Student Achievement in Mathematics in Norway and Sweden as Evidenced by TIMSS

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Abstract

TIMSS is a major source of information about level of achievement in mathematics in Norway and Sweden. TIMSS 1995 was the first time ever that Norway participated in an international study in mathematics. Decrease in students' achievement in mathematics has been measured in both countries since the mid 1990s, at all levels from primary, through lower secondary till the end of upper secondary school. Norway and Sweden have a lot in common in education, as organization of school, curriculum content in subjects, methods for instruction as well as for how and when initiatives for changes take place. To compare students' achievement levels and trends internationally and nationally is complicated. However, TIMSS give us the best and most reliable sources we have for such analyses. Comparing student achievement level between countries and over time depend heavily on definitions of the populations in terms of students' age and years of schooling. These factors may have a significant impact on the results and thereby on any conclusions drawn. This paper presents the results of reanalyzing data from three TIMSS studies (1995, 2003, and 2007) adjusting for differences in age and years of schooling. The adjusted data are used as the basis for a discussion of level of achievement in Norway and Sweden compared with the international average, and about trends in levels of achievement in Norway and Sweden. A main question is whether the results in these countries were as low as it was concluded after the 1995-study; another is to give some possible explanations for the overall drop in achievement. It is concluded that too little attention given to differences between countries with respect to age and years of schooling may have lead to the results after 1995 being underestimated for Sweden and Norway.

Keywords: Mathematics, Trends, TIMSS, Age effect, Schooling effect

Background and Purposes of the Study

The high-quality data from TIMSS has been a main resource for quantitative analyses of educational achievement in Norway and Sweden, as in several other countries. This has resulted in a significant contribution to research in mathematics education. Nevertheless, we may still improve the type of comparisons and conclusions that are made based on data from such studies. Improvement concerning methodological issues and interpretations of analyses of data from international comparative studies of student achievement in mathematics is still needed.

One main aim of the paper is to illuminate and discuss problems related to comparisons in achievement level in mathematics based on data from TIMSS. A main problem is how to define the population that is focused upon. In IEA studies different population definitions have been used and principles of population definitions have changed over time. In TIMSS 1995, the basic principle for defining the population was students' age, for example 13-year-olds, where choice of grade was based on which grade most students of this age attend. This was changed in the early 2000s when a change was made to population definitions based on students' years of formal schooling, a so called grade based definition. However, none of these types of population definitions is without problems when it comes to comparing achievement levels between countries or over time. The change from an age based to a grade based definition in TIMSS also causes extra challenges when making comparisons over time.

However, it should be noticed that the change is well founded in research about effects on achievement of one chronological year in age and one year of formal schooling. Cahan and Cohen (1989), who used the regression discontinuity design to investigate effects of age and schooling on cognitive abilities, concluded that schooling exerts twice a strong effect as does chronological age. Subsequent research based on similar approaches has found similar results with respect to mathematical knowledge and skills, but also indicating that the effect of schooling is even stronger in the mathematical domain (refer ??).

Another aim of this paper is to look for factors that can contribute to explain the overall negative trends in mathematical achievement in Norway and Sweden from the mid 1990s. In this part, possible influences on the achievement levels of students in Norway and Sweden in TIMSS 1995 will be discussed.

Data and Methods of Analysis

This study relies on data from TIMSS 1995, 2003, 2007, and to some extent also from TIMSS Advanced 2008. The main method is to adjust the observed results for Norway and Sweden in order to take into account the age and the number of years of schooling of the students in the samples. The adjustment is based on a mathematical model derived from the knowledge about the relative effects of on age and schooling on achievement. The model used in this paper was developed using Swedish data from 1995 in grade 6, 7, and 8 (Cliffordson, in press; Gustafsson, 2010). This provides a basis for comparisons and for describing and analyzing the development of achievement over time for the two countries from mid 1990s.This method is described in more detail in a paper by Gustafsson (2010).

