THE EMERGENCE OF DISPARITY IN PERFORMANCE IN MATHEMATICS CLASSROOMS

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In this discussion paper we consider questions related to research which attempts to consider structural elements such as social and family backgrounds, language and nationality and how these factors influence the internal dynamics of the mathematics classroom and students' achievement. We discuss difficulties encountered when trying to study the discursive and interactive dynamics that produce disparities in mathematical classrooms while taking into account socio-cultural structures of our societies. In addition we ask what role an inter-cultural comparative approach could play in studying these complex relationships. We explore the extent to which broad social categories (like "class") are useful in classroom research and difficulties in locating a suitable theoretical framework for comparative work addressing both classroom dynamics and socio-cultural structures.

Disparity in achievement is one of the major concerns in mathematics education research studies. Some studies, for instance, examine the mathematics achievement of *large groups* and relate differences in achievement to social categories such as nationality, language, and class. PISA, TIMSS, and other large scale assessment studies fall into this group. In these studies, the social categories are present as independent variables. Other studies examine mathematical activity in classrooms and the *interactions* between and among students and teachers. These studies do not consider social categories as input-variables only, but consider the social dynamics within mathematics classrooms, which might amount to successful or unsuccessful participation of students. Finally, there is a large body of work that focuses on individuals' differences in *understanding* of mathematics.

In this discussion paper we will consider questions related to research which attempts to consider structural elements such as social and family backgrounds, language and nationality and how these factors influence the internal dynamics of the mathematics classroom and students' achievement.

Research that focuses on "socio-cultural contexts" as for example Abreu (2000) and others (see below) have conducted research at these two levels, but such research has normally focussed on a particular socio-cultural group, as for example sugar cane farming families or street children in Brazil. In our research and in this discussion paper we are considering especially the challenge of a socio-anthropological perspective when the focus is on comparisons between socio-cultural groups. Our on-going comparative research into the construction of social disparity in mathematics classrooms in (rural) Canada and (urban) Germany will be used to ground the discussion in actual events and circumstances.

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BACKGROUND OF OUR RESEARCH

Teachers and students in mathematics classrooms quickly come to know which students perform well in mathematics and which do not. This occurs even in classrooms where selection processes are intended to produce homogenous classes and in contexts where the students are together for the first time. In selective school systems, disparity in performance is both a goal and an effect; the practice of streaming makes this evident. But even within different streams in which students are supposed to be starting at a comparable level, differences in performance are detected within a short time. Likewise, inclusive (unstreamed) school systems accept and produce divergence of achievement.

That such differences are observed so quickly may appear as "natural" in cultural systems (such as Canada's and Germany's) where "natural ability" is part of the implicit theory about how children learn mathematics. However, cross-cultural comparative research (Stevenson & Stigler 1992, Azuma 1998) has revealed that other cultural systems (notably Japan's and China's) explain performance through other implicit theories and that different implicit theories may influence students' success in school mathematics. This suggests that it would be useful to investigate the emergence of disparities from a theoretical perspective that examines their social construction in the context of the social practices of the mathematics classroom. Further, an intercultural comparative approach seems promising as it reveals implicit theories of different classroom cultures and institutional systems.

Further, large-scale quantitative studies show that there are gaps in achievement and that those gaps are wider in some contexts than in others. For example, the gap in Germany is huge compared to many other countries (Bos et al. 2004). The mathematics achievement gap is generally defined along lines of students' class, gender, ethnicity, language of instruction and immigrant backgrounds. In the case of Germany, a number of factors have been found to be related to differences in the mathematics achievement of students. The selection or streaming of students into different school types, family structure, immigrant background, and gender have been shown to influence students success in schools (Baumert / Schümer 2001).

In Canada, for example, the provincial variation in mathematics performance is striking. Three provinces, Quebec, Alberta and British Columbia usually have scores higher than other Canadian provinces and the Atlantic provinces (Nova Scotia, New Brunswick, Prince Edward Island and Newfoundland) usually have scores lower than other Canadian provinces (Robitaille & Taylor 2000; Bussière, Cartwright & Knighton, 2004).

The discussion we would like to induce by this article is twofold: 1) How we can study the discursive and interactive dynamics that produce disparities in mathematical classrooms (the "micro-perspective"), while taking into account socio-cultural structures of our societies (the "macro perspective")? 2) What is the role that

an inter-cultural comparative approach can play in studying these complex relationships?

