TEACHERS' PROFESSIONAL DEVELOPMENT IN A LESSON STUDY TEAM: THE CASE OF COUNTING PROBLEMS

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Counting problems are hard for students. Making and ordering a selection with respect to repetition create students' insecurity and frustration. Why do students think that they need abstract expressions as combinations and permutations instead of relying on their own common sense? These questions were the start for six Dutch mathematics teachers in a Lesson Study Team focussed on stimulating students' independent thinking and raising self-confidence. Lesson Study is a cyclic process where teachers cooperatively choose a topic, prepare and live observe lessons, discuss the observations and redesign the lessons. The study focuses on teachers' professional development in a Lesson Study Team. Teachers' learner reports and field notes revealed that learning experiences originated from a situation that did NOT work out.

THEORETICAL FRAMEWORK

Lesson Study

Lesson Study (LS) originates from Japan, where it is a leading approach for teachers' professional development. In a Lesson Study Team (LST), teachers collaboratively analyse their teaching method by developing (new) teaching methods on a topic, planning, executing, live observing, discussing and finally refining these lessons as shown in Figure 1 (Stepanek et al., 2007). The focus is on observing the students, not the teacher. The live observations, followed by discussions on student learning and reflecting on the teaching method and its impact are the central activities of the LS. (Fernandez & Yoshida, 2004; Hart et al., 2011; Lewis et al., 2006; Saito, 2012).

Even though the approach is to observe the students, the process forces the teachers to consider their teaching method, makes them predict how students will react and provides feedback through the observations. The refinement activates teachers' professional development. Lesson Study results often can be extended to other topics, results are not necessarily restricted to the focus of this study.

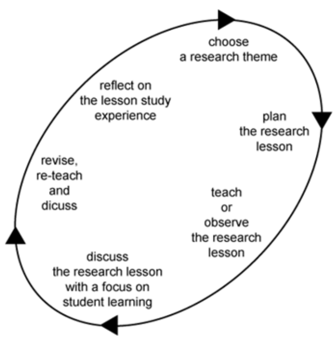

Figure 1: The Lesson Study cycle

Counting problems

Research outcomes on combinatorial reasoning showed the various difficulties and pitfalls that students experienced (Batanero, 1997; Eizenberg, 2004; Hadar & Hadass, 1981; Lockwood, 2011). From this, a teaching method was designed on the topic of counting problems, starting from thirteen problems as discussed in Batanero (1997).

Teachers' professional development

To analyse teachers' professional development we use the model of Clarke and Hollingsworth (2002) as depicted in Figure 2.

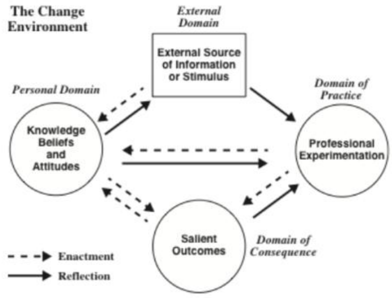

Figure 2: The Interconnected Model of Professional Growth (Clarke & Hollingsworth, 2002, p. 951)

The IMPG suggests that teachers develop in recurring cycles through the processes of 'reflection' and 'enactment' in four distinct domains. Three of these domains are situated in the teachers' daily world, the fourth (the External Domain) is outside this daily world. Teachers' knowledge, beliefs and attitude are situated in the Personal Domain (PD). The External Domain (ED) is where a teacher meets new ideas. In the case under discussion the ED exists of specific literature, the live observations and the discussions. The Domain of Practice (DP) involves all possible kinds of teacher classroom experiences, in this study the carrying out of the designed lessons. The Domain of Consequence (DC) (salient outcomes) focuses on the consequences of student learning. This domain is coloured by teacher's expectations beforehand. Clarke and Hollingsworth (2002) emphasized the effect of a change in one domain as a sequence of changes in the other domains. They identified temporal changes named 'change sequences'. When the change is more than momentary, this is seen as professional growth and the associated change sequence is termed a 'growth network'. We use IMPG to describe teachers' professional growth in terms of personal knowledge, beliefs and attitude, through external sources, classroom experimentations and salient outcomes. Teachers develop by conscious actions and reflection between the domains. Using LS all domains are addressed as will be discussed below.