We focus on students in grade 7 in TIMSS 1995, and on students in grade 8 in TIMSS 2003 and 2007. However, in TIMSS 2003, Norwegian students in grade 8 still only had 7 years of formal schooling. According to the change in school start in Norway which took place in 1997, these Norwegian students skipped class 2 and went directly from grade 1 to grade 3. This was not the case in Sweden, which therefore in 2003 tested students with one more year of schooling (i.e., grade 8) and who were one year older than the Norwegian students. In TIMSS 2007, both countries tested students in grade 8, the Swedish students being one year older than the Norwegian students.

In order to adjust the Norwegian and Swedish results to be comparable over time and with other countries, the expected performance effect of grade was first determined. In TIMSS 1995, grade 7, Norway and Sweden had 1.08 school years less than the overall average, which is here defined by the subset of countries belonging to the EU/OECD group. According to Gustafsson (2010), the difference in achievement related to one year of schooling in mathematics in grade 7 is an effect of d=0.24 and there is an age effect of d=0.17. To adjust for the differences in years of schooling, a value of 1.08*0.24=0.26 needs to be added to the observed values for Norway and Sweden. The Norwegian and Swedish students were also slightly younger than the overall mean, with a factor of d = 0.12. To adjust for this age difference, 0.12*0.17 = 0.02 has to be added to the observed values as well. The observed values in achievement in mathematics for both Norway and Sweden therefore have to be increased by 0.28 to adjust for differences in both years of schooling and age.

Results of adjusting the observed data

Table 1 presents both observed and adjusted results for the studies in mathematics for Norway and Sweden in TIMSS 1995, TIMSS 2003, and TIMSS 2007. All observed values are adjusted to be comparable with grade 8 from TIMSS 1995. The first two columns present the observed *d*-values for Sweden and Norway computed for the different studies. Positive values indicate achievement higher than the mean of the participating countries. It must be observed that these results in some cases are somewhat different that the officially reported ones, which is because the current analysis focuses on the subset of the countries that belongs to the EU/OECD group or that has participated in several studies. The two last columns present the adjusted values for Sweden and Norway where the observed values have been adjusted according to the estimated effects of age and years of schooling.

The observed value for the Swedish students in grade 7 in TIMSS 1995 was close to the international mean, while the Norwegian students' observed value was below the international mean. When these results are adjusted for grade level and age, there is an interesting change in performance level. The Swedish result is clearly above the international mean, and the Norwegian result is at the international mean.

Table 1 *displays results in mathematics in TIMSS for Sweden and Norway 1995 – 2007 (d-values). Observed data for Norway and Sweden in mathematics in grade 7 in TIMSS 1995, grade 8 in TIMSS 2003 and TIMSS 2007. It also displays data that is adjusted to 8 years of schooling and for students' age. Positive values indicate values above the international mean, negative values below the international mean.*

	TIMSS 1995		**TIMSS 2003**		**TIMSS 2007**	
	Sweden	***Norway***	***Sweden***	***Norway***	***Sweden***	***Norway***
Observed value	-0.12	-0.29	-0.15	-0.62	-0.19	-0.46
Adjusted value	0.22	0.05	-0.27	-0.29	-0.28	-0.13

The general impression in reports from the TIMSS 1995 study, was that that the achievement levels of students in Norway and Sweden were rather weak. ”Not only Norway, but all the Nordic countries perform rather low” (Lie, Kjærnsli & Brekke, 1997, p. 25, my translation). Based on the fact that adjusting for years of schooling and age makes the Swedish and the Norwegian results in 1995 that much better, lead us to conclude that more attention needs to be paid to years of schooling and age when comparing achievement levels internationally. The Norwegian report from 1995 pointed to age as a problematic issue in the study by concluding that the general impression of the weak performance of the Nordic countries may be modified a little taking into account the age of the students (ibid.). However, the results of our adjustments indicate that we are talking about more than ”a little moderation”. A more valid conclusion seems to be that the level of achievement in TIMSS 1995 for these two Scandinavian countries was not generally weak, in spite of reports that concluded otherwise.

