THE LEARNING OF MATHEMATICS TEACHERS WORKING IN A PEER GROUP

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The research described in this paper is part of a study in which we will follow mathematics teachers during a certain period and describe the development of their practical knowledge. Teachers' practical knowledge is their knowledge and beliefs that underlie their actions. In this study we are focused on what teachers know and believe about learning and teaching statistical investigation skills. Concept maps and semi-structured interviews are used to represent and archive teachers' practical knowledge. In addition, a system of four categories is developed which, in our view, is appropriate for exploring mathematics teachers' practical knowledge. The results show that although changes in practical knowledge occur within a year, not all changes are due to working together in a peer group.

INTRODUCTION

Because of educational changes teachers should be able to learn permanently, individually as well as together with fellow teachers. This study reports on the learning of mathematics teachers from the same school, collaborating in a peer group for a longer period. The area of interest is the development of teachers' practical knowledge by collaborating in a peer group in order to achieve an educational design in statistics for students in lower secondary school. By creating an environment in which teachers can learn and develop, they have an opportunity to revise their practical knowledge by using each others expertise. The researcher guides the meetings, but the teachers are making the final decisions in order to create ownership. This kind of professional development is new to the teachers involved. During the peer group meetings, teachers are developing a research task for students which also will be implemented and evaluated. The research task is aimed at students doing statistical investigations about a theme of their own choice. Implementing research tasks is one of the goals of mathematics education in The Netherlands.

THEORETICAL BACKGROUND

Learning of experienced teachers in a peer group

A considerable amount of current research on teaching and teacher education focuses on teacher collaboration. Teacher collaboration is presumed to be a powerful learning environment for teachers' professional development (Meirink, Meijer & Verloop, 2007). However, empirical research about how teachers actually learn in collaborative settings is lacking. Learning in collaborative settings stimulates teachers to use the expertise of colleagues for improving their own teaching practice, and therefore adjust, enlarge or change their practical knowledge (Borko, Mayfield, Marion, Flexer & Cumbo, 1997). Borko et al. (1997) mention: "We believe that teachers would learn best by actively constructing new assessment ideas and practices based, in part, on their existing knowledge and beliefs, and sharing ownership of the workshop content and processes”. Furthermore, learning in a peer group is more intense when people with different ideas and opinions cooperate (Putnam & Borko, 2000). Verloop, Van Driel & Meijer (2001, p.453) mention that exploring teachers’ practical knowledge can be relevant in consideration of educational changes. In certain educational innovations teachers were only the executors instead of also the developers (see Van den Akker, 2003). To commit ownership in this study, teachers are developers and implementers of an educational design for learning and teaching statistics for students of the 7th grade of secondary school. Teachers afterwards evaluate the implementation of the design. Because they work together we expect an increased teacher learning, leading to more in-depth practical knowledge.

Development of practical knowledge

The research presented in this paper is focused on the development of teachers’ educational goals and practical knowledge of mathematics teachers when they collaborate in a peer group. The term *knowledge* as well as the term *beliefs* may frequently be found in studies about teachers’ cognitions. The concepts that these terms refer to are often not easily distinguishable. On the other hand, to explore and analyse the learning of teachers, the term practical knowledge is frequently found in studies about teachers’cognitions (Kagan, 1990; Pajares, 1992) In most studies, only one term is used to refer to both knowledge and beliefs. Kagan (1990) states that: “Readers should note that I often use beliefs and knowledge interchangeably (…)”. Pajares (1992) also pretends that knowledge and beliefs are not distinguishable. He states that teachers’ beliefs are personal values, attitudes or ideologies and knowledge is a teacher’s more factual proposition, sometimes formal and sometimes practical. Meijer (1999, p.22) puts forward that: “Taken together, teachers’ knowledge and beliefs are a huge body of personal theories, values, fractional propositions, and so forth, that is to be found in teachers’ minds, and that teachers can, sometimes more easily than other times, call up and make explicit”. In this study, following Pajares (1992) and also Meijer (1999), teachers’ beliefs and teachers’ knowledge are viewed as inseparable. This will be referred to as teachers’ practical knowledge.