In this article we will begin by presenting studies that have investigated the existence and emergence of educational disadvantage. Most of these studies have been based on sociological theories that assume that teaching is less free than one might think, but restricted by structural elements such that actions of students and teachers are influenced by factors that have their origin "outside" the classroom. Two theoretical perspectives from sociology that have been useful in qualitative research into differences in mathematical achievement are those of Bourdieu (1991) and Bernsein (1990). We will then present our own current research on the emergence of disparity in mathematical classrooms, which is also embedded in a sociological theoretical framework, based on Bernstein. We will outline the focus of our study, its methodological and theoretical approach, which will lead us then to some theoretical considerations and finally to an important discussion. Empirical results of our own study and other research indicate the complex dynamics of "inner" and "outer" factors and how difficult it is to determine simple "outer" factors that might lead to the exclusion of some students. It seems necessary to reflect critically on what shapes the dynamics of the emergence of disparity within mathematical classrooms and how we can research these complex interplays.

STUDIES ON THE EMERGENCE OF EDUCATIONAL DISADVANTAGE

The following studies are a sampling of those that illustrate the many subtle and indirect ways that schools produce (rather than reproduce) class identities, which has been a focus of empirical research based on critical sociological theory over the last twenty years (Arnot et al., 2003).

Teese (2000) found significant quantitative relationships between students' socio-economic background and their success in mathematics final exams in the state of Victoria, Australia. He explains these relationships by a qualitative analysis within a theoretical framework based on Bourdieu (1991, 1992). He argues that this discriminating potential is implicit in a curriculum which raises cognitive demands over successive levels of mathematics by calling more and more on embedded scholastic attitudes and behaviours. Teese observes that the choice of content, the relative stress placed on different tasks, the compression of the content and the pace of teaching are based on the implicit view of an ideal student, who is "the young scholar-intellectual" (Teese, 2000, p. 4). Zevenbergen (2001) finds in her research that the linguistic habitus of Australian middle-class students works as cultural capital as in school – at least at the discursive level – the discursive practices are close to practices that are common in middle-class families.

Cooper and Dunne (2000) investigate how students with different socio-economic backgrounds react to word and context problems. They analysed large sets of data from the Key Stage 2 Tests for 10-11-year-old students in England. The study

documents that students of families where the parents do manual work have significantly lower achievement. Cooper and Dunne use the work of Bourdieu (1990, 1994) and Bernstein's framework (1990, 1996) to explain their results. The researchers find that these students tend to misinterpret the problems and to solve them with their everyday knowledge, which means that their mathematical competence is systematically underestimated in the tests.

Boaler (2000) illustrates through her analyses of interviews with grade nine students from groups with different achievement levels that it is not only the difference between "everyday" and mathematical discourse that makes it difficult for students to give meaning to mathematical tasks, but that students in London feel disconnected in demographically inhomogeneous classes. These studies are important for our research as they try to identify mechanisms that can explain if and how structural elements can be found in classroom interactions.

There is also research that does not focus on mathematics teaching but is of relevance for our study, as classroom interactions are analysed from the perspective of sociological theory.

Bourne (1992, 2003) investigates urban schools in Great Britain where students with low educational and social backgrounds show higher achievement than students with similar backgrounds in other schools. Using Bernstein's concepts of "vertical" and "horizontal" discourse, Bourne shows, through micro-analyses of the discourse in English lessons in an elementary school with bilingual students, how the teacher manages to arrive at a normal distribution of performance. She illustrates how the teacher attains this goal by student attributions of "natural ability" in verbal and nonverbal interactions.

Morais and Miranda (1996) investigate if students are familiar with the assessment and evaluation criteria of their teachers and if they can use these criteria to mark solutions of their peers, in the context of science teaching in grade 5 in Portugal. Making use of a theoretical framework based on Bernstein's work, the authors see relationships between students' achievement and their family and social background, the expectations of the teacher, and the explicitness of these criteria in the classroom.

THE EMERGENCE OF DISPARITY WITHIN THE FIRST WEEKS OF SCHOOL: OUR STUDY

In our research we study how teachers and students come to know which students perform well in mathematics and which do not within the first weeks of school. Our research focus is on mathematics classrooms at the first grade after primary school, where in a new school the students and the teacher are together for the first time. We compare classrooms in two countries, Germany and Canada, which differ in the degree of streaming in their school systems. In Germany, the students are in grade 5 or 7, when they move to the Gymnasium, the Hauptschule, Realschule, or Gesamtschule. In Canada, the students are in grade 6 or 7, when they move from

elementary school to junior high school (middle school). We will include classrooms from Sweden in our study in 2008. There the students will be in their first year after compulsory school in grade 10.