In TIMSS 2003, both Norway and Sweden tested students formally enrolled in grade 8. The year for starting school in Norway was changed in 1997, from the year the child becomes 7 to the year the child becomes 6. For that reason, students in grade 8 in Norway skipped one year, going directly from grade 1 to grade 3. Thus, grade 8 students in Norway still had 7 years of formal schooling. There were not any such changes in Sweden. This led to Sweden testing students which in reality were one year older than students tested in Norway, and with one more year of formal schooling. In table 1, the observed value for Norway in 2003 has been adjusted to grade 8. Observed values for both countries have been adjusted for both age and years of schooling to be comparable with the international mean achievement.

Comparing students' achievement in TIMSS 2003 and TIMSS 1995, Norway and Sweden were the two countries with the greatest decrease in observed achievement, and even more pronounced so for Sweden than for Norway (Grønmo et al. 2004). This is in accordence with the results adjusted for age and years of schooling in table 1. The Swedish students' achievement level is lower than shown in the observed value compared with international mean. Also, Norway had a clear decrease in achievement from 1995 to 2003. But in contrast to Sweden, the adjusted value is closer to the international mean than the observed value indicated. Altogether, the results from TIMSS 2003 show that both Norwegian and Swedish students performed at about the same level, both countries being clearly below the international mean. However, the decrease for Sweden was from a position above the international mean in 1995, while for Norway the decrease was from a position close to the international mean.

In TIMSS 2007, as in 2003, there was a one year difference in age between Norwegian and Sweden students. The students in Norway this year had 8 years of formal schooling, categorized according to international ISCED codes, since they started school the year they became 6. However, a study comparing the first year of school in Norway with the last year of kindergarten in Sweden concluded that the content and learning goals were very much the same (Bjørnestad, 2008). Based on this, it may be suggested that the Norwegian grade 8 students tested in 2007 as compared with Swedish students still have 7 years of schooling. The adjusted data in table 1 compare students from both countries referred to as having 8 years of schooling. The results are adjusted for age and year of schooling compared with the international mean achievement. The validity of this procedure of course depends on the assumption that other countries in grade 8 are not in the same situation as Norway, namely that the first year of schooling is more to be compared with kindergarten than formal schooling

The observed value for TIMSS 2007 shows that Swedish students achieved below the international mean, a little lower than the observed value in 2003. The adjusted value for Sweden is, however, lower than the observed value indicates, which is because the Swedish students are older than the international mean. In contrast, the adjusted value for Norway is closer to the international mean than indicated by the observed value, and somewhat higher than the adjusted value in TIMSS 2003. The adjusted value for TIMSS 2007 shows Sweden as achieving lower than Norway. The Norwegian report for the 2007 study identified some increase in the Norwegian students' performance from 2003 to 2007, but not any increase for the Swedish students (Grønmo & Onstad, 2009).

Discussions and Conclusions

This paper thus concludes that the results for the grade 7 students in Norway and Sweden in TMISS 1995 underestimated the level of achievement in these two countries, because they were compared to samples of grade 8 students in most other countries. This underestimation continued for Norway in TIMSS 2003 and 2007, when the student samples were nominally from grade 8, but in reality only had seven years of schooling. For Sweden, however, samples of grade 8 students were used in TIMSS 2003 and 2007, and because these students were somewhat older than students in most other countries the observed results in TIMSS 2003 and 2007 somewhat overestimated the level of achievement in Sweden.

However, it also must be concluded that there has been a dramatic decline of mathematics achievement after 1995 in both Norway and Sweden. A main question thus is to identify possible explanations for the decline in achivement in these two Scandinavian countries, that have been known to have a major focus on education for all students and at all levels in school. Compared with the 1995 results, Sweden has had a more pronounced decline than Norway. Sweden has gone from a result well above the international mean in 1995, to a result well below the international mean in both 2003 and 2007. Norway goes from being at the international mean in 1995, to well below the international mean in 2003, even though there is a slight improvement in 2007.

