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Characteristics of mathematical tasks and social class-related achievement differences among primary school children

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ABSTRACT

Children from socially disadvantaged backgrounds are less successful in mathematics classes than more privileged children. Based on the theoretical work of Bourdieu (1987) we assumed that class differences in mathematics tests can be related to the presence of everyday knowledge in a mathematical task: Due to their "habitus" acquired via socialization, working-class children might be more often misled by references to the real world than service-class children and therefore answer the word problem incorrectly. We asked 473 year-3 pupils and 360 year-4 pupils in nine primary schools to answer mathematical items which varied only with regard to whether items were embedded in experience-based contexts ("realistic") or not ("pure"). Our findings indicate that correct response rates of working-class and service-class children were not systematically related to item context. Since the impact of social class on correct response rates varies significantly among classes for realistic test scores, but only to a minor extent for purely mathematical test scores, further studies should focus on the differential impact of classroom instruction on mathematics achievement of children with different social backgrounds.

1. Introduction

In recent years, the relationship between mathematical achievement and student background has been a central concern to international educational research. Large-scale studies such as TIMSS and PISA have consistently and unequivocally shown that children from socially disadvantaged backgrounds are less successful in mathematics classes than more privileged pupils (for instance, Stubbe, Tarelli, & Wend, 2012). Some studies show that when controlling for cognitive abilities, this gap widens during primary education due to the influence of school context and classroom practices, among other factors (e.g. Fryer & Levitt, 2004). Particularly at the first transition point in an educational system, class-related achievement differences mainly account for social inequalities in educational participation at the secondary school level (Jackson, Erikson, Goldthorpe, & Yaish, 2007; Neugebauer & Schindler, 2012).

Since low achievement scores have a huge impact on the future opportunities of pupils, it is important to explore the reasons for the class-related achievement gap (Lubienski, 2008). A number of researchers have explored the connections between different social and cultural backgrounds, attitudes and behaviour of teachers, and mathematics achievement. Results have shown that teachers in classrooms mostly attended by children from less affluent backgrounds generally have

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lower expectations (Straehler-Pohl, Fernández, Gellert, & Figueiras, 2014) and are less clear regarding their evaluation criteria (Hoadley, 2007). Children with a working-class background seem to struggle more than children with an intermediate-class background with problem-centred and discourse-oriented mathematics instruction (Lubienski, 2000), while benefiting more from pupil-oriented pedagogic practices with clear evaluation criteria (Morais, Fontinhas, & Neves, 1992). Some studies indicate that compared to service-class pupils, working-class pupils are less successful in answering word problems with references to real life than purely (i.e. non-realistic) mathematical tasks (Cooper & Dunne, 2000; Piel & Schuchart, 2014; Lubienski, 2000; Morais et al., 1992). Despite this, research in the field of mathematics education has frequently pointed out that learners with math-related learning problems and low achievers have particular difficulties answering word problems (e.g. Andersson, 2008; Hasemann, 2005; Passolunghi, 2006).

However, it can be argued that the reasons for the observed difficulties with word problems are *not the same for* low achievers as for pupils from lower social strata. Generally speaking, sociologists claim that class-related achievement differences 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 prepare children from privileged socioeconomic backgrounds better for educational requirements in school than less privileged children. For instance, the handling of word problems as expected in mathematics classrooms depends on cognitive ability (Gray, Pitta, & Tall, 1997), but is furthermore linked to "cultural competence" (Bernstein, 1972; Bourdieu, 1987) acquired in socialization processes. In word problems, mathematical problems are embedded in experience-based realistic contexts. One example of this is the shopping item used by Cooper and Dunne (1998): Children are given the information that a drink and a box of popcorn cost 90p, and that two drinks and a box of popcorn cost £1.45 (p. 123). They are then asked how much a box of popcorn costs. Cooper and Dunne (1998) report the written response of a working-class girl who thinks of the usual price of a can of Coke and deduces the price of the popcorn asked for by the shopping item from this everyday experience (p. 122). Cooper and Dunne argue that children from lower social strata in particular are more likely to "misrecognize the demands of the problem background" (p. 128). Instead, they draw on their everyday experience, which often does not lead to a correct response. Similarly, Lubienski (2000) points out for world problems, children from disadvantaged backgrounds "seemed to focus more on the real word constraints, involved with the context as they solved the problem, thereby missing some of the intended mathematical ideas" (p. 476). Further, teachers seem to underestimate the difficulties students from disadvantaged backgrounds have with word problems (Hachfeld, Anders, Schroeder, Stanat, & Kunter, 2010).

From this point of view the problems of working-class children in answering word problems are—in contrast to low-achieving service-class children—related to mathematical and cognitive ability to a *lesser* extent. However, until now no effort has been made to use quantitative methods to analyze whether *a systematic relationship* exists between the presence of a realistic context in a mathematical item and class-related differences in the correct response rate. As long as this relationship has not been corroborated, practical consequences for teacher training or mathematical instruction (for example) cannot be drawn. For this reason, our study uses an experimental approach to investigate whether differences in the amount of correct responses of working-class children and service-class children vary systematically according to whether the mathematical task to be completed is embedded in a realistic context or not. Therefore, with this study we want to enhance our knowledge on the reasons of class-related differences in mathematics achievement in primary schools, which are related to mathematics education, in our case, to word problems. Since word problems are a common part of mathematics education in primary school all over the world, our results are of interest to mathematics educators at this level in general.

In the following, we describe the theoretical explications for class-related differences in word problems and present the empirical evidence at hand, which lead to our research questions (Section 2). In Section 3 we describe our study and our methodical approach and present the results in Section 4. Finally, we discuss our study and the results in Section 5.

2. Theoretical and empirical background

2.1. Social class, family socialization, and reaction to mathematical tasks

In general, mathematical items can be classified as "realistic" or "purely mathematical" (for a theoretical understanding of this difference in terms of power relations in schools, see Bernstein, 1977, 1990, 1996). 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 (such as the shopping item described above) embed the mathematical context in everyday situations. For these items, the boundaries of two given contexts (mathematics and everyday life) are blurred. Although realistic contextualized mathematical items make use of everyday life situations, they require the recognition of universal mathematical models and techniques. Following Bernstein (1996), pupils have to possess certain rules to (a) recognize the specialty and the boundaries of a specific category such as school subject mathematics (the recognition rule) and (b) to produce a "legitimate text" which meets the requirements within a category (the realization rule).

The selection of rules—for instance when pupils are confronted with word problems—is structured by social experiences which have been acquired in socialization processes. Particularly in early years of schooling (when school socialization is still in the beginning) this act of selection is rather based on feelings than on knowledge. For instance, realistic test items require