METHOD

Participants

The participants of the LST were six Dutch mathematics high school teachers from different schools. The teachers' ages varied from 30 to 56. Teacher's work experience varied from one to 36 years in lower as well as upper level high school mathematics education.

Research instrument: learner reports

The participants filled out learner reports, giving comments on what they have learned, when they learned this, what happened to trigger this learning experience and what they plan to do with the newly acquired knowledge (Endedijk & Vermunt, 2013; Van Kesteren, 1993). The learner reports distinguished preparation, execution, live observation and discussion/evaluation. For reliability, the classroom practices and the meetings were taped on video whenever possible. The teachers were asked to fill out a small exit questionnaire regarding their learning process.

Research instrument: field notes of live observations

As much as possible, members of the LST observed one student in particular and the dynamics of the group as a whole. The field notes of the live observations functioned to stimulate the discussion after the lesson at the school directly.

Analysis

The learner reports were ordered in the aforementioned categories. The field notes were categorized in observing, listening, copying, attempting, working independently and quitting (Poortman, Illerus, & Nieuwenhuis, 2011). The researchers related these data in: “What was learned”, “How was it learned”, “What prompted the learning experience” and “What are you planning to change after this learning experience”.

RESULTS

Learner report

Table 1 reports what and from what the teachers learned in phases: preparation (P), execution and observation (O), discussion after the first lesson (D) and evaluation at the end, after the revised lesson (E). The teachers are shown by the capitals A up to F.

Teacher	Phase	The teacher learned that…	The teacher learned from…
A	P	… my students, with me being unaware, apply tricks - there is a difference between choosing and ordering	… discussing the answer to a question
	O	… when students see numbers in an exercise they start multiplying, even though this has no meaning	… observing a group of three student work
	D	… students learn from acting out a counting problem	… discussing observations and results of the research lesson
	E	… visualizations are important for student understanding	… trying to make a visualization myself
B	P	… I should enrich my lessons with more pictures.	… discussing what happens in students minds
	D	… the teacher should help students tackle counting	… discussing observations and

		problems by showing them practical applications	results of the research lesson
C	P	… students need to count systematically as a basis to learn combinatorics and they need to build on that	… discussing the first teaching method and its goal
	O	… students have no idea whether their approach to a counting problem is correct	… observing a group of three student work
	D	… problems should be acted out as drawing a picture does not seem to help	… discussing observations and results of the research lesson
	E	… students need to imagine the process described by a counting problem … the perspective in a counting problem is important … visualizations and plays are important tools to understand counting problems	… discussing the second lesson
D	P	… certain approaches need to be developed very far for most (students) to see the chosen approach does not work. There is a tunnel vision, which costs a lot of time.	… discussing how to plan the lesson and what observation framework we could apply
	D	… it is hard to teach students by letting them discover things by themselves	… discussing observations and results of the research lesson
	E	… it is very hard to reach a simple approach … suitable practical examples are hard to find	… discussing visualizations and acting them out
E	P	… students are not capable yet to systematically write out all possibilities.	… discussing where the problems are in combinatorics
	D	… students first try to work everything out in their head before writing out any part and continue from there	… discussing observations and results of the research lesson
	E	… there are many ways to look at counting problems and students should be made aware of this	… discussing how to visualize permutations
F	P	… the importance of systematic counting and the way to write this out. I will give more attention to that.	… discussing what mistakes students make in counting problems
	O	… students need to systematically write out all possibilities to feel certain their solution is correct	… observing a group of four student work
	D	… acting out a situation really helps students to understand counting problems and differences therein	… discussing observations and results of the research lesson
	E	… students should be able to switch the point of view in counting problems	… trying to visualize a problem from different points of view

Table 1: Teachers' professional development in the LS on counting problems

Some of the interesting aspects that were noted by multiple teachers at each stage (preparation, observation and evaluation) of the LS are shown in Figure 3.

