Societal Demands on the Profession of the Mathematics Teacher in Iceland in a Historical Context

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The histories of official teacher education and school legislation in Iceland coincide with the history of ICMI. Iceland, a marginal country in Northern Europe, may be taken as an example when evolution of societal demands on the profession of the mathematics teacher is submitted to analysis and consideration. The following aspects will be considered:

- goals of mathematics teaching and the teachers' role as perceived by them and others
- mathematics education of teachers, teacher subcultures and didactical divide
- the present situation of education of mathematics teachers

The century will be divided into three periods; the early 20th century, 1946 to the 1970s, and the present time. Iceland is sparsely populated (70,000 in 1900, 300,000 in 2006) and the number of mathematics teachers low, so the history is traced by historical anecdotes.

Theoretical Background

Iceland belonged to the Danish realm until the 1940s, and Icelandic teacher education has its roots in Denmark. Niss and Jensen's (2002) description of the divide between the seminar tradition and university education in teacher education (81-82), and consequent teacher subcultures (160-162), applies to Iceland as well. Cooper (1985) and Gjone (1983) have also described a clash between teacher subcultures at the introduction of the "New Math" in the 1960s-70s. Lately, Bergsten and Grevholm (2005) have written about the didactical divide in mathematics education, i.e. the lack of connection between different kinds of knowledge, such as disciplinary and pedagogical knowledge, and its relation to teacher education. Niss (1996) has analysed the goals of mathematics teaching at various times in different societies and concluded that the focus has varied between utility-oriented reasons, cultural maintenance of society, and equipping the individual to cope with life (24). This paper will discuss goals observed in 20th century Iceland, teacher subcultures and the possibility of didactical divide in the light of these papers.

The Early 20th Century

At the implementation of schools legislation in 1907 primary teachers were needed. The requirements were preferably some school education, but otherwise intelligent people. Physically handicapped people, not fit for farming work, were often appointed to teach. In 1903-1904, 415 persons worked as teachers. Of these, 134 had never been to school themselves, 24 had been to a teacher training college, 99 were graduates from lower secondary schools, 11 high school graduates and 18 university graduates, mainly theologians. The remaining 129 included people with some vocational training (Finnbogason, 1905: 16). The teacher's task was to "hear" the pupils about their homework, one at a time, and the teacher was called a "hearer" (Halldórsson, 2001: 64-65). The author of the legislation wrote:

> ... The children learn the methods of calculation and use them without understanding at all ... *why* one does this and not that. Such things destroy all understanding and independent thinking ... He who can think and use commonsensically the four main calculating operations, can … solve any … problem (Finnbogason, 1903/1994: 92-93).

The first Icelander with a university degree in mathematics, Dr. Ólafur Daníelsson, built up mathematics education of primary teachers when the Iceland Teacher Training College was founded in 1908. One of his students recounts:

> … I once stood at the board … I solved the problem easily, as I had learnt by heart … the Doctor asked: Why is it correct to solve the problem this way? This I did not know ... [His] teaching opened my eyes for how futile it is to teach to children … calculation methods without their understanding what they are doing (Þórleifsdóttir, 1958: 188).

Dr. Daníelsson called his students to the board as tradition demanded, but he also awoke questions in their minds. In his textbooks he expressed his views on the goals of mathematics teaching and the capability of teachers to implement them:

> ... many learn the methods by heart without understanding their reasons; and more so as many of those who work at teaching may lack sufficient skills to explain the arithmetic down to its roots, without having for that any support from the textbooks (Daníelsson, 1906: iii-iv).
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> … the purpose of mathematics education in schools is completely hidden from some intellectuals; they think that the goal of geometry teaching is … to measure cabbage patches ... the purpose … is to train the pupil in precision of his thinking and … his inventiveness, in which no other subject trains him to the same degree (1920: iii–iv).
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> … pupils … come up to ... [entrance] examination, prepared in algebra in such a way that they … do not ... know the basis of the symbolic language, have … had no tuition … some of those who work on teaching do not … have a clear idea about the purpose ... (1927: 3–4).

Dr. Daníelsson left teacher training for Iceland's only gymnasium (high school) when a mathematics stream was established there in 1920. Some mathematical content knowledge and pedagogical content knowledge of primary teacher student teachers for the primary-school level was ensured in Dr. Daníelsson's time. However, many teachers were not familiar with the subject. For teachers at lower secondary schools, study of theology was the accepted preparation. The teachers' task was to question the pupils, but many may not have had the capability to awaken their thinking or perceive it as their task.