In this study we developed and used a system of four categories which, in our view, are the most appropriate for exploring mathematics teachers’ practical knowledge. Statements of teachers will be classified into the named categories. These categories are derived from the categories used by Meijer (1999, p.61) and Van Driel, Verloop & De Vos (1998). The categories will be described and explained below.

1. Educational philosophy

The category ‘Educational philosophy’ includes the vision of teachers on education in general, what motivates him or her to teach. Teacher’s educational philosophy can deviate from, for example, his actions in the classroom and does not need to correspond with reality. This category is an extension of the categories used by Meijer (1999). Meijer used the category ‘Student knowledge’, this are thoughts about students in general, which is part of the category ‘Educational philosophy’ in this study. Teachers’ educational philosophy is of great importance on his actions and thoughts.

Teachers’ former experiences in the classroom have a strong hold on their educational philosophy, just like experiences with professional development and consultation between fellow teachers (see Meijer, 1999). Ernest (1989) mentions that the mathematics teacher's mental contents or schemes includes the vision on mathematical knowledge, beliefs concerning mathematics and its teaching and learning. Ernest states that educational changes only can take place when teacher’s deep-rooted beliefs about mathematics and about the learning and teaching of mathematics will change. We expect to find particularly deep-rooted beliefs in this category, and therefore we expect the fewest changes in practical knowledge.

2. Learning and teaching statistics

This category includes teachers’ practical knowledge of school mathematics, in particular of statistics. Within the scope of pedagogical content knowledge (PCK) also specific perception of statistics, learning difficulties and learning strategies of students within the domain of statistics are gathered in this category. Knowledge of teaching statistics is therefore also part of this category. This category is a combination of the categories ‘Subject matter knowledge’, ‘Curriculum knowledge’ and ‘Knowledge of student learning and understanding’ in the research project of Meijer (1999).

Next to practical knowledge, teachers need understanding of the subject matter content to teach a subject (Sowder, 2007). Shulman (1986, p.25) mentioned: “Where the teacher cognition program has clearly fallen short is in the elucidation of teachers’ cognitive understanding of the subject matter content (..)”. He thereby introduced the term pedagogical content knowledge (PCK). Verloop et al. (2001, p.449) indicated that PCK can be considered as a specific form of teachers’ knowledge due to the focus on students and on subject matter. The category ‘Learning and teaching statistics’ is strongly related to teachers’ working together in a peer group on the educational design and its implementation in the classroom. The teachers in this study are not used to working in a peer group. We therefore expect important changes in this category.

3. Student activities

This category describes teachers’ practical knowledge about students in the first class of secondary school and students in general, their activities during the lessons of this course and their learning activities. A direct relation with the subject matter (statistics) is not necessary. This category is an extension of the category ‘Knowledge of purposes' used by Meijer (1999).

Together with the category ‘Learning and teaching statistics’, this category is expected to be strongly influenced by teachers’ collaboration in a peer group. We expect a connection between the objectives of the design formulated by the teachers, how important teachers think research tasks are in math classes and the student activities during the course.

4. Teacher activities

On the one hand this category describes teachers’ practical knowledge of the use of materials during the math classes and the practical knowledge of statistical research assignments. On the other hand this category contains teachers’ practical knowledge of designing, implementing and evaluating lessons in statistics and teachers’ role during the implementation. This category is a combination of the categories ‘Curriculum knowledge’ and ‘Knowledge of instructional techniques’ by Meijer (1999).

Research questions

The main question presented in this paper is: How does the practical knowledge of mathematics teachers develop as a consequence of designing, implementing and evaluating an educational design (altogether this is called the intervention) for learning statistical investigation skills by working in a peer group?

The main question can be determined by answering three basic subquestions:

1. What is the practical knowledge of the participating teachers prior to and after the intervention?
2. What are the changes in practical knowledge of the participating teachers during the intervention?
3. Which are possible causes of changes in practical knowledge?

METHODOLOGY

In this study four mathematics teachers of the same school are collaborating in a peer group. During the seven peer group meetings they are developing an educational design in statistics for students in lower secondary school. After the implementation of the design, the last peer group meeting serves to evaluate the design in order to improve the content.

