A COMPARISON OF TEACHERS' BELIEFS AND PRACTICES IN MATHEMATICS TEACHING AT LOWER SECONDARY AND UPPER SECONDARY SCHOOL

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The focus of this paper is a comparison of lower and upper secondary teachers' beliefs regarding teaching mathematics in general. This is linked to a research project concerning the transition from lower secondary to upper secondary school and the learning and teaching of functions. In Norway the transition from the 10th to the 11th grade always involves these separate institutions. The results presented here are based upon interviews with teachers at both lower and upper secondary level of schooling and some interesting differences in their views of mathematics teaching are uncovered. Hopefully, these preliminary findings could give rise to meaningful discussions related to how a qualitative approach to the transition issue might be carried out.

Keywords: mathematics teaching, transition, lower secondary, upper secondary

INTRODUCTION

In Norway, the transition between different phases of schooling, particularly in relation to the learning and teaching of mathematics, is an area where little research has been done and the major part of the international research in this field concerns the transition from upper secondary school to university/university college (often denoted as the secondary-tertiary transition) (Gueudet, 2008; Guzmán et al., 1998). My own experiences as a student and a teacher, at both lower and upper secondary school levels have led me to believe that the traditions and beliefs in these institutions differ in ways which in turn might affect students' learning. As a PhD student (in my second year), I have chosen this transition as the focus of my research. It is important to note that in Norway, upper secondary schooling is divided in two main programmes: the vocational programmes, which are orientated towards practical professions and the general study program, which aims to prepare students for higher education. The curriculum is different in these programmes and is considered to be more 'theoretical' at the general study program. This is also the case for mathematics as a subject. Both of these programmes are included in this research. Further, I have chosen to focus on *functions* as this is an area highly relevant to both levels of schooling, and personally I find the development of students' conceptual understanding of functions to be an interesting research area. It is also possible to expand this area of research, for example by taking the universities/university colleges into the consideration, as the learning and teaching of functions is an important issue in several of these study programmes. However, in this paper I will focus on mathematics teaching in general (not only teaching related to functions).

RESEARCH QUESTIONS

I pose the following research questions, relevant for this paper:

What are the differences in the didactical approaches related to mathematics teaching, in lower secondary versus upper secondary school? How are such possible differences perceived by the teachers at both these levels of schooling?

To approach the first question, I compare the lower and upper secondary teachers' views and practices concerning the teaching of mathematics in general. Concerning the second question, I present the lower secondary teachers' statements related to how they think upper secondary teachers perceive the teaching of mathematics in lower secondary school. These statements are then being compared to the actual statements of the teachers at upper secondary school.

THEORETICAL BACKGROUND

An established and well-documented argument within educational research is that teachers' beliefs are one of the best indicators of the decisions teachers make throughout their career (Pajares, 1992). The link between beliefs and actions, therefore, motivates for many of my interview questions. As indicated by Mosvold (2006, p. 37) research shows that many of these "beliefs are shaped from the experiences of those who taught them". What often seems to be conflicting interests, or even paradoxes, experienced in teachers everyday practice, is described by Mellin-Olsen (1987; 1991) as characteristics of a 'double bind'. According to Mellin-Olsen, double bind can be recognized at many levels. One aspect of this can be that the individual is tightly connected with his environment, and consequently left with few individual choices. Often this relates to the 'didactical contract' which in its simplest form means that "the teacher is obliged to teach and the pupil is obliged to learn" (Mellin-Olsen, 1987, p. 185). Hidden (or in some countries even explicit) competition between teachers at the same time as they need to cooperate can be an example of a double bind. The confidence the teachers often express that they feel in traditional teaching, for example the early introduction of standard algorithms without giving their students 'permission' to use alternative methods, can be another example. Such 'permission' could, from the teachers' point of view, imply a break in the didactical contract. In turns this could lead some teachers into what they consider as 'safe' and effective curriculum-oriented teaching, preparing students for an oral or written exam. According to Mellin-Olsen (1987, p. 150), a double bind "is due to the handling of *metaknowledge* about the control caused by the taxonomies." Based on information found in some of my interviews, I have reasons to believe that at least some of the teachers on different levels experience what could be described as aspects of double binds. Some, especially recently educated teachers, state that their "ideals of teaching" often have to be set aside because of their obligations to the curriculum and the upcoming exam.

As my observations in the classroom concern the teaching of functions I find it relevant to include the Leinhardt et al. (1990) quote: “There is no proven optimal *entry* to functions and graphs” (p. 6). It is therefore, in my view, important to be aware of the multitude of different didactical approaches and to be conscious about the various conclusions.