Reconstruction of Secondary Education and "New Math"

Middle schools were established by school legislation in 1946. Algebra and geometry, which had hitherto been taught in the six-year gymnasium programme, were now to be taught at middle schools all around the country. These topics were not even taught at the Teacher Training College. Only graduates of the gymnasium mathematics stream were familiar with the subject. Few had studied mathematics at university; the discipline first became available in Iceland as part of engineering studies during World War II. The requirement for tenure at middle schools was 1-2 years' study at university, preferably in the teaching subject, and some general teacher training. The first middle school mathematics teachers had e.g. begun studies in law, medicine, business administration or engineering.

In 1951 a B.A. programme for middle school mathematics teachers was established as part of the engineering programme. Over a period of 20 years, 26 people graduated in mathematics and physics. Nineteen of them became teachers, 15 in middle schools. I interviewed three headmasters of three of those middle school teachers, whose pupils had performed relatively better in mathematics than in other subjects at a national entrance examination into the gymnasium. The headmasters were not aware of the value of their teachers' education. One of them (November 2002) had noticed the good performance in mathematics, but attributed it to the personal qualities of the teacher and had not connected it to his specialisation. Another (October 2002) remarked that the general average had declined when entrance had been restricted, and blamed it on the teacher who had suffered from periodical mental illness. He had not noticed the relatively good performance in mathematics. The third headmaster (December 2003) knew his school's performance was better than in the neighbouring towns, but as his school exceeded them in most subjects, he had not been aware that the mathematics

performance of the pupils in his school was by far the best in the country (Bjarnadóttir, 2006: 286-289). While the performance records pointed to a gap in mathematics education between university-educated teachers and others, even headmasters were wary about mathematics, and had more belief in teachers' personal qualities than in specialisation in the subject.

A crucial moment in the history of mathematics education in Iceland was marked by influences from the OECD, advocating new concepts of the role of education, i.e. that it contributed substantially to economic and social progress (Efnahagsstofnunin, July 1965: 9). Another source of influence was a seminar held 1961 in Royaumont, France, where the OEEC gathered mathematicians, mathematics educators and government officials to create new policy in mathematics education. The result was the "New Math"; school mathematics, based on concepts from set theory and logic. No Icelander attended the seminar, but information soon filtered into the small community of mathematicians and to politicians and led to increased attention to mathematics education. A survey showed that Icelandic teaching material was years behind that in the other Nordic countries (Björnsson, 1966); another survey, now lost, made by G. Arnlaugsson in 1965, indicated a lack of mathematical skills at compulsory level (Lárusson, interview 2002). The inadequate training of mathematics teachers was blamed. A main proponent of the "New Math" movement, Arnlaugsson, wrote:

> Many teachers in the primary and middle schools have never in their studies met mathematical thinking ... mathematics … should … be the tool to train the child in logical thinking. If this is clear to the teacher, and he/she has an overview of the coherence of the topics of arithmetic that he/she is teaching, he/she could doubtless achieve a better result than ... now, even if there were few actual changes in the syllabus (Arnlaugsson, 1967: 43–44).

The movement had great influence. The government supported wide-reaching reform of mathematics education, while teachers reconsidered their teaching methods. One of the five gymnasium mathematics teachers who were educated before 1960 to master's level or more, said in an interview: "I stopped taking pupils up to the board and began lecturing (Jónsson, 2003)." A young, recently graduated Ph.D., who had one year's experience of gymnasium teaching, criticised the current situation in mathematics teaching:

> I think [it] is neglected … that the teacher gives a lecture ... The purpose is not only to explain … but … to show the pupils how they should think. … To transform a practical problem into a mathematical problem always requires … mathematical thinking. … it must not be neglected to supply the pupil with some training in talking clearly and understandably about a mathematical subject, to express his/her thinking ... (Elíasson, 1966: 95–99).

In a teachers' guide to a primary level textbook series belonging to the "New Math" wave of the 1960s, the teacher is encouraged to build his/her teaching on dialogues:

> The role of mathematics in developing language sense has increased greatly by the introduction of new attitudes to mathematics teaching ... Teachers' dialogues with pupils about the topics will now become a much greater factor in the teaching than … hitherto … mathematics makes strong demands of clear and logical use of language, as logical thinking is the prime condition for mathematical thinking (Gíslason, 1967: 7).

The citations point to change in attitudes to the desirable way of teaching mathematics at all levels, away from questioning pupils or "hearing," towards lecturing or even dialogues, and training in mathematical thinking. Soon there was a backlash to the "New Math". The set-theoretical syllabus at primary level aroused debates and reactions. There was a clash between the perspectives of the two types of teachers, those trained at universities vs. teacher training colleges, where the former were the initiators and the latter were expected to implement the university version of mathematics. Similar problems occurred in other countries (Cooper, 265–266, 282; Gjone, i, 53, viii, 14–19; Høyrup, 55–59). In many cases the teachers missed

the point of the reform, and saw only yet another method in addition to the old ones (Arnlaugsson, 1967: 43). The public saw cumbersome methods, wordy explanations and a decline in computation skills.

