

# **MATHEMATICS TEACHERS' BELIEFS ABOUT TEACHING AND LEARNING MATHEMATICS AND CONSTRAINTS INFLUENCING THEIR TEACHING PRACTICE.**

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*In my doctoral work I studied three mathematics teachers in lower secondary school in Norway and how they interpreted a curriculum reform, L97 (Kleve, 2007). This was an ethnographic study which included methods as focus groups, conversations with teachers, teachers' self estimations and classroom observations. In this paper I point out constraints influencing mathematics teachers' teaching practice and discuss the relation between the three teachers' beliefs about teaching and learning mathematics and their teaching practices relating to the research literature more widely. Finally I emphasise the importance of identifying such constraints.*

## **MATHEMATICS TEACHERS' TEACHING PRACTICE; A REVIEW OF RESEARCH**

One of the main outcomes of the TIMSS study, which was the largest international comparative study carried out and which created the background for studies on teachers' reactions on reform movements, was the comparison of students' performance in mathematics across the participating countries. Taking the results from the TIMSS study as a starting point, Stigler and Hiebert in 1995 carried out a video study of lessons in Japan, Germany and the US in which they described and compared mathematics teaching in the three countries. They revealed that there were differences in teaching practices within each culture and that differences between each culture were enormous (Stigler & Hiebert, 1999). Although the teachers in the three countries said that they had read the reform documents and that they used the reform ideas in their teaching, studies of the videos from 1995 also revealed that there were great unevenness in how reform ideas were interpreted among the teachers and little evidence was found that the teachers' classroom practices reflected the goals of the reforms (Stigler & Hiebert, 2004). This was also emphasised by Jacobs, Hiebert, Givvin, Hollingsworth & Wearne (2006). They gave a questionnaire to the teachers who participated in the TIMSS video studies in 1995 and 1999. The results from the questionnaires gave the impression that the majority of the teachers were teaching in line with the ideas in the NCTM standards (NCTM, 2000). The teachers also reported that the videotaped lessons illustrated this. However, the researchers found that classroom practice was not consistent with the Standards and that "the typical eighth-grade classroom displays teaching at odds in many respects with the recommendations" (p. 28). Thus these studies demonstrate findings that teachers' teaching practices were different from what the teachers had reported.

The teachers' teaching practice, as it turns out in the classroom, has been an important subject of research in investigating how teachers have been responding to curriculum reforms. This part of the curriculum, the enacted curriculum, which is what takes place in the classroom, is the curriculum jointly constructed by the teacher and the students and the teaching material (Remillard, 1999, 2005; Ross, 2003; Spielman & Lloyd, 2004; Tarr, Chávez, Reys, & Reys, 2006).

There have been pointed out many constraints and issues between the intended curriculum and the one enacted. Even when teachers have reported their agreement in the principles lying behind a reform, the actual classroom practice, the enacted curriculum, has turned out to be traditional in style (Broadhead, 2001; Norton, McRobbie, & Cooper, 2002). Traditional beliefs and practices regarding school mathematics are challenged by reform oriented curricula and teachers' deeply held beliefs can serve as obstacles in implementing new reforms (Lloyd, 2002; Manouchehri & Goodman, 1998; Reys, Reys, Barnes, Beem, & Papick, 1998; Smith Senger, 1998/1999). Also obstacles and constraints are reported as lying outside the teacher such as other colleagues, the school's discourse, and parents' expectations, perceptions and concerns. Furthermore, the classroom context and the students' contributions during the lessons are of decisive importance for how the enacted curriculum turns out (Remillard, 1999; Skott, 2001a, 2004).

There have also been reported varying degrees of consistency between teachers' conceptions of mathematics and their instructional practice (Thompson, 1992). There seems to be higher degree of consistency when teachers report traditional conceptions about mathematics and its teaching than when teachers report a more reform oriented view. The importance of the relationship between teachers' teaching practice and teachers' conceptions about mathematics and mathematics teaching in connection with the implementation of a curriculum reform was also emphasised by Cooney (2001). He viewed teachers' teaching practices as highly influenced by their views about mathematics and mathematics teaching.