Norway and Sweden have a lot in common when it comes to education, as well as with respect to more general factors. These two countries are culturally close, and they were one country until Norway got independent from Sweden in 1905. The similarity between profiles of achievement in Norway and Sweden is more pronounced than between most other countries, as has been documented in several articles (Grønmo, 2010, Grønmo & Olsen, 2006; Olsen & Grønmo, 2006). These studies have, on the basis of cluster analyses, documented a Nordic profile that is consistent over time and TIMSS and PISA. Typical for the Nordic profile is a focus on applied mathematics, with relatively little focus on pure mathematics. The fact that pure mathematics has not been emphasized has been referred to as a possible reason for the low achievement in mathematics in Norway. An important driving force underlying changes in curriculum over the last decades, especially in the Nordic countries, has been an emphasis on everyday applications of mathematics (Grønmo, 2010; Mosvold, 2010; Grønmo & Olsen 2006). As some have argued, an increasing focus on applied mathematics seems to have resulted in too little attention given to what we may call pure mathematics (Gardiner, 2004). Grønmo (2005) and Grønmo and Olsen (2006) have pointed at problems created by underestimating the importance of pure mathematics and that only emphasizing applied mathematics may be one possible reason for the low performance of Norwegian pupils in both TIMSS and PISA. (For more about the decrease in achievement in Norway, see Grønmo (2010). The close relationship displayed in analyses of the Nordic profile, make it reasonable to make similar conclusions for Sweden.

In the early 1990s Sweden made radical changes to its educational system, transforming it from one of the most centralized and regulated systems in the world, to one of the most decentralized and deregulated educational systems in the world (Gustafsson, 2010). Norway also made several changes in the educational system in the 1990s. A new curriculum was introduced in 1994 for upper secondary school and in 1997 for comprehensive school. In Sweden a new curriculum for comprehensive school was introduced in 1994. The curricular changes in Norway and Sweden went in similar directions. More emphasis was put on students' responsibilities for their own learning, and the teacher's role as leader in the classroom was deemphasized. The teacher's role became more of a facilitator than a leader of the classroom (Kjærsnli et al., 2004, Grønmo et al., 2004). There is reason to believe that one or more of these changes, in Sweden as in Norway, have contributed to the decline in achievement (Grønmo et al., 2004; National Agency for Education, 2009).

It has thus been suggested in national reports in Norway, both for TIMSS 2003 and 2007, that the decrease in achievement is due to the education in Norway being more individualized, that there has been an extensive use of calculators, that little focus has been on training of basic skills, and little focus on methods as discussions and reflections in the classroom on strategies to solve problems. The Norwegian profile in teaching methods, with much focus on individual work, and less on discussing concepts and strategies seem to be characteristic of all levels in Norwegian schools, in grade 4, grade 8 and the last year of upper secondary school (Grønmo, Onstad & Pedersen, 2010). These characteristics for Norway seem to be much the same in Sweden (Int. rapport TIMSS 2007 and Adv 2008; Grønmo, 2010). Thus, not only profiles of achievement on items seem to be the same for Norway and Sweden, but also characteristics of instruction in school, as shown in students' and teachers' answer to questionnaires. The lack of focus on learning strategies as training of basic skills, as well as discussions in the classroom of strategies for solving mathematical problems, are in contradiction to theories about how to develop mathematical competence (Sfard; 1991; Sfard, 2005; Pirie & Kieren, 1994; Martin, 2008). It seems that the value of both these strategies is underestimated in Norway and Sweden, and that most of the time is used for students' individual work, in comprehensive school as well as in upper secondary school (Grønmo, 2010, Grønmo, Onstad & Pedersen, 2010). Thus, a possible misinterpretation of the constructivist perspective on learning and its implications for the implemented curriculum in the schools may have contributed to more attention given to activities in themselves and to individualization, rather than to the goals for learning (Grønmo et al., 2004b; Kjærnsli et al., 2004).

It must be emphasized that the adjustments made here are only meaningful for a strict age-based decision rule for school start. If students do not start school because of low performance it makes no sense to apply these types of adjustment. The same is true if students are retained in a lower grade because of poor performance. This is not the case in Norway or Sweden, which make the adjustments between these two countries unproblematic from that point of view. When comparing with the international mean, in this paper mean for OECD countries, it seems reasonable to conclude that such factors have been relatively constant from 1995. For more about problems and cautions to be taken when interpreting results from these types of adjustments as those applied in this paper, we refer to Gustafsson (2010).

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