The introduction of "modern" mathematics placed the two types of mathematics teachers at loggerheads, each interpreting and implementing school mathematics according to their own education and professional experience. Mathematicians emphasised the indirect purpose of training the mind, while most primary teachers were occupied with preparing pupils for their perceived future business in everyday life. The ultimate change was in content, rather than in pedagogy or new understanding of mathematics. Yet the arduous experience of "New Math" released teachers' initiative. Some primary level teachers began to create new mathematics material, a task that no-one had been considered able to take on.

Middle school teachers were in between: they had some university training and more mathematical knowledge than primary level teachers and were better able to adapt to the new ideas. However, societal demands, as expressed by headmasters, focussed on their general personal qualities and pedagogical intuition, rather than on their mathematical knowledge.

The Present Day

Teacher training was transferred to tertiary level in 1971. The requirements for middle school teachers were no longer a B.A. or B.Sc. mathematics degree of 90 university credits in a sequential model of two teaching subjects, followed by a general 30-credit course in pedagogy and didactics, with gymnasium mathematics stream as prerequisite. The B.Ed. degree from Iceland University of Education with mathematics as an elective required a total of 25 credits in mathematics and didactical courses in two subjects with no special mathematics prerequisites. In 2003-2004, 35% of mathematics teachers in grades 8-10 had a B.Ed. degree with mathematics as an elective or a B.Sc. degree in mathematics. At the upper secondary level, 46% had a B.Sc. degree or higher qualification in mathematics (Menntamálaráðuneytið, February 2005: 16).

The lack of mathematical training of teachers may be reflected in the PISA 2003 results. The scores of Icelandic pupils placed them 10^{th} to 14^{th} of 29 countries, similar to Danish and Czech pupils. The OECD average for level 6 of highest score was 4.0%. Of Icelandic pupils, 3.6% achieved level 6, compared to 4.1 % of Danish and 5.3% of Czech pupils. The three countries' performances at the lowest level were more similar, in the range 4.5-5.0%; Iceland's figure was 4.5%. Iceland's above-average performance was mainly based on a relatively large group at level 4, 23.2% (OECD, 2004).

Most University of Education students have a background in the social-studies stream at the upper secondary level, where mathematics requirements have recently been reduced from 15 to 6 out of 140 credits (Menntamálaráðuneytið, 1999). Applications in 2005 reveal that 88% of upper secondary school graduates in 2003 or before had completed 12 mathematics credits or more, compared to 61% of graduates after 2003 (Applications 2005). This may be counterbalanced by changes in requirements for mathematics education of student teachers, implemented in year 2007: for those preparing for primary teaching the requirement was raised from 4 credits to 10, and for lower-secondary teaching from 25 credits to 40. Other student teachers will be exempted from studying mathematics.

It is generally acknowledged that complicated computational skills are no longer needed. Yet parents ask what procedure the teacher wants the child to learn, while the teacher wants to encourage the child to find out his/her own procedure and promote thinking skills (Riesto, 2007).

Summary and Conclusions

The history of the 20th century reveals an ongoing tension between university mathematicians (Daníelsson, Arnlaugsson, Elíasson), emphasising training in mathematical thinking and cultural goals, and traditional utility-oriented demands to calculate accurately and quickly the types of problems pupils were expected to meet, but which may have been obsolete.

The teachers' task was to see that pupils obeyed the rules, to "hear" them. When it became a world-wide opinion that the frame of set-theory and logic would ease the study of mathematics, and that the purpose of the studies should move away from technicalities towards clarity in thinking, teachers at the compulsory-school level (ages 6-16) faced a dilemma. They tried to transfer their teaching techniques towards explaining and conducting dialogues. They observed a decline in the technical skills which were demanded by the parental sector of society, while a possible gain in thinking skills was hard to demonstrate. Teachers have been in this dilemma ever since.

In addition to different education of teachers at upper and lower levels, explained by Niss and Jensen, and their different prerequisites for their task, the situation becomes more complex when it is taken into account that scarcely half of mathematics teachers, at either level, have any specialised training in the subject. Most Icelandic teachers have, however, a good general education, and social problems relating to immigrants and other minority groups are minimal, which may explain above-average performance in international comparison studies. However, it seems reasonable to blame the relative lack of excellent performance on many teachers' lack of either disciplinary knowledge, or pedagogical knowledge, or both. A didactical divide as defined by Bergsten and Grevholm is thus not the main problem of Icelandic mathematics teachers, but their general lack of formal mathematics teacher education.

One may conjecture that the ability of Icelandic mathematics teachers to cope with their professional dilemma has still to be improved, and may not improve until the situation of their education has changed considerably.

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