Skott (2001b) challenged much of the underlying rationale and premises lying behind research about teachers' beliefs and he questioned research which has as an implicit premise that a teacher's beliefs can serve as explanatory principles for practice. Being inclined to take more cultural factors into account he claimed that what the teacher does in the classroom makes sense for the teacher based on the multiple motives for the present action even if those actions may seem inconsistent for an observer. "Students' and teachers' actions do make sense, [ ], teachers cannot be inconsistent" (Skott, 2001b, pp. 6-7). Instead of assuming that there is something lying behind a teacher's practice which is called a teacher's beliefs, he looked upon the motives determining a teacher's practice not as predetermined beliefs but rather as entities emerging from the interactions with the students in the classroom. This underpins how the socio-cultural complexity of the classroom plays a role in research about teachers' beliefs.

Taking Skott's (2001b) claim that "inconsistency is an observer's perspective" Leatham (2006) accounted for the problem of consistency or inconsistency between a teacher's beliefs and practice by the introduction of the beliefs as a "sensible system". Viewing teachers' beliefs about teaching and learning mathematics as a "sensible system" Leatham (2006) suggested interpreting teachers' beliefs not as inconsistent with their actions in the classroom, but rather as systems where certain beliefs have more influence over actions than others. He exemplified this perspective by accounting for how a teacher's beliefs about classroom management had more influence over her classroom practice than that of her beliefs about the effect of group work. Therefore the students did not work in groups although the teacher had expressed her beliefs about group work as an effective learning activity.

## **MY STUDY AND FINDINGS**

In my study I focused on teachers' interpretation of the curriculum reform, L97, and on their implementation of it. I used research methods fitting largely into an ethnographic approach. A simultaneous use of several data-gathering methods gave me the opportunity to grasp a complex reality. I observed three teachers one lesson a week for 3 months, and I had conversations with them before and/or after the lessons. I also used focus groups interviews with the teachers which together with the individual conversations I had with them, gave me information about how their teaching practices were related to the beliefs about teaching and learning mathematics. All of this was audio taped, transcribed and analysed. I also have information from the teachers obtained through questionnaires, self estimation and their writings about what they looked upon as "ideal" teaching of mathematics.

The three teachers in my study, Bent, Cecilie and David, were all mathematics teachers in lower secondary school. Below I offer a general presentation of their teaching practices before explicitly pointing out the constraints which I saw were influencing their practices. In the last part I discuss how the teachers' practices were related to their expressed beliefs about teaching and learning mathematics.

David said very explicitly that he did not relate to L97, which also characterised his teaching. However, he thought very carefully about his way of teaching which had developed throughout many years of teaching experience and work with mathematics. He expressed a greater belief and faith in his own judgement of good teaching than what was recommended in L97. His beliefs about teaching and learning mathematics were thus very socio-culturally rooted both in his own educational background, in his own experience as a teacher and in the school context. He had experienced that his way of teaching mathematics had worked well; he had experienced success as a teacher; his students performed well on exams and according to what he said, students and parents liked his way of teaching. David demonstrated a sure grasp of mathematics as a subject, and he always had an answer ready to present when a student asked for help. He also strongly advised the students what to have in their rulebooks (which according to the reform were supposed to be self-made) and he handed out photocopies he had made for them to paste in. Their

use of the rulebooks on the exam had shown to work well. Based on this there was no reason for David to consider changing his way of teaching.

