Structural and Pedagogical Diversity in Swedish Grade Six Algebra Classrooms

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This paper addresses the structural and pedagogical diversity in four Swedish grade six algebra classrooms. Drawing on video recorded observation and survey data from an international comparative video study, the results show wide variation of conditions for learning that highlight questions of inequality in decentralised educational systems such as that in Sweden.

Introduction

There is an on-going discussion in Sweden about inequality in schools based on a large variation in student achievement when measured in nationally administered standardised tests. The National Board of Education (Skolverket, 2012) reports that the variation in student achievement between schools has consistently increased since the late 1990s. Commonly this variation is attributed to socioeconomic and Swedish language skill issues. However, the variation in student achievement is great between classes as well as between schools, suggesting that the disparities could also be a result of pedagogical or structural variables. Since 1989 when much of the responsibility for administering public schools was decentralized and began to shift from the national to municipal level, there has been a series of reforms that have progressively strengthened local authority. There is, for example, no national regulation of the number of students in a class or any inspection of the textbooks used. In the regulations concerning school time tables, at the time of this study every student was entitled to 900 hours of mathematics instruction during their nine years of compulsory schooling. This equates to 100 hours of mathematics instruction per year or roughly 2.5 hours per school week (on July 1st 2013 the total was raised to 1020 hours)[1]. Adding to this, how these hours are distributed over the nine years of compulsory schooling is up to the local school to decide. A grounding principle descibed in policy documents is that there should be a wide variation of approaches and that although goals should be the same there are many ways to reach these goals. (Skolvernet, 2003). In short, local schools and districts have great structural and pedagogical freedom and are also financially regulated at the municipal level. In such a situation it is then perhaps not surprising that large structural and pedagogical variations have appeared over time that potentially have a significant influence on student achievement. In this paper the question examined is: given the decentralized nature of the Swedish school system, what diversity of structural and pedagogical conditions for learning exist in classrooms? We address this question in relation to the case of grade six mathematics classes.

The results reported in this paper are based on a subset of data from a comparative video-recorded study of mathematics classrooms in Sweden, Norway, Finland and the USA. A tentative comparison of some of the conditions for learning in the four countries indicates greater variation within than between countries (Partanen & Kilhamn, 2013). However, the Swedish data stands out as showing the greatest range of internal variation. This paper is an attempt to map the variability found in the Swedish data and raise questions that can be examined in subsequent studies. The results identify and unpack a diversity of conditions through detailed examination of weeklong sequences of lessons in four classrooms. While the data and results are focused on the situation in Sweden, they speak more broadly to the situation within decentralized educational systems.

Background

The project this paper reports on, VIDEOMAT[2] (see Kilhamn & Röj-Linberg, 2012 for a thorough description of the project), builds on previous studies of a similar character such as the TIMSS Video Study (Hiebert et al, 2003) and the Learners Perspective Study (Clarke, Kietel & Shimizu, 2006). It was designed as a comparative video study in mathematics education with a common focus on introduction of variables in algebra. As Clarke (2006) writes, an examination of classrooms across a variety of cultural settings and school systems makes our own educational assumptions visible and possible to challenge. The VIDEOMAT design as a cross-cultural video study seeks to view the practices of some algebra classrooms alongside the practices in others where the content area can be considered to be roughly the same. The overall aim of the VIDEOMAT project is not, as in the TIMSS Video Study, to identify and describe national differences in mathematics teaching, but instead to use the variation found in an international data set to compare classrooms to help reveal previously unidentified dimensions of algebra teaching.

Method

The research design for VIDEOMAT involved classes corresponding to Swedish grades six (last year of middle school, age 12) and seven (first year of secondary school, age 13) in each of the participating countries. This paper draws on a subset of the VIDEOMAT data including a sequence of video recordings of four consecutive teacher-planned lessons on introductory algebra from four Swedish grade six classrooms, teacher interviews, a written questionnaire completed by the teachers, and complementary material such as student work, lesson plans and curricular documents.

The results presented in this paper draw on video recordings and observational data from four Swedish grade six teachers, their pre- and post-interviews, and the questionnaire. The data collection was carried out during the 2011/2012 school year. During interviews and in the written questionnaire, the teachers were asked general questions about their teaching work in their grade six classes. As a reference point for student achievement in the classes, we use results from the nationally administered standardised test in mathematics[3] that the students took four to seven months after the observed lessons.