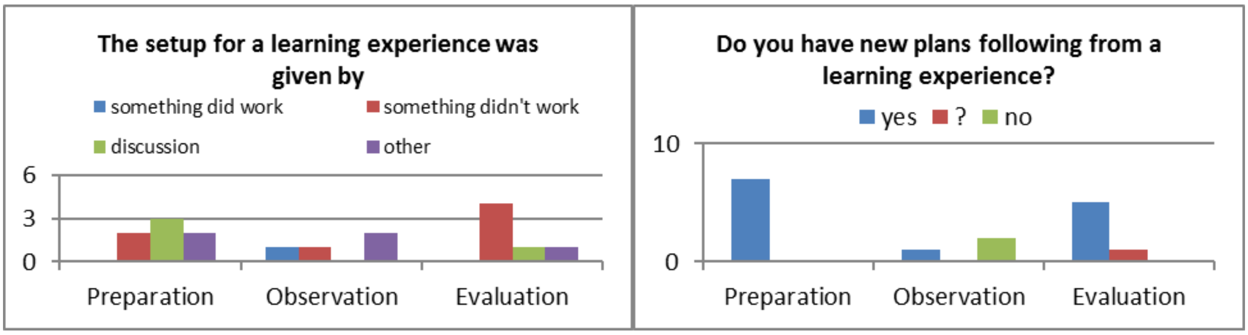

Figure 3: Results from the learner reports

At all stages of the LS the teachers concluded that they had learned something from a situation that did not work (Figure 3 left side). At the preparations, formulating a framework for the observations did not seem successful. Also, it was hard to predict which difficulties students would encounter when dealing with counting problems. This provided a lot of insight for the teachers regarding their own view on what their students are capable of and how they can investigate the students' thinking processes. During the observation it became clear that the chosen teaching method was unsuccessful, creating a lot of material for discussion and revising the views on what the capabilities of the students are. Almost all participants concluded in the evaluation of the first lesson that the chosen approach had not worked, but were very pleased with the conclusions they could take from it, resulting in an adjusted second plan with a focus on the visualization of the problems. None of the teachers had anticipated this to be a vital part of the lesson plan at the beginning of the LS, so after these steps each teacher had adjusted their personal domain. This conclusion can also be drawn from Figure 3 (right side) as all teachers in the preparation of the second lesson conclude they would no longer use their previous approach with regard to counting problems.

Observation field notes

Even though the learner reports regarding the observation did not show a lot of change in the plans of teachers, the field notes made during the observations show that it was the observations that made clear changes needed to be made. In the preparations the teachers predicted a different reaction of the students on the first teaching method. During the discussions, conclusions were connected to the results of the observations. Using the framework of Poortman, Illerus, & Nieuwenhuis (2011) the field notes facilitated the teachers to see the learning processes of the students. Focusing on student reactions to the teaching method in the sense of observing (O), listening (L), copying (C), attempting (A), working independently (W) and quitting (Q) showed that students at an early stage were at a loss about what to do. The students are shown by the capitals M and N.

Activity	**Classification**
M takes a first card with a counting exercise and reads it out. Student N listens. [Exercise about permutation of size 4]	L
M : “That’s easy, it must be 4x4”. [Incorrect]	A
N ignores the answer and tries to solve the exercise	A / W
M reads the next exercise “This is the same” [Exercise with repetition, so different]	A
N: “I don’t know what we have to write down”	Q
M tries to write out all possibilities, without system	A
N looks at the list that M compiled, copies it and points out a double	C/O
M and N look around: “Others also write out a lot”	O
M and N lose interest and start chatting	Q

Table 2: Example of field notes and classification

Observation shows that one or two students attempted to solve an exercise, whereas the rest copied the result. Even though groups were formed, most students worked independently on exercises and failed to explain to other students how they had reached their result. As they did not find any confirmation that they were on the right path, most students quit after a first feeble attempt.

