What Characterises Mathematics in the Nordic countries?

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International assessment surveys such as TIMSS and PISA aim at establishing reliable and valid scores for achievement which can be compared across countries or across groups of pupils within countries, and to relate achievement to various background and context variables that may give ideas about possible indicators for characterisation of high or low performance in mathematics. These studies offer opportunities for secondary analyses to answer a great number of research questions about mathematics education in countries all over the world.

An interesting research question is if it is reasonable to distinguish between different types of mathematics education in different countries or groups of countries. Several analyses based on data from TIMSS and PISA has been conducted to answer this question (Grønmo, Kjærnsli & Lie, 2004; Grønmo & Olsen, 2006; Olsen & Grønmo, 2006). The method used is a so-called cluster analysis investigating “item-by-country interactions” in order to find similarities and differences between countries or groups of countries across cognitive items. It has to be recognised that in these analyses, one is talking about relative performance. This cluster analysis displays groupings of countries according to similarities in relative response patterns across items. Countries in one group tend to have relative strengths and weaknesses in the same items. In the discussion of grouping of countries, the focus is on groups that are meaningful from a geographical, cultural or political point of view. A possible Nordic profile in mathematics education has played a central role in the discussion of the results of these analyses (ibid; Grønmo, 2010).

Data from TIMSS 1995 were used to point out for the first time that is was reasonable to speak of a specific Nordic profile in mathematics education (Gronmo Kjærnsli & Lie, 2004). Later analyses of data from TIMSS and PISA have confirmed this conclusion (Grønmo & Olsen, 2006; Olsen & Grønmo, 2006). Other profiles in mathematics education that are stable over time and in different studies are an Eastern-European, an Eastern-Asian and an English speaking profile (ibid.) The English-speaking profile is closely related to the Nordic profile; just as the East European and East Asian profiles has pronounced similarities. Nordic and English-speaking countries perform relatively best on mathematics items closer to daily life like estimation and rounding of numbers, lower on items in classical, abstract mathematics like fractions, exact calculations with numbers and manipulations in algebra. In contrast, East Asian and East European countries perform relatively best in classical, pure, and abstract mathematics such as algebra and geometry. Daily life
mathematics has to a greater extent than in a lot of other countries, been a driving force for curriculum changes in the Nordic countries in the last decades.

Another important issue to be discussed based on analyses of TIMSS data from 1995 to 2011 is the development of trends in achievement in the Nordic countries. Figure 1 show trends in achievement in mathematics in lower secondary school for the three countries, Norway, Sweden and Finland, where we have such data. As shown in the figure, there is a significant decrease in students’ performance in both Sweden and Norway from 1995 to 2003. After 2003, there is an increase in students’ achievement in Norway, while the negative trend continues for Swedish students. Several analyses have been conducted to find reasons for this shift in trends in Norway, but not in Sweden (Nilsen, Grønmo & Hole, 2013). Important factors to be investigated are students’ opportunity to learn mathematics (OTL) and school emphasis on academic performance (SEAS).

Figure 1. Trends in students’ achievement in Norway, Sweden and Finland in lower secondary school for TIMSS from 1995 to 2011. The students in Norway and Finland are of the same age, while the students in Sweden are one year older.

Students in Finland had a significant decrease in achievement from 1999 to 2011. The size of this decrease is about the same as was measured for Norway and Sweden from 1995 to 2003. Students in all the three Nordic countries for which we have data achieved lower in mathematics in lower secondary school after 2000 than they did in the 1990s. Taking into account that Swedish students are one year older than students in Norway and Finland, the difference between students with the same age in Norway and Finland is small; while Swedish students perform clearly lower than in in these two other Nordic countries. Another interesting issue to discuss is the pronounced decrease in performance for Finnish students from 1999 to 2011, especially because Finland has been known internationally to be a high achieving country in mathematics.
Several studies of classroom and school factors affecting students’ achievement in mathematics based on TIMSS data have been conducted (see e.g. Lamb & Fullarton, 2002). Some researchers, such as Creemers & Kyriakides (2008), have studied the influence of school leadership and school climate on students’ achievement. As shown in Figure 1, TIMSS data displayed a negative trend in students’ performance both in Norway and Sweden from 1995 to 2003 (Grønmo, Bergem, Kjærnsli, Lie & Turmo, 2004), a trend that changed in a positive direction in the two last TIMSS studies in 2007 and 2011 for Norway but not for Sweden (Grønmo, Onstad, Nilsen, Hole, Aslaksen & Borge, 2012; Grønmo & Onstad, 2013). Investigating factors which may have contributed to this difference in development between countries that traditionally are close, both culturally and in school politics, may give important information about school factors influence on students learning of mathematics.