Participants

The four Swedish grade six teachers were recruited from three schools in the vicinity of Gothenburg[4]. All four described their decision to voluntarily join the project because they saw it as an opportunity for professional development. Two of the participating teachers were in the same school; school one teacher one (S1T1) and school one teacher two (S1T2). The other classrooms were in two separate schools; school two (S2) and school three (S3). The teachers in school one had three (S1T1) and 22 years (S1T2) of teaching experience, while both the others had 10 years experience. They were all educated as generalist teachers (Swedish: klasslärare) but due to frequent reforms in Swedish teacher training programs, their educational backgrounds were all slightly different. They all worked in schools with a traditional middle school structure where generally one teacher is expected to teach the same group of students in most subjects from grade four through grade six. The three schools represented different demographic regions. School one is situated in a small rural municipality close to Gothenburg, school two is located in the Gothenburg archipelago, and school three was an inner-city school. All three schools were public schools and none of them were located in extremely high- or low-income areas. Although there were students in all schools who did not have Swedish as their first language, all the students could comprehend and speak Swedish well, Swedish was the language of instruction and the common language of communication among students.

Analysis

As a theoretical frame, the VIDEOMAT project as a whole is placed in the field of sociocultural research and therefore focuses on the activities, artefacts and types of interaction that took place in the classrooms. As a first step for organizing the video-recordings collected from the four classrooms, a coverage code system was created describing the content in the videos and partitioning them into smaller more manageable instances of activity. This coding scheme drew on the codes used in the TIMSS Video Study (Hiebert et al, 2003) with adaptions made to reflect the particular activities found in the classes in our data. To meet the interest in the introduction of variables in algebra in the VIDEOMAT project, codes were attuned to identify the introduction of new content and the use of variables in written work. Following the approach taken in

TIMSS, the coverage codes we used are mutually exclusive descriptions of what can be identified as the main activity for a particular instance of class time. When the teacher orchestrated a shift of activity or a majority of students shifted into a new type of activity, a new code was applied. For the purpose of consistency between coders, we took the shortest time for a coded instance to be one minute.

The coverage codes are descriptive of the type of activity in a classroom (e.g. *No Mathematics, Mathematics Whole Class* activity or *Mathematics Student Work*). Whole class activities are coded as either *Introduction* or *Follow up* to distinguish instances where the teacher gives instructions or introduces new content from instances where s/he reviews student work or revisits previously introduced content. Beyond the scope of the data presented in this paper, whole-class activities have been further coded to identify different types of interactions between teacher and students. All mathematical activity that was not whole class activity was coded as *Student Work*, either *Individual* or *Group*, where group indicates that the students worked on the same task together in pairs or small groups. In such group work activities, documentation and written work were coded as being conducted *Individually*, as a *Group* or not at all (*None*). Student individual work was most often identified in instances when students worked individually from their textbooks or with worksheets, with the teacher walking around interacting with individuals. In these situations student-to-student interactions occasionally occurred but not for the majority of students and not with a consistent focus on shared mathematics tasks. Figure 1 shows the coding system at the level of analysis reported on in this paper.

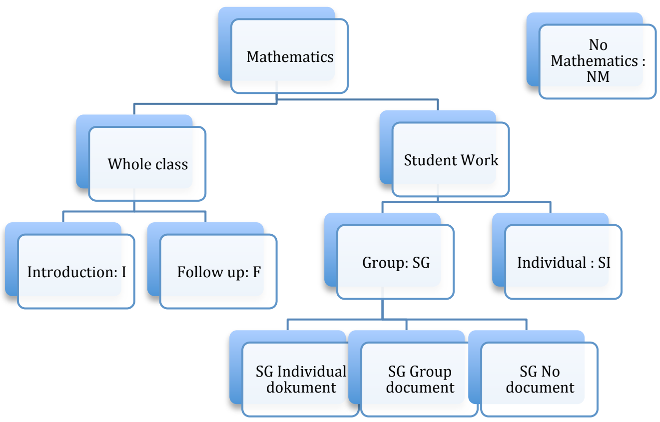

Figure 1: Coverage coding referred to in this paper.