METHODOLOGY

Five different classes in five different lower secondary schools participated in this research. Two of these schools are private schools while the other three are public. The private schools were included in an attempt to seek some diversity in the sample, while the public schools were somewhat randomly selected, with the only criteria being that they, due to practical reasons, were located within a ‘reasonable’ distance from my working place. As the Norwegian school system is quite homogenous I believe that these schools are representative to their area. The headmasters were contacted via telephone and their school was invited to participate. The number of students willing to participate from each class varied from three to ten. In total 33 students participated and I am currently conducting follow-up research on ten of these as they have now entered upper secondary school. I have chosen the follow-up students on the basis of three criterions: equal gender distribution, students at both vocational and general study programmes, and variations of ‘skills’ (on the basis of their marks). The purpose is to gain a rich material with some diversity. My data collection at lower secondary school mainly consisted of five “phases”: Observations of the teacher teaching, recorded conversations with the students engaging in mathematics in the classroom, interviews with the students, collection of students’ handwritten material and an interview with their teacher. This provides me with a diverse and rich data material which allows me to study mathematics education from various perspectives. The data collection at upper secondary school is done in a similar way, and I consider the fifth phase (teacher interviews) to be most valuable for this paper, as this relates to both teachers beliefs and practices. My use of research instruments did vary somewhat from school to school, primarily due to the fact that some teachers imposed restrictions for example on my use of a video camera. By the use of semi-structured interviews I aim to seek information mainly about teachers’ beliefs. However, I also try to get a broader picture of their teaching practice, by asking them to estimate the use of different teaching methods. They were interviewed for about 45 minutes, and in addition to their teaching practice they were asked about their views on ‘good teaching’ in general. They were also asked to provide some personal background information. I have aimed to design the interview questions in accordance with Kvale (1997, p. 77), suggesting that “The questions should be easy to understand, short and free for academic terminology” [1].

It was also important for me to formulate questions that would make it possible to compare teachers’ beliefs and ideas in lower and upper secondary education. These interviews were all recorded with a Dictaphone.

EXAMPLES AND ANALYSIS

Teachers at lower secondary school

I will start this section by presenting excerpts from teachers own statements regarding what they consider as good teaching in mathematics. These first three statements are excerpts from the interviews with the teachers at the 10th grade at lower secondary schools.

In your opinion, what characterises good teaching in mathematics? [2]

Jon: Good teaching…eh…variation, organised towards the individual student…eh…, adjusted according to different teaching styles, and that you go through the given exercises with this in mind.

Interviewer: Could you please go into some details about how you organise teaching towards the individual student in your practice?

Jon: Yes, this can be done by different tools, we might use the blackboard as a medium, and we might use the computer as a medium. We can do some practical exercises, where we work in a physical way, or we can make some problem solving exercises. We can do this interdisciplinary along with other subjects.

……

Sue: Good teaching in mathematics…eh…ideally, good teaching in mathematics, the start of a lesson…eh…it should be some repetition from the last time, in terms of "what did you learn?" Eh…maybe about five minutes, "what did you learn the last time?" Then a period in which you go through new content on the blackboard. And maybe a longer period, where the students can do some exercises.

……

Ann: In general, I think it is important that the individual student is making progress from his or her own starting point, within the subject that we are dealing with. Of course this has to be done in accordance with the curriculum, and so forth. But you have to achieve this. That is what I think.

Interviewer: Do you have any concrete ideas related to how this might be carried out?

Ann: Well, this has to do with differentiation. You know…eh…it is a very big gap, and you have to motivate students to make progress from where they stand, actually. But this is difficult to achieve. This can be done by giving different levels in the tasks given at the students' working plans. We also try to differentiate in the tasks given in the folder. [3]

We notice that their answers are not quite univocal, and the three teachers' views on "good teaching in mathematics" seem to differ in some ways. Jon seems to give an account of some general aspects of good teaching, and Sue seems to relate the question to a concrete situation, like a recipe of a good lesson. Common for both Jon

and Ann is the importance of differentiation. The tables below show the teachers' suggestions of how frequent different teaching methods are used. The time measured in minutes estimates the time used in each lesson. The three schools all have 4 lessons a week, each 45 minutes. These numbers are only based upon what they have done related to the class participating in this research.

Teacher	**Lectures-blackboard**	**ICT**	**Homework Discussions**	**Individual Exercises**	**Pair/group-work**	**Problem solving**
Jon	1-3 lessons a week 15-20 min	1-3 lessons a week 30 min	1 lesson a week 10 min	Almost each lesson 30 min	2 lessons a month Whole lessons	Sometimes (hard to establish)
Sue	Each lesson 30 min	6 lessons (this year) Whole lessons	Each lesson 5-10 min	2-3 lessons a week 15 min	Not organised[4]	Never
Ann	2 lessons a week 30 min	Sometimes (hard to establish)	2 lessons a month 5-10 min	2 lessons 15 min + 2 whole lessons	2 lessons a month Whole lessons	A few Times (hard to establish)