The main contribution of this paper is the insight that teachers professionalize not only by critically looking at their own teaching, but important insights are obtained by discussing lesson plans and observing student communication. Especially for the subject of counting problems, teachers discovered that coaching students to use their common sense and to build up their confidence can be more valuable for them than theoretical insight. Most teachers concluded after the LS that in the future they will not use the same approach as they used to, but let students attempt problems in their own way and act more as a coach than as a plenary teacher. The use of visualizations, as also found by Verhoef and Tall (2011) in a LS on a different topic again proves to be of high importance. However, for the chosen topic, acting out a problem proved to provide more insight than the use of pictures.

Teachers’ professional development

Teacher’s PD had a large influence determining the following teaching method. Combining the beliefs of the teachers with the literature on counting problems (ED), a renewed lesson was designed. By trying out this lesson (DP) the teachers were able to see the impact on the students. The salient outcomes (DC) observed during the lessons caused changes in the other domains following different structures as described by Clarke & Hollingsworth (2002).

At first, the Naïve Linear Model (Clarke & Hollingsworth Fig. 9, p. 960) was used. The literature provided by the researchers (ED) gave the teachers the belief (PD) that they should use the 13 problems of Batanero (1997) and let the students classify these problems into categories. This was executed in the first lesson (DP) providing the first outcomes (DC).

As the results obtained in the first lesson were far from the desired results, a learning process started as described in Clarke & Hollingsworth (2002), see Figure 3. The observations during the literature based first lesson (ED->DP->DC) changed the beliefs of the teachers (PD), in Figure 3 denoted as “Guskey”. Due to the cyclic nature of the LS, a new teaching method was developed after which the process repeated, in Figure 3 denoted as “Clarke/Peter”.

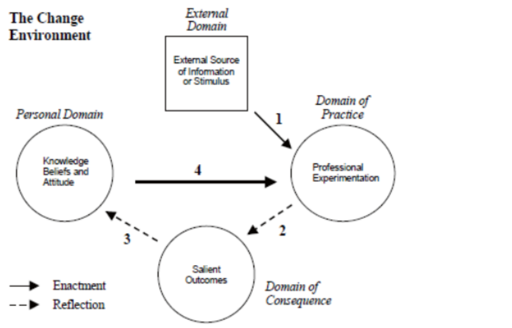

Fig. 10. Sample growth network 2: incorporating “Guskey” (arrows 1, 2, 3) and “Clarke/Peter” (arrows 2, 3, 4, and repeat).

Figure 3: Growth networks (Clarke & Hollingsworth, 2002, p. 961)

As a result, in the PD the view on the goal that needed to be reached changed drastically from theoretical knowledge to a systematic framework for approaching problems. Also in the DP changes were made, as teachers found that the teaching method needed to be adjusted from letting students solve problems and classify them to acting out solutions to problems to show the power of visualization.

DISCUSSION AND CONCLUSION

The goal of the LS approach was to professionalize mathematics teachers by designing, live observing, implementing and evaluating teaching methods. Using the Interconnected Model of Professional Growth the different steps of the LS showed that the teachers developed in multiple domains. Valuable insights in the learning process of the students were obtained by observing that a teaching method did not work. The LS focused on counting problems. The results obtained for teachers’ professional development no doubt relates to the chosen topic. Especially for counting problems, the insight students have in understanding the exercises is a key part. For more theoretical topics this may be of lesser importance. However, as also concluded by Verhoef and Tall (2011) for the more theoretical topic of the derivative, visualizations are an important step for students in tackling mathematical problems. So both studies show that the participating teachers developed their view on teaching and the importance of the approach they choose. As the cyclic nature of a LS shows, the process never really ends. This study only considers two ‘rounds’ so that the insights of the teachers still need more rounds for the expected improvements to be confirmed. Nevertheless, even if the newly proposed teaching method does not provide the expected results, this research shows that the teachers developed on different domains.

Also the teachers experienced that a LS is a valuable tool to not only understand their students learning process better, but also develop their own skills as a teacher.

In conclusion this research shows that the participating teachers developed their personal domain and their domain of practice through interaction with the external domain and the domain of consequence, provided by the setting of LS.

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