Results

Drawing on the coding of the types of activity undertaken in the four Swedish classrooms along with interview and questionnaire data, our results shed light on the diversity of structural and pedagogical conditions present in Swedish mathematics classrooms. The results are divided between the interrelated issues of structural variability, reflecting such considerations as class size, homework policy and teaching responsibility, and pedagogical variability, addressing such factors as types of activity and proportions of class time used.

Structural variability

The most obvious variation in structural conditions amongst the four classrooms was the number of students present. The smallest class (S1T2) had only 13 students while the largest class (S2) had 30. S1T1 had 18 students while in S3 the situation was complicated by a schedule of whole and half class lessons. Here the organisation of lessons meant that, while the class had 20 students, every second lesson was a half class lesson with only 10 students. Along with class size, there was also significant variability in the amount of time dedicated to mathematics in the four classes. In the survey we asked how much time per week students were scheduled for mathematics (A) and how much time per week the teacher estimated that s/he spent on preparation and correction of student work in mathematics (B), see table 1.

Table 1: Structural variables concerning time

	S1T1	S1T2	S2	S3
A: mathematics per week (min)	160	160	180	200
B: teacher preparation per week (hours)	1-2	1-2	6-10	3-5

A clear variation in time for both teaching and preparation is seen among the schools but not between the two teachers in the same school. The time allotted to mathematics instruction highlights an inconsistency in the application of rules from the national board of education, while the difference in teacher preparation time combined with the survey and interview data suggests inconsistency in how teachers are expected to distribute their preparation time.

Another structural variable with similar diversity across schools concerns school level policies and actual practices related to homework. On the questionnaire three items addressed homework. One shows the number of assignments students receive per week (C), and the length of time students are expected to spend on them (D), see table 2.

Table 2: Homework assignments

	S1T1	S1T2	S2	S3
C: assignments per week (avg)	<1	<1	1	1
D: time on each assignment (min)	<30	<30	30-60	30-60

Consistent with the situation in many Swedish schools (Forsberg, 2007), homework was scarce in the participating classes in our study. However, despite the overall limited amount there was a distinct variation among schools with one homework assignment per week forming an important part of the instructional practices in two of the schools (S2 and S3) but not in school one.

The other survey item connected to homework concerned extra curricular mathematics. The question asked was: are there any situations outside of the ordinary mathematics lessons when you know or believe your students spend time learning mathematics? In school one, where very little homework was assigned, the teachers described no extra curricular mathematical activities. However, in the two schools where homework was assigned consistently, the school offered homework assistance once a week and both teachers noted that around six students in their classes regularly attended.

A fourth structural variable relates to teacher responsibility and presence during mathematic lessons. Although the generally recognized model for Swedish grade six classes is one teacher per class, this was not the actual situation in three of the four classes. In S1T2 there was one teacher present during our observation, however another teacher had the overall responsibility for mathematics teaching in the class and the observed teacher only taught some mathematics lessons. In S2, two teachers also shared the class; one teacher had the responsibility for mathematics instruction but a second teacher sometimes assisted. Similarly, in S3 one teacher was responsible but there was sometimes a special needs teacher or a teacher assistant present. The diversity visible in our four classes shows that the uniform model of one teacher per class at the middle school level may not represent the practice in Swedish middle schools. This reflects the wide variety of structural conditions we found in the schools.

Pedagogical variability

While there was significant structural variability between schools, we also identified a number of pedagogical variables that show diversity between classrooms even within the same school. The four pie charts in figure 2 show the coverage coding for the four grade six classrooms in terms of the percentage of lesson time spent on various types of activity. As addressed earlier in relation to survey question (A), the total amount of lesson time per week varied among schools. Since the length of each lesson also varied and in some schools often deviated from the set timetable, the four coded algebra lessons each had different lengths of lesson time. To address this, we observed and coded the four consecutive lessons from the point of view of student experiences of mathematics lessons rather than scheduled class time (e.g. in S3 an 80 minute long half-class double lesson was repeated in each group but only counted once). The total coded lesson time across classes was as follows: S1T1 - 2 h 27 min; S1T2 - 2 h 42 min; S2 - 3 h 57 min; S3 - 3 h 6 min.

We can see from the pie charts in Figure 2 that the variation is large for several types of activity. Between three and 76 per cent of the available classroom time was spent on individual student work, and between zero and 36 per cent was spent with students working in groups. The distinct variation in amount of time spent on non-mathematical activities can partly be connected to different types of student work. In S3, where most of the time was spent on Student Individual work, only three per cent of the lesson time was used on organization and classroom management. In S2, where students worked frequently in groups, time was spent moving students around, reorganizing the classroom and discussing rules for group work. All teachers spent time introducing new concepts (between 14 and 31 percent of lesson time), but the variation was greater in relation to the amount of time spent on whole class follow-up activities (between 5 and 36 percent).