Table 1: The frequencies of different teaching methods (assumed used most frequently)

Teacher	**Interdisciplinary Projects**	**Excursions**	**Outdoor Activities**
Jon	2-3 weeks a year	Never	Never
Sue	2 weeks a year (together with Art and Design)	Never	Never
Ann	Never	Never	1 day a year

Table 2: The frequencies of different teaching methods (assumed used less frequently)

The tables show for example that Sue states that she never uses 'problem solving' as a method of teaching and seldom uses ICT. She also seems to use the blackboard and discussions related to homework more frequent than the others. It is also interesting to notice Jon's relatively frequent use of ICT. The pre-assumed more rarely used methods, as interdisciplinary projects, outdoor activities, and excursions appear with quite similar frequencies.

The idea behind the next question is to grasp one aspect of the teachers' beliefs concerning upper secondary school.

How do you think that the teachers at upper secondary school conceive of the teaching in mathematics at lower secondary school?

Jon: I do not really know – maybe they shake their heads and think "what in the world have we done at lower secondary school?" But I also think they have completely different pre-conditions for their activity.

Interviewer: In what way?

Jon: Well, you do not have "the herd" in an ordinary class at upper secondary school – they come there because they have applied for going there – but we have the average of the whole Norwegian population in one class!

……

Sue: I am very convinced that the teachers at upper secondary school feel frustrated about the students at lower secondary school and their total lack of knowledge.

Interviewer: Ok…?

Sue: Well, maybe, and here they come at upper secondary school, and they can not add two fractions!

Interviewer: Mm…?

Sue: Here they come at upper secondary school and do not manage this! They have not learned anything…

……

Ann: I do not really have any strong opinions here, but my impression was, when I worked there myself, that the teachers there were very different. I also think that there was a big difference among the students, related to which lower secondary school they attended before they started.

Although this question could be regarded being a bit speculative, since most of the answers are hypothetical, I was surprised by the level of consensus. As we can see, both Jon and Sue indicated some negative assumptions, while Ann was more neutral. Both of them seemed to share the worries that the teachers at upper secondary school, to some extent, are frustrated by the limitations of their students' starting point. The negative assumptions were also shared by the two other teachers, not presented here.

Teachers at upper secondary school

I will now consider four of the teachers at upper secondary school answering the corresponding questions. The first two excerpts are from teachers at the general study programme.

In your opinion, what characterises good teaching in mathematics?

Tony: Well, maybe the most important aspect in such a subject dealing with systematics, is clarity. Clarity in the presentations and that one manages to simplify complicated issues. The teacher's job, in a way, is to simplify the textbook for the students, because we observe that this is a subject that is very hard to study on your own and you are very dependent on going through the content.

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Mary: It must be teaching…eh…in such a way that the students understand what they are doing. Eh…and that they are motivated to continue to work with mathematics

Interviewer: Do you have any thoughts of how this can be done?

Mary: I think on this level, if they are mastering the mathematical content, this in itself is good enough for motivation. Helping them to master the exercises is very important, because most of the students like mathematics.

In this next excerpt, the same question is asked to a teacher at a vocational programme.

Lisa: I have some years with experience from the lower secondary school, and I think that working with concretes and go outdoors and do things is a good way of working with mathematics. Good teaching will be to organize such activities in a good way. Now at upper secondary school I almost only teach by giving lectures at the blackboard, in and old-fashioned way.

Interviewer: What is the reason for that, you think?

Lisa: It is another culture here. They are all working, determined to get the students through the textbook in an efficient way.

Interviewer: Why do you think it is difficult to teach the way you would like?

Lisa: Well, I am new here and I do not want to go against my colleagues.

It is interesting to notice Lisa's reflections on her own situation, probably much due to her background from lower secondary school. The two other teachers at the general study programmes do not express the same kind of worries. They both seem to share the value of good explanations and the importance of doing exercises from the textbook. Jon stresses the importance of clarity and Mary the importance of mastering the textbook content.

In the same manner as for the teachers at lower secondary, the teachers at upper secondary school were asked about their use of different teaching methods. The results are presented in the tables below. Tony and Mary's classes have five lessons a week and Lisa's has three.

Teacher	**Lectures-Blackboard**	**ICT**	**Homework Discussions**	**Individual Exercises**	**Pair/group-work**	**Problem solving**
Tony	Each lesson 15 min	2 lessons a month 30 min	1 lesson a week 10 min	Each lesson 30 min	Not organized	Never
Mary	Each lesson 15 min	5-10 lessons this year Whole lessons	1 lesson a week 10 min	Each lesson 30 min	Not organized	Never
Lisa	Each lesson 20-25 min	Never	A few times (hard to establish)	Each lesson 20-25 min	Not organized	Never

Table 3: The frequencies of different teaching methods (assumed used most frequently)

Teacher	Interdisciplinary Projects	Excursions	Outdoor activities
Tony	Never	Never	Never
Mary	Never	Never	Never
Lisa	Sometimes at the mechanical working rooms	Never	Never

Table 4: The frequencies of different teaching methods (assumed used less frequently)

As illustrated the use of methods assumed less frequently, are rarely/never used. The more common methods appear in quite similar frequencies, and the 'typical' lesson seems to be divided in two, with the first part consisting of a lecture at the blackboard and the second part consisting of individual exercises from the textbook. In general it seems like there are only small variations between these teachers and their use of methods.