Beginning from a sociological perspective, we study empirically the interactions that may produce disparities in these mathematical classrooms. Our central research question is:

Which discursive and interactional mechanisms provoke a stratification of achievement within the mathematics classroom? What are the characteristics of these mechanisms in relatively homogeneous and in heterogeneous groups, in socially advantaged and disadvantaged groups?

As we have outlined above, the research literature and our own theoretical perspectives support the hypothesis that disparities in achievement, as perceived by the teacher and students in the classroom, may reflect external factors, as well as the internal dynamics of the classroom. In developing our methodology and designing the studies that constitute this research program we have attempted to look at the emergence of disparity in a number of ways that capture both internal classroom dynamics and external factors.

First, data are gathered at data sites across and within two national contexts: Berlin and Hamburg, Germany and Nova Scotia, Canada (Northern Sweden will be added in autumn 2008). In each context, data are gathered in two types of schools: in Germany in two Gymnasien and two Hauptschulen, in Canada in public schools and a private school. The choice of two types of schools in each context is guided by consideration of the most obvious systemic difference that might account for the difference in disparity. Most schools in Germany are, from grade 5 or 7 on, selective. At that grade level, students go to different kinds of schools, Gymnasium, Realschule, Hauptschule and Gesamtschule, which lead to different future educational and professional opportunities. In Nova Scotia, in contrast, an inclusive approach is the official public school policy, at least up to grade 10, when some streaming occurs in mathematics and science. If this systemic difference contributes to the emergence of disparity in classrooms, a comparative approach in the two contexts should make it possible to explain this contribution.

Second, the methods used to gather data focus on the emergence of disparity both through the interactions within the classroom and from an outer perspective using sociological factors. It is important to study the emergence of disparity from within the classroom because that is where the teachers' and students' knowledge of differences between students is constructed. To follow classroom interactions, video recordings are made at the start of the school year and continue for six weeks. In addition, copies of written work handed in to the teacher or marked and handed back by the teacher are collected, as such documents also form a part of the communicative interaction in the classroom. The teachers are interviewed twice, once before the beginning of the school year and once at the conclusion of the classroom

observations. The initial interview focuses on the teachers' expectations of the incoming class and their history of encountering diversity in their classes. The final interview focuses on the teachers' emerging view of the students in the class. Groups of about six students are also interviewed, beginning in the fifth week of observations. The focus of these interviews is the students' perceptions of, and accounting for, the diversity in mathematics achievement in the classroom.

To gather data from the outer perspective, a questionnaire is administered to students to collect standard measures (e.g., socio-economic indicators, educational resources in the home, etc.) that have been found to be correlated with mathematical achievement in large scale studies. If necessary, individual interviews are conducted to provide more detailed data or to account for anomalous data.

DISCUSSION

At first glance finding out how the students in a mathematics classroom fit into the categories that have been found useful in large scale studies seems an obvious way to relate classroom interactions to social structures of our societies. Large scale research suggests that achievement is related to socio-cultural factors such as social class, gender, ethnicity, language of instruction, parents' education and occupation, and immigrant background. However, when we apply these categories to the complexity of students' backgrounds in a mathematics classroom in rural Nova Scotia, it becomes apparent that these categories are problematic.

Difficulties arise in a number of ways. Most pragmatically, it is not clear that students in grade 6 (11 years old) can provide accurate information about their parents' backgrounds, education and occupations. What does one make of a claim that a mother with only a high school education is working as a substitute teacher (an occupation that normally requires six years of post-secondary education)? Follow-up interviews can provide some clarification, but in some cases students simply do not know about their parents' backgrounds in the detail we might like. Interviewing parents could provide these details, but even then there are other difficulties inherent in the use of these categories.

Large scale studies necessarily group together occupations into broad categories. But even precise labels can be misleading. Several students in our study reported that their fathers are carpenters, but the degree of skill (and mathematics use) in carpentry can vary. Descriptions such as "stairway carpenter" and "worker in a carpentry workshop" may indicate access to very different skills. If the broad categories used in large scale studies are deconstructed to individual occupations' descriptions, in what sense are we relating classroom based research to large scale studies?

A related issue is the way in which the other parents' occupation is considered. In large scale studies assumptions are made as to the importance or status of occupations and only one parent's occupation is considered. In traditional societies in which the father is the main wage earner this may be valid, but in our study such an approach

denies important realities. For example, in three families where the father is a carpenter, the mother is absent in one case, stays home with the children in another, and is a university professor in the third.