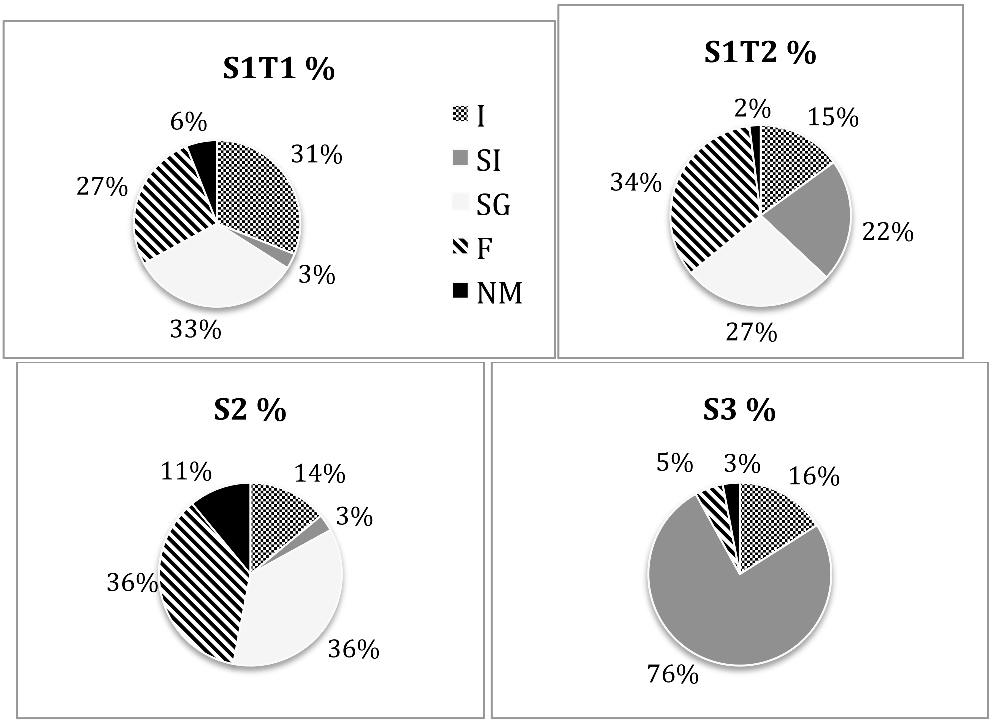

Figure 2: Pie charts showing the distribution of lesson time by type of activity expressed in percentage of total lesson time. Codes: Whole class Introduction (I), Whole class Follow-up (F), Student Individual work (SI) Student Group work (SG), Non Mathematical activity (NM)

Another feature of the classroom activities captured how much students' practiced expressing mathematics in written documents. Figure 3 shows the distribution of time spent in each class on student work, differentiating between different types of writing practices in individual and group work.

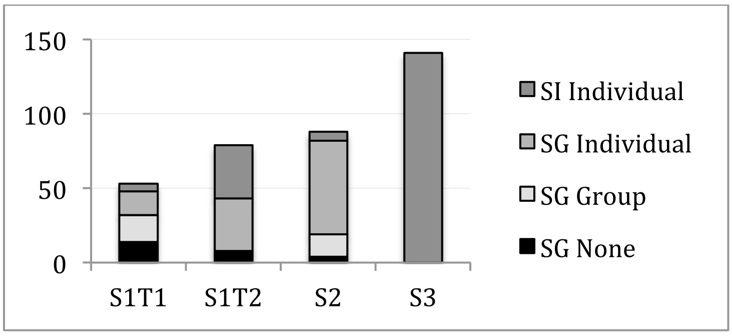

Figure 3: Bars showing lesson time in minutes spent on student work differentiating between different types of documentation.

Student Individual work (SI) assumes individual documentation, and Student Group work (SG) was either documented Individually, in a shared Group document or Not at all. As is clearly visible in Figure 3, the practices of writing in the algebra classrooms were all distinctly different.