In the study presented in this paper, we use two of the three instruments Meijer (1999) used, completed with three other instruments. The instruments below were used in this study and are at the same time provided with an explanation:

1. *A questionnaire about teacher background variables*
   Just like Meijer, Verloop & Beijaard (1999) we use a list with questions about the teacher’s background. There are patterns that indicate that it is of crucial importance how a teacher deals with his or her experience, training, and consultation with colleagues.

2. Two *concept maps* by each teacher referring to the teaching and learning of investigative skills: one concept map was drawn before the intervention (this is called CM[0]). The other concept map was drawn afterwards (CM[1]). *Explanations* by the teachers about their concept maps, directly after the drawing of the concept maps. The explanations of the teachers are all recorded on tape and are used as an additional source of information to the concept map.
3. *Semi-structured interviews*. Like the concept maps we had two interviews: one before (Int[0]) and one after the intervention (Int[1]).
   The interviews were hold immediately after the explanation of the concept map, in one session.
4. *Registrations* and *evaluations* of all seven peer group meetings. All peer group meetings are recorded on a voice recorder and evaluated through written evaluation forms filled in by each teacher.
5. *Observations* of the lessons taught within the project. All the nine lessons of all the teachers were observed and recorded on videotape.

The first source of information gives an idea of teacher’s experiences with teaching investigative skills during the past years. This will be used for an explanation of the teacher's development. The next two sources of information will be used to determine changes in practical knowledge of teachers. The fourth source of information serves to find causes for the observed changes or to indicate professional development. The fifth source of information serves as a validation-check and is meant to see if teachers ‘teach as they preach’.

The combining and analyzing of data from the different sources of information was a procedure with six phases (Morine-Dershimer, 1993; Meirink et al., 2007). In this paper not all the phases will be described, only phase four, where we look at the similarities and the changes in practical knowledge by first comparing CM[0] with CM[1] and Int[0] with Int[1] and after that divide teachers’ statements and answers over the named categories. To describe possible changes in practical knowledge and to find out what causes these changes, we use two interesting cases. The first case is a less experienced teacher, Ann, and the second case is an experienced teacher, Bart. The names of the teachers mentioned here are fictitious.

RESULTS

Case Ann

Teacher background variables

Female, 48 years old, ten years of experience in adult education and three years of experience in grades 7-10 of secondary school. Little experience with implementation of research tasks.

Changes in practical knowledge

Below, in table 1, a list of differences in pre- en post-concept maps and in pre- en post-interviews from Ann is presented. The differences are divided over categories and the instrument concerned is also specified in table 1. There is also a list of similarities, but this list will not be given here. We will focus on the differences, because the differences are more interesting.

Table 1: *Differences in pre- en post-concept maps and in pre- en post-interviews from Ann in categories*

Category	Differences
Educational philosophy	1. These students are too young to state a hypothesis (from CM[1]). 2. “How did I learn it myself?” (from CM[0]).
Learning and teaching statistics	1. The introduction assignment was not applicable, there was no relationship between variables (from Int[1]) 2. Nowadays you need a computer for presenting and processing data. (from CM[0]) 3. Statistical concepts should come up for discussion during the introduction (from Int[1]). 4. Evaluating the process with students is important (from CM[1]). 5. Implementation of statistical research requires a systematic routine (from CM[0]).
Student activities	1. Some children could not work together at all (from CM[1]). 2. Students can ask each other critical questions about their posters (from CM[1]).
Teacher activities	1. The role of the teacher is to guide the students (from CM[0])

Looking at the differences in table 1 it is obvious that the differences in the category ‘Learning and teaching statistics’ are dominantly present. This is partly a consequence of the used methods. The focus question of the concept maps is ‘Learning and teaching statistics’ and the interviews are also focused on the learning and teaching of statistics. Furthermore, the differences are mainly caused by Ann's basic assumption. Before the implementation of the educational design, in CM[0], she noticed “to be blank”. Afterwards, in CM[1], she changed her basic assumption and noticed that the implementation of the design was the most important. Ann’s teaching experiences in the past play an important role, enforced by experiences during the implementation of the educational design. However, Ann’s research experiences do not play an important role anymore, though this was often a success (see CM[0]). During the evaluative peer group meeting it becomes clear that Ann still is enthusiastic about the educational design, although she proposed a few revisions like more interest in students working together and adjust the introduction assignments. Ann composed the student groups herself. She mentioned that she would do that again, because she is convinced that students have learned a lot by this way of working. Observations of lessons show that Ann is a good coach. She encourages her students to reflect on choices made and she is able to revise her goals if necessary. Repeatedly, she succeeds in creating a good atmosphere, in which students are able to work undisturbed.