Analyses of the influence of a construct that may be labelled “School Emphasis on Academic Success” (SEAS) have been carried out by Nilsen, Grønmo & Hole (2013). The SEAS construct, as defined in these analyses, is related to a number of similar constructs aimed at measuring the emphasis on academic success and the degree of support offered by the school organisation and the school environment. Among these constructs, we find the concept of academic optimism considered in Hoy, Tarter and Hoy (2006), the concept of academic pressure (Cosmovici, Idsoe, Bru & Munthe, 2009), the concept of academic success (McGuigan & Hoy, 2006) and a construct called school emphasis on academic success in Martin, Mullis, Foy and Stancato (2012). The SEAS construct is based on seven questions presented for school principals about teachers’, students’ and parents’ emphasis on academic success and support for the school (Nilsen, Grønmo & Hole, 2013). The two-level analysis was carried out using Structural Equation Modelling (SEM) and Confirmatory Factor Analysis (CFA). The SEM/CFA- analyses use the Mplus software program (Muthen & Muthen, 1998–2010). Nilsen, Grønmo and Hole’s (2013) main findings were that for grade 8, SEAS has had a positive influence on mathematics achievement in both Norway and Sweden in lower secondary school, and that the increase in SEAS from 2007 to 2011 in Norway can explain the observed increase in mathematics performance in Norway from 2007 to 2011. For Sweden, no significant change was found in SEAS from 2007 to 2011, so this factor cannot explain the decrease in achievement in Sweden.

When discussing possible reasons for trends in achievement in the Nordic countries, it is also interesting to discuss the development in students’ achievement in Finland. We do not have data available to do the same in-depth analysis for Finland as we have for Norway and Sweden. Nevertheless, the case of Finland is worth reflecting upon (Grønmo, Borge & Hole, 2014). The high performance of Finnish students, especially in PISA, has received a lot of attention internationally. At the same time, more than 200 mathematicians working in the Finnish education system warned in 2005 that the PISA results only tell part of the story about the actual mathematical skills of Finnish children:

One reason for the increase of poor standards in the matriculation exam and in the beginning of university studies is, undoubtedly, the weakness of the foundation received in the comprehensive school. New, more difficult concepts are hard to learn because still in upper secondary school much energy is spent in reviewing concepts that should have been learned in the comprehensive school. This vicious circle continues in tertiary education: the high-school concepts are not properly learned, and further learning becomes
more difficult. The PISA survey provides us with useful information regarding the mathematical literacy needed in everyday life and the ability to solve simple problems. These skills are simply not enough in a world which uses and utilizes mathematics more and more. (Astala et al., 2005, retrieved 24.03.2014)

School Emphasis on Academic Success (SEAS) is quite a general factor and says little about the content taught or the methods used in school. Also, there are several ways of interpreting what it actually means to say that schools put more effort into emphasizing the academic success of students (Gronmo, Borge & Hole, 2014). The questions used in the SEAS definition indicate that teachers emphasizing students’ academic success tend to have a better understanding of the curriculum goals and that they tend to be more successful in implementing the curriculum goals in their teaching. Parents emphasizing the academic success of their children also can reasonably be assumed to give good support to their children’s schoolwork as well as to the school in general. In particular, it is reasonable to assume that such parents will encourage their children to work hard at learning mathematics. It is interesting to link this to the mathematical content students are tested on in TIMSS as a background to discuss students opportunity to learn (OTL) different domains in mathematics. TIMSS data have been used also for these types of analyses (Gronmo, Borge & Rosén, 2013).

The use of the concept Opportunity to Learn (OTL) varies. Some researchers use it to cover a broad range of factors influencing the learning process; whereas others use it to study a few well defined factors that earlier research has shown are central to students’ opportunity to learn (Carroll, 1963; McDonnell, 1995). An important aspect of OTL is what content knowledge students have been taught, as well as how much time that is allocated to different types of content. We may say that the more intensively students have been taught a particular domain in mathematics (or a subdomain); the higher the OTL factor is for that content knowledge. A high or low OTL factor is related to school curriculum, both the intended curriculum (the written curriculum) as well as the implemented curriculum (to what extent the written curriculum has been implemented in the school).

Analyses of data from TIMSS 2011 showed that instructional time in grade 8 in Norway and Sweden use more time than the international mean to give students instruction in numbers, and less than the international mean to give students instruction in algebra (Gronmo, Borge & Rosén, 2013). Students’ learning in the domain numbers is important, but it would probably be a better use of time if more of this content knowledge were implemented earlier in school. Both in Norway and Sweden, less time than the international mean is used to give students instruction in numbers in primary school, while more time than the international mean is use for instruction in this domain in lower secondary school. A main problem in mathematics education in the Nordic countries seem to be that little attention is given to pure abstract mathematics, especially to algebra. Analyses of how many topics different countries cover in mathematics confirm this conclusion. For grade 8, Norway, Sweden and Finland all report that they have covered all domains in numbers, but fewer domains than the international mean in algebra (Gronmo, Borge & Rosén, 2013). Emphasizing numbers earlier may leave more time for instruction in algebra at higher school levels in Norway and Sweden.
Results presented in this paper enlighten the importance of discussions about what type of content should be emphasised at different levels in school. It seems that both in Norway and in Sweden, there is little emphasis on numbers at the lower levels and more at the higher levels compared to other countries. A main problem in the Nordic countries seems to be that too little attention is given students learning of algebra. Consequences of this, for individual students, as well as for the society at large, is an issue that need to be discussed (Grønmo, 2014). A high dropout rate in higher education in Norway is for example due to students’ lack of elementary knowledge in algebra (NOKUT, 2018). This is knowledge which some decades ago was an important part of the content in mathematics that was emphasised in the school curriculum in lower secondary school (Lie, Angell & Rohatgi, 2010, Grønmo, Onstad & Pedersen, 2010). A main problem about students not learning elementary algebra in compulsory school is that students are not given the opportunity they need further on to go into the professions they want. For the society the problem is low recruitment of people in a number of professions as engineering, natural sciences, economy and mathematics, professions of high importance for a positive development in most countries today (Grønmo, 2014).

References