A third pedagogical variable we identified as showing large variation was the use of textbooks and teaching materials. In the planning interview all four teachers stated that they use the same textbook, but as it turns out they use it very differently. S1T1 and S1T2 had recently invested in an activity box containing teaching materials with hands-on algebra and patterning activities[5]. In part due to this recent purchase, both teachers decided not to use the textbook at all for the unit on algebra. Instead they used activities and material from the box and additional worksheets from the National Centre for Mathematics Education[6]. In S2, tasks were taken from the textbook and worksheets, and were often projected onto an interactive whiteboard. However, the students in the class only had access to paper and pencil and did not use their own copies of the textbook during the time we observed. By contrast, in S3 the textbook was used in a traditional manner where all students had their own copy and worked through the sequences of tasks at their own pace in the order provided by the authors. This variability in use of the same textbook highlights the potential differences in pedagogical conditions even given the same or similar structural conditions. Combined, the spectrum of structural and pedagogical conditions identified give rise to different classrooms with variable opportunities for learning.

Discussion

The results presented are based on a video study involving only four classrooms. We do not know to what extent these classrooms represent Swedish grade six mathematics classrooms at large. However, the diversity of structural and pedagogical conditions found warrants questions of how valid national characterisations of schooling can be, particularly in relation to largely locally controlled systems such as that in Sweden. Many of the differences identified largely depend on decisions made at school and school district levels. The large differences between how much mathematics education a sixth grade student is offered (160 or 200 minutes per week), to what extent homework is used as a complement to school instruction (less than once a week or up to 60 minutes per week, with or without homework assistance at school), and how much preparation time teachers spend preparing for their mathematics lessons (between 1-2 and 6-10 hours per week) indicates an inequality in the conditions for learning that students are offered. The various different ways of organising lessons and classes, with class sizes of between 13 and 30 students, half-class lessons, assistant teachers and shared responsibility for mathematics instruction may be a result of pedagogical considerations, but they may equally be a result of financial considerations. In addition, there is a pedagogical diversity in how lesson time is spent and how textbooks and other teaching materials are used that our interview and survey results suggest are largely a consequence of decisions made by individual teachers or teacher teams while clearly being connected to structural and pedagogical conditions decided upon at other levels.

The presented results have illustrated structural and pedagogical diversity found in four classrooms in three different schools in the Gothenburg vicinity. Diversity was also great when student achievement was measured in these classrooms. The results on the grade six national test in mathematics in the three schools in spring 2012 showed a variation between 51,1% in school one and 96.4% in school two for students who demonstrated reaching a level of learning expectations considered to meet national standards for their grade level. While it is important to recognize that this study offers no evidence of a correlation, it does raise questions about possible relationships between structural and pedagogical variables and student achievement. For example received wisdom often assumes that large class size is negative for student achievement while in this study the students in the largest class ranked the highest on the national test.

There is much research about possible factors that may influence a teacher's pedagogical decisions, such as their mathematical content knowledge or beliefs (e.g. Boaler, 1999; Hall et al, 2008). Different pedagogical approaches, such as making use of written work, interaction, and whole class feedback and follow-up identified in this study may be a result of a knowledgeable teacher's adjustment to the different needs of his or her students. However, such decisions may also be a result of differences in a teacher's knowledge or beliefs. For future research we suggest that the variation we have seen in these four classes is investigated on a larger scale to see if the diversity is as great in Sweden as a whole as it was in our sample. Our results raise questions about the connection between pedagogical diversity and student achievement and indicate that structural and pedagogical variables should be seriously considered alongside such factors as socioeconomics and language skills. If a future aim is to slow the increase in inequality amongst Swedish schools, we may have to reconsider the grounds on which achievement levels are explained and on which decisions about students' mathematics education are made.

Notes

1. http://www.skolverket.se/laroplaner-amnen-och-kurser/grundskoleutbildning/grundskola/timplan
2. Financed through a grant from The Joint Committee for Nordic Research Councils for the Humanities and the Social Sciences; NOS-HS (Project No.: 210321/F10).
3. http://siris.skolverket.se (retrieved 2013-10-21)
4. Information was sent out with the help of school board mathematics specialists
5. NTA(Naturvetenskap och Teknik för Alla)-lådan: Mönster och Algebra [*NTA(Science and Technology for All)-box: Patterns and Algebra*]
6. Activities from the National Centre for Mathematics web page e.g. "Strävorna"

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