Unlike David, Cecilie expressed that she liked L97 and that she used it in planning her lessons. She was the only teacher who said that she actively used L97 in her teaching and that she rarely used textbooks. Just like David rather “used his own head” (David’s own expression) than L97 in his teaching of mathematics, Cecilie used her own ideas and ideas picked from other literature rather than the textbook. “I liked it [i.e. L97], but I did not like the textbooks following it”, she said. Thus both Cecilie and David can be seen as teachers who had faith in what they were doing, and who had made their own judgements how to teach and on what aspect of mathematics to focus. They had constructed their own conceptions of good mathematics teaching based on their own ideas and experience. Cecilie believed that students learn best from exploring things themselves and that they then learn some mathematics they would not learn by only using “ready made” formulae. She therefore prepared for “exploring activities”. However, the way it turned out in the classroom, the enacted lessons, was that she being *the teacher* did the exploring and the students were channelled through the activity by answering the teacher’s easy manageable closed questions. Another significant aspect in the course of her lessons was that many students lost track throughout her exploration and stopped paying attention. A few clever students followed her and contributed with comments and suggestions. This shows that factors such as having students with different mathematical abilities and different interest for the subject in the same classroom and the complexity of the classroom, in which there were contradictory demands on individual students (some students were very interested and captured the teacher’s attention while others talked to their class mates), influenced the enactment of the lesson. This suggests how Cecilie’s visions about doing exploring activities were not so easily translated into her classroom practice.

The third teacher, Bent, expressed that he both wished and thought he ought to do more exploring activities, as recommended in L97, than he currently did. He thus expressed more uncertainty about his own teaching than the other two teachers. Contrary to Cecilie, who was able to prepare exploring activities, Bent indicated that he was not sure how to do that. He said “there I have a way to go myself”. Bent reflected more than the other two teachers on how he saw himself as not yet sufficiently accomplished as teacher. Furthermore he demonstrated a more inquiring attitude towards his practice than the other teachers. In addition to admitting that he did not know how to do exploring activities, Bent suggested other reasons for not responding adequately (as he saw it) to L97. These reasons can be seen as “constraints” in Bent’s teaching. Time pressure and parents’ and students’ expectations were the most evident ones. One outcome of the analysis of the observed lessons with Bent was how he dealt with a highly complex classroom with many disciplinary issues and with demanding students. However, in analysing data from his lessons, I also saw that he took the often demanding students’ contributions into account in whole class and that he challenged and structured their thinking

during individual seatwork. These were also elements of teaching mathematics reflected in L97, a challenge he thus seemed to have accomplished.

In analysing the data obtained from my work with Bent I noticed his reflections on how much time to spend on conceptual understanding as opposed to the method of mastering a procedure and that some students are happy just knowing the rule and using it. David also expressed the same kind of awareness with regard to relation between students' abilities and working methods. There was a difference, however, in how the awareness was presented. Whereas Bent offered a reflection on and expressed an uncertainty how much weight to put on computational methods as opposed to relational understanding, David expressed a certainty that the weak students would manage in the classroom while exercising procedures, but would forget later because, as he said, "they won't digest it". He demonstrated an acceptance of that.

Both Bent and David expressed a view that for the weaker students it is better to focus on the method than to spend a lot of time to explain the *why*. Bent expressed an uncertainty about how much time to spend on the *why* to make a few more students understand, and David said that there is a "balance" how much time to spend, and therefore some students can rather "do it mechanically". In the analysis of Cecilie, I saw the relation between the working methods and students' abilities in her teaching. She focused more on methods and the procedural aspect of mathematics for the weaker students than for the clever ones. Hence, an indicated relation between focus on the procedural aspect of mathematics and students' abilities was common for all three teachers.

In the literature there has been pointed out how mathematics teachers, even when teaching in the same school, have responded differently to a reform and thus have carried out different teaching practices. Based on the study of the teachers in my study I saw three types of teaching which can be summed up as follows:

Bent focused on students' conceptual understanding. In his teaching he challenged students' thinking and encouraged them to see connections between different mathematical entities. He was thus "bridging" between previous and new knowledge. Cecilie prepared exploring activities. She expressed a belief that students learn best by exploring things themselves, and that they then will discover mathematics which cannot be learned from only using ready made formulae. From my perspective, the lessons turned out differently from what the teacher (according to what she said) had intended. The teacher carried out the exploring activities through which the students were channelled by easy manageable questions.

According to David the best way for students to learn mathematics is to have it well explained. The mathematical focus in his lessons was procedural and the discourse in the lessons was characterised by him showing and telling as if mathematics could be transmitted from the teacher to the students.