Case Bart

Teacher background variables

Male, 47 years old, eighteen years of experience in teaching in secondary schools. In the past, he implemented two small research tasks, of which one was a statistical task.

Changes in practical knowledge

Table 2 below shows a list of differences in pre- en post-concept maps and in pre- en post-interviews with Bart.

Table 2: *Differences in pre- en post-concept maps and in pre- en post-interviews from Bart in categories*

Categories	Differences
Educational philosophy	1. “Students understanding of the subject matter is very important. I didn’t mention that because I haven’t the impression that they really understood what they were doing” (from CM[1]). 2. “In any case, in my view students must have learned enough. There has to be a sufficient amount of data, the result has to be satisfactory and the teamwork should be good”(from Int[1]). 3. The factor time is important: “How labour-intensive is it?” (from Int[1]).
Learning and teaching statistics	1. Strenghten that which is in the newspaper and on tv. Bart mentions: “That did go wrong. I couldn’t make that clear either” (from CM[1]). 2. In CM[1] Bart is focused on students: “You now know what it was. You do not know that in advance. I automatically focus on the students. That is correct. intended or unintended” (from CM[1]). 3. Statistics in the observation period is not really hard: “We use the chapter Statistics to catch up in time” (from CM[0]).
Student activities	
Teacher activities	1. “I found the teaching part rather awkward. In fact, I had no time left because of the method we used. Perhaps therefore I skipped it unintended” (from CM[1]).

Looking at the differences in table 2 it is obvious that the amount of differences in the category ‘Educational Philosophy’ and the category ‘Learning and teaching statistics’ are the same. It is remarkable that there are no differences in the category ‘Student activities’, while Bart is focused on the students during the construction of CM[1]. During the construction of CM[0] he also focuses on the teacher by adding the term ‘teaching'.

The differences are mainly caused by the experiences of Bart preliminary to the implementation of the educational design. Bart is skeptic about students working in a team, because he experienced teamwork as unsatisfying. He thinks the lessons are more chaotic and that he looses control. However, lesson observations give another impression. Bart’s lessons are well prepared with clear explanations and a great deal of structure. From the explanation of CM[1] and during the evaluative peer group meeting, it appeared that Bart doubts whether students learnt the statistical concepts sufficiently and if it would be better to use a more didactic teaching method. At least, that will save him a lot of time. It is remarkable that, although Bart does not believe in teamwork, he once again would choose for students working in teams. Next time, he will choose smaller groups (two students) and let students compose the groups themselves.

CONCLUSIONS

To get an accurate insight into teachers' practical knowledge and its changes, the construction of concept maps combined with the semi-structured interviews give important information. The classification used here gives a structural description of the practical knowledge of Ann and Bart. It turns out that this knowledge of both Ann and Bart is deep-rooted; it is derived from former experiences and confirmed by implementing the educational design (see Ernest, 1989). The category 'Learning and teaching statistics' embodies the most similarities in practical knowledge, but also the most differences. The practical knowledge in the category 'Learning and teaching statistics' depends highly on the experiences perceived during the intervention. Besides, the changes in this category are probably due to the experimental design. Even though he had a less positive experience before the implementation of the design, Bart's ideas about teamwork do not change. He maintains his opinion that direct instruction is more effective than teamwork. On the other hand, Ann could adjust the goals easily during the lessons. She was more flexible and she showed more persistence during the selected trajectory (see Pajares, 1997). Both Ann and Bart, however, were willing to make concessions during the peer group meetings. They experienced the interest of combining each other's ideas and constructing an educational design to which everybody could commit.

In a follow-up study it would be interesting to look at the different roles teachers play in peer group meetings. Ann, for example, appeared to be a leader, highly committed and motivated. Bart appeared to be a follower, trusting the ideas of Ann (Shamir, 1991). We also need to look more closely at the categories involved in this study. It is difficult to categorise teachers' statements. Furthermore we may need to use sub-categories or rename existing categories.

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