Class is a very important category in sociological research, however comparative research like ours can reveal ways in which it may be a problematic category. For outside observers who are used to thinking in terms of class, a different context can reveal differences in indicators of class not only in the context being observed but also in the reference contexts of the observers. For example, in discussions between Knipping (raised in Germany) and an English research assistant surprising differences occurred in the class identifications of students based on their observations in the classroom and the characteristics used as markers of class. This indicates the importance of some sort of additional measures of social-cultural background beyond observers' classifications (as e.g. questionnaires or interviews), but it also indicates the lack of universality in the category "class" which makes it unclear whether a statement such as "Social class is a predictor of mathematics achievement." means the same if this is said about German students or Canadian students.

These issues bring us back to our question: 1) How can we study the discursive and interactive dynamics that produce disparities in mathematical classrooms (the "micro-perspective"), while taking into account socio-cultural structures of our societies (the "macro perspective"). How can we answer this question if such methodological attempts to bring the "macro" and "micro" perspective together seem to fail? The problem seems to be the suggested starting point. Instead of beginning with categories identified in large scale studies as predictors of mathematics achievement could we instead start at the micro level? Could we use the disparities that do emerge in a classroom as a starting point for identifying aspects of the larger socio-cultural context that are significant?

Starting with the micro context requires a theoretical framework that allows us to describe the emergence of disparity in terms of the relationship between everyday knowledge derived from the larger socio-cultural context and school knowledge that is related to success in classrooms. Bernstein's theoretical framework is promising as a starting point, but also brings with it some difficulties.

THEORETICAL FRAMEWORKS FOR DESCRIBING THE EMERGENCE OF DISPARITY

Bernstein's theory of pedagogic discourse is concerned with the production, distribution and reproduction of knowledge and how this knowledge is related to structurally determined power relations. Bernstein (1971) introduced the terms "classification" and "framing" to distinguish two different systems of "educational knowledge codes". According to his analyses curricula and pedagogy can be characterised by these codes.

“Classification” refers to the curriculum, areas of knowledge, or what is taught. Strong classification means that strong boundaries between subjects are maintained. For example, a traditional mathematics curriculum has strong boundaries as few connections are made to other disciplines. A project-based mathematics curriculum, on the other hand, has weaker boundaries, as mathematics teaching is integrated with other subject areas inside or outside school. This means that everyday knowledge and subject knowledge are less separated. According to Bernstein, weak or strong boundaries establish a relation to everyday knowledge and therefore students’ contributions in class can appear more or less appropriate. Teachers’ evaluations of students’ achievement will reflect their decisions about what areas of knowledge are to be selected, how these areas are related within the subject, and how they are related to other subject areas inside or outside school.

“Framing” refers to pedagogy, that is, to the how of teaching. Strong framing is linked to explicitness of the social rules. Weak framing is indicated by implicitness of the rules.

Though classification and framing are theoretically distinguished (which is helpful for purposes of analysis), these different systems overlap in classrooms and so together create the conditions of learning and the grounds for evaluation. In Bernstein’s model, almost by definition, certain combinations of framing and classification exclude some students.

In addition classroom discourse is structured by implicit rules to which not all students have equal access. These rules allow for the recognition of legitimate classroom discourse and also the production or realisation of such discourse. As access to these rules are related to both mathematical achievement and to socio-cultural background they could provide a basis for connecting the micro with the macro starting with analysis of classroom activities in terms of classification, framing and recognition and realization rules.

While this theoretical framework seems to offer many of the features we require for working at the micro and macro levels together, it is not without problems, both practical and theoretical.

Practically, in our analyses of classroom interaction, we find strong classification mostly connected to strong framing, and weak classification to weak framing. This suggests that the distinction between classification and framing may not be as useful as we expected. Dowling (in press) argues that this is the case.

Within classroom discourse one can distinguish between instructional and regulative discourse. Instructional discourse refers to the (school) mathematical part of the discourse, e.g. what is valued as a mathematical argument; hence it is related to classification. Regulative discourse refers to the structuring of social interaction, e.g. which ways of turn-taking or working with others are acceptable; hence it is related to framing. Bernstein claims pedagogic discourse to be the process which leads to the

embedding of instructional discourse in regulative discourse, “to create one text, to create *one* discourse” (1996, p. 46). But it is not clear if the distinction between instructional and regulative discourse is empirically observable, nor that the embedding of one discourse in another can be detected.

These issues of the theoretical basis for comparative research connecting macro and micro contexts is the subject of Jablonka, Gellert, Knipping & Reid (2008, MES symposium).

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