in their PD. In this context, our results are similar to those of Franke et al. on secondary level, because we also used reflecting students' learning results to emphasize student-centered teaching. Furthermore, the teachers reported that they used students' solution to reflect their own teaching and to get to know information of other teachers' approaches and also about their students. This is in line with the results of Little et al. (2003), because teachers consider the ideas of their students in their deliberations more strongly after taking part in the PD course. In addition, belief change caused by reflection is reported by Decker et al. (2015) in the way that there is a relationship between the extent of reflection and teachers' belief change. For this reason, it is possible that all teachers of this study changed beliefs because they reflect intensively about their own practice. Skott (2015) stated that substantial new experiences are necessary to change beliefs. Concerning our research, we hypothesize that the intensive reflection of the own classroom practice includes the mentioned new experiences.

There are some limitations of this research. At first the interviews took place after the whole PD course. For this reason, teacher reports about the practice before the PD course can be influenced by the experiences of the PD. For a more precise research approach it would have been necessary to interview the teachers at the beginning of the PD. Considering the external circumstances in this research project, it was not possible to interview teachers, because they took part in PD voluntarily and the first meetings last about the whole day. In addition, these qualitative data provide no proof for "reflecting students learning results" as a feature of effective PD, but there are hints that beliefs can change and teacher reflect their own practice during this part of PD. Furthermore, the teachers of the second group were not interviewed. For this reason, it is not possible to indicate whether the teachers of the second group also changed their beliefs. In addition, we do not know whether second group teachers reflect on their own practice as deep as teachers of the first group.

Future research

This part of the whole research project considers qualitative data of the first PD course. Future research should use also quantitative data (measured by items of Staub & Stern (2002)) to support the results of teachers' belief change during PD. This could also show whether reflecting students learning results is one element that is connected with teachers' belief change empirically. In addition, it is necessary to link the qualitative data analyzed in this paper and the quantitative data which will we analyzed in the future. Combination of both resources can show the positive impact of reflecting students' learning results on teachers' knowledge, beliefs and motivation.

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