The next question was posed with the intention to compare the upper secondary teachers' statements with the lower secondary teachers assumptions.

Which thoughts do you have concerning mathematics teaching at lower secondary school?

Tony: It is always easy to blame the teacher responsible for the class, the previous year, but they have whole classes with enormous gaps between the students. Probably much time is used just to keep them quiet. So the students coming to us may not have got the follow-up which they should, from the lower secondary school. They take to easy on it [the students] and their efforts are not as they should have been.

……

Mary: I think teaching at lower secondary school is very dependent on the personality of the teacher…eh…and this is of course also the case at upper secondary school. But in general I will assume that it is quite similar. Maybe it is more group work at lower secondary school.

……

Lisa: I think the students get to work on their own to much, and they do not take that responsibility, they are not keeping up and they end up here. That being said I think the teachers vary their methods more, as I said before. I also think that much of the differences are due to the teachers' background. At lower secondary school they are educated at general teacher education institutions, but here they are educated at universities.

By the exception of Mary being more neutral to the question, the other two seem to express some kind of worries. Common for these are the suspicions that the students do not get the required follow-up from their teachers. It is also interesting to notice

how Lisa is pointing to the teachers' background as a possible reason for different ways of teaching.

The comparison of these interview excerpts and the tables from the lower and upper secondary level of schooling, gives rise to some reflections. While at least two of the teachers at lower secondary emphasized differentiation and the importance of reaching the individual student, the teachers at upper secondary school tend to emphasize the importance of good explanations, techniques and individual task solving, mainly from the textbook. The exception here is Lisa, who expresses some frustration of being 'forced' into a teaching tradition which seems to go against her own principles. The tendencies expressed by these teachers are also to some extent reflected in the tables, and the overview of the teachers' use of methods in the classroom.

The lower secondary teachers' beliefs concerning the upper secondary teachers' perception of teaching in the lower secondary level showed some consensus. These were at most negative assumptions, and to some extent they were in accordance with what the teachers in upper secondary actually stated. Although their suspicion of the insufficient follow-up of the student was not actually stated among the lower secondary teachers, they shared the worries concerning their students' 'insufficient' mathematical knowledge. Despite these remarks, it is important to notice that the statements within the group of teachers at both lower and upper secondary school are far from univocal. This is also the situation if we study the interviews in a more holistic manner.

CONCLUSION AND FURTHER DISCUSSION

So what can we infer from the examples above? The teachers at lower secondary school related some of the challenges in teaching to their students' abilities, and the diversity within their group of students. This was also mentioned by some of the teachers at upper secondary school. I think that common to these, and similar statements, are the relation to what Mellin-Olsen (1987; 1991) denotes as a double bind. This is because the concerns of most of these teachers relate to what in their view are conceived of as conflicting issues. The obligations of getting through a given curriculum, and at the same time being able to teach in a fruitful way, for some, seemed to cause a dilemma. Apparently the teachers at upper secondary school feel that the most 'safe' way of coping with the demands of the curriculum is in terms of traditional teaching methods. One reason might be that there usually is a higher probability for the students in upper secondary school having to take an exam. Another reason, also indicated among both group of teachers, could be that there exists a view that students at upper secondary level have made a more specific choice related to their career, and the mathematics is in a way a part of that choice. Therefore it becomes important for the teachers that nothing is 'omitted', and hence few 'risks' are taken. Being aware that these are only speculations, I still think these could be important hypotheses to investigate further upon. In Lisa's case, being loyal to her

colleagues and at the same time manage to teach in a way that she considered as appropriate obviously constituted a dilemma.

As Lisa further mentioned, cultural issues such as the fact that teachers at upper secondary level tend to have a university background while teachers at lower secondary tends to come from general teachers education should also be considered, in an attempt to understand possible differences in their beliefs and practices.

NOTES

1. Translated from Norwegian by the author.

2. All the transcriptions are translated form Norwegian, with an attempt to preserve the teachers' original statements as authentic as possible.

3. This teacher regularly gave her students exercises which they were supposed to put into a folder. The folder was evaluated by the teacher. In total the folder counted as one third of their final marks in mathematics.

4. This means that the students were allowed to cooperate at their individual tasks, but no group work was organized by the teacher.

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