

LEARNING MATHEMATICS WITHIN THE CONTEXT OF LINGUISTIC AND CULTURAL DIVERSITY – AN EMPIRICAL STUDY

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Abstract

In the research project presented in the following, the role of pupils' linguistic and cultural background for learning and teaching mathematics in a multi-lingual classroom is studied. Recent results of educational research show how strongly learning success depends on the school-relevant command of the predominant language in which lessons are conducted - in Germany the German language. These results convey the impression that teaching itself does not cope with it's task to impart it's own language. In this paper a description of an empirical study will be presented - as a kind of a workshop report - in which we examine the relationship between learning/understanding of language and learning of mathematics in multi-lingual classrooms.

Zusammenfassung

In dem im folgenden vorgestellten Forschungsprojekt geht es um die Frage, welche Rolle und Funktion dem sprachlichen und kulturellen Hintergrund von Lernenden im Mathematikunterricht zukommt, der sich im vielsprachigen Klassenzimmer abspielt. Jüngere Ergebnisse der empirischen Bildungsforschung zeigen auf, wie stark die Abhängigkeit der Chancen auf Bildungserfolg davon ist, dass die vorherrschende Unterrichtssprache - also in Deutschland das Deutsche - im schulrelevanten Sinne beherrscht