### **Three types of constraints**

I started this article by discussing obstacles, constraints and issues in teachers' decision making which have been pointed out in mathematics educational research. As an outcome of the analysis of the three teachers in my study, I see three types or levels of constraints influencing the different stages in teachers' implementation of a curriculum. I have had conversations with the teachers (both in focus groups and individual conversations), estimation form, questionnaire, teachers' writing about ideal teaching and classroom observations. Based on what the teachers said about L97 and about their own teaching related to L97, I have got ideas of what beliefs each teacher had about L97. I see these expressed beliefs which are highly influenced by socio-cultural factors as one level of possible constraints preventing the teacher from implementing a reform curriculum. If a teacher does not believe in the reform, if s/he does not want to teach according to it, if s/he believes that the way of teaching mathematics s/he has always done is the best way, then one cannot expect that s/he implements the curriculum. I look upon this as one type of constraints. These constraints which are preventing the teachers from implementing the reform are lying in the teacher's beliefs. This is the level of constraints that I found most visible in David's teaching.

The second type of possible constraints influencing the teacher in another stage is seen when the teacher expresses a wish to implement the reform. A teacher believes in the reform, s/he believes that L97's recommendations enhance students' possibilities for learning mathematics, but does not teach according to this to the extent s/he wishes because factors like parents' expectations, students' demands, the work plan and lack of time are constraints that prevent him/her from doing it. These constraints are lying between the teacher's beliefs and his/her teaching practice in the classroom, and they influence the extent to which the teacher teaches according to his/her beliefs. This was where I found the constraints in Bent's teaching most visible.

The third type of possible constraints is seen when the teacher believes in the reform, prepares the lessons according to it by choosing exploring activities and thus an investigative approach to teaching as L97 recommends. However, the way it turns out in the classroom becomes quite traditional. The constraints are in the classroom. The teacher's classroom practices together with the complexity of the classroom are the constraints; they are lying in the activities jointly constructed by the teacher, the students and the teaching material used, in the enacted curriculum. This was most visible within Cecilie's teaching.

### **The three teachers' beliefs and their classroom practice**

There are many factors influencing a teacher's decision making when teaching in the classroom. Skott (2001b) claimed that teachers cannot be inconsistent, and that if inconsistency is observed, that is from the observer's perspective. Leatham (2006) suggested that some beliefs are more central than others, for example the wish to

keep control of the class is more central than believing in group work. The constraints I identified can be looked upon as beliefs being more central than other beliefs. A belief that it is important to comply with demands from parents and thus to teach from the board, seemed to be more central to Bent than his belief that students ought to engage in exploring activities. For Cecilie a belief that doing (showing on the board) exploring activities was important seemed to be more central than a belief that all students in class ought to participate in the activity. With regard to David, whose teaching I in the analysis characterised being traditional in style, he did what he said he did and what he believed was the best way to teach and thus for students to learn. Hence in the case of David, consistency between his expressed beliefs and his teaching practice was observed. Thompson (1992) reports findings in research about seemingly higher degree of consistency between teachers' beliefs and their teaching practice when they express traditional conceptions about mathematics teaching. Thus in the case of David, the strong relation I found between what he said and what he did is also recognisable in the literature.

### **WHY IS IT IMPORTANT TO IDENTIFY CONSTRAINTS?**

For a teacher educator with the purpose of in-service training, knowledge about constraints is valuable. I suggest that enhancement in a teacher's practice has a greater possibility to take place when factors constraining the practice are identified. I have reported constraints as lying in the complexity of the classroom, in the difficulties of transition of visions about good mathematics teaching into practice; between the teacher's beliefs and practice, in the socio-cultural environment as society's and parents' expectations and the school context. Being conscious of such factors, which to a certain extent can be dealt with, can thus open up possibilities for professional development of mathematics teacher educators' and teachers' teaching practice. However, constraints lying in the teacher's beliefs are more difficult to deal with, because only the teacher him/herself can change his/her own beliefs. Mason (2002) writes: "I cannot change others, but I can work at changing myself" (p. xii). I suggest that collaboration between teachers and with teacher educators can influence beliefs so the teachers and teacher educators can work at changing themselves.

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