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Social origin and success in answering mathematical word problems: The role of everyday knowledge

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ABSTRACT

International achievement studies have repeatedly shown that working class children are less successful in mathematics than service class children. This study aims to contribute to an explanation for the achievement gap in mathematics. Based on the theoretical work of Bourdieu (1987) we investigate whether reference to everyday knowledge in mathematical items is linked to differences in the response behavior of working class and service class children. We develop a classification system to classify 31 TIMSS 2007 (primary school) items of average item difficulty as either "realistic" (i.e. the math problem is embedded in an everyday setting) or "pure" (i.e. the problem is not). The single item analyses of the correct response behavior showed that, net of cognitive ability and sex, class differences were more likely to occur in the group of realistic items than in the group of pure items. Other characteristics, such as item complexity, number of words ("wordiness"), mode of response, and cognitive/content domain, did not deliver a more systematic explanation of class related differences within or beyond the characteristic "realistic"/"pure". The limitations of the study are discussed, as well as the study's implications for further research.

1. Introduction and Background

In recent years, the relationship between mathematical performance and students' social background has been a central concern to international educational research. Comparative studies in educational achievement have consistently shown that students from socially disadvantaged backgrounds are less successful in mathematics than their socioeconomically more privileged classmates. The Trends in International Mathematics and Science Study (TIMSS) found that 13% of all 4th grade students from more privileged socioeconomic backgrounds in Germany reach the highest possible mathematical level, but only 2% of students from less privileged social classes do. The mean differences between these social groups amount to 61 achievement scores. This difference equals 2/3 of the standard deviation, therefore indicating a learning lag of more than one school year (Bonsen, Frey, & Bos, 2008, p. 150–154).

Social class differences in performance increase during primary school, and they are of crucial importance for the educational participation of children at higher school levels. Unfortunately, not much is known about the connected processes in families and schools which explain class-related achievement differences. The few recent studies in this field

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draw on sociological theories claiming that these inequalities mainly result from an unequal distribution of different forms of capital (Bourdieu, 1992, 1997). This "objective structure" (Bourdieu, 1992, 1997) determines socializing processes, which in turn better prepare children from privileged socioeconomic backgrounds for educational requirements in school than less privileged children. For instance, children's ability to abstract from a local experience-based ("realistic") context to an universal one can be seen as an acquired "cultural competence" (Bourdieu, 1987) which is particularly needed to solve some kinds of mathematical tasks, such as certain word problems. In word problems, mathematical problems are embedded in "realistic", i.e. experience-based, contexts. Empirical findings indicate that children from lower social strata in particular have difficulties 'decoding' word problems and identifying the (abstract) mathematical problem which has to be solved. Instead, they draw on their everyday experience, which often does not lead to a correct response (Cooper & Dunne, 2000; Lubienski, 2000).

However, this contradicts those mathematical educators who believe that mathematics in school has to be learned "so as to be useful" (Freudenthal, 1968, p. 3). Realistic mathematical tasks are expected to awaken students' mathematical interests and motivate students, rather than forcing them to perform 'meaningless' mathematical operations (Cockcroft, 1982). From this point of view, mathematics can be understood as a tool students acquire in order to be prepared for future everyday life situations which require mathematical ability. In line with this view, realistic mathematical tasks have increasingly entered curricula, school books and classrooms. If the empirical findings cited above are correct, this type of mathematical task particularly hinders pupils from lower social strata from fully demonstrating their mathematical ability in a testing context. As a result, poor test scores and weak marks lower their chances of participating in academic school tracks or high achievement tracks.

Findings on social class differences in students' performance on realistic and purely mathematical items will contribute to a better understanding of the practical use of realistic mathematical items in assessment and school mathematics. Following Cooper and Dunne (2000), we want to explore whether the use of realistic test items (compared to purely mathematical items) is associated with social differences in mathematical achievement in primary school. We use a selected sample of 31 items of average item difficulty from the 2007 Trends in International Mathematics and Science Study (TIMSS) which have been made available to the public.

2. Theoretical and empirical framework

Mathematical items can be categorized as either realistic or pure (for a theoretical understanding of this difference in terms of power relations in schools, see Bernstein, 1977, 1996, 2005). Purely mathematical test items exclusively use mathematical objects and terms, and thus only make reference to the mathematical context. These items can be characterized by well-marked boundaries and specialized, unambiguous objects. An example would be an arithmetic problem such as 6 + 7 = ?. In contrast, realistic test items embed the mathematical context in everyday situations (for an example, see Table 3). For these items, the boundaries of two given contexts (mathematics and everyday life) are blurred. Although realistic items make use of everyday life situations, they require the recognition of universal mathematical models and techniques. Pupils need to make appropriate decisions about which context (mathematics or everyday life) has to be taken into account in the problem-solving process. Furthermore, pupils have to know how to produce the legitimate answer. Since the competency required to do this can better be characterized in terms of "feeling" than in terms of a rule-based knowledge (Cooper & Dunne, 1998, p. 122), Cooper (1998) sees an analogy to Bourdieu's concept of habitus:

The habitus, a system of deeply internalized schemata of perception, thinking and acting, is acquired as a function of the position of individuals in the social field and sets boundaries within which individuals are able to generate a variety of behavior patterns (Bourdieu, 1992, p. 33). Bourdieu suggests that the socialization of individuals from more privileged social backgrounds is more likely to cultivate a "cultural competence" as part of the habitus, which enables individuals to abstract from a local experience-based context to more abstract principles (Bourdieu, 1987). He shows that while discussing a photograph of an old woman's hand, the articulated impressions of working class individuals tend to reflect everyday life situations. According to Bourdieu, individuals from less privileged social backgrounds tend to reduce "the things of art to the things of life" (Bourdieu, 1987, p. 44) by expressing "more or less conventional emotions or an ethical complicity, but never a specifically esthetic judgment" (Bourdieu, 1987), as do members of higher social status. In the case of realistic mathematical tasks, the simulated real world context may stimulate the learner to focus on his individual experience, even if this orientation is originally unintended. Being confronted with realistic test items in mathematics, working class children are more likely to inappropriately "reduce" the complex content of realistic test items to their everyday life experience, whereas service class children are more able to apply legitimate (mathematical) ways of solving these items. As a consequence, working class children are less successful in solving those items than intermediate or service class children.

Some empirical studies show that when children are asked to classify different items, middle class children are more likely to use universal (taxonomic) strategies than working class children, who rather rely on strategies related to everyday life (i.e. functional strategies) (Holland, 1981; Mpofu & van de Vijver, 2000). Studies in the field of mathematical education link the ability to generalize from an everyday context to the ability to successfully complete mathematical items. Cooper and Dunne (2000) investigated class and sex-related differences in performance on "esoteric" (purely mathematical) items and "realistic" items. Using 110 test items from an UK national curriculum assessment test which was administered to 123 primary school students between the ages of 10 and 11, Cooper and Dunne (2000, p. 84ff.) found social class differences to the disadvantage of working class children (especially girls) in both the realistic and purely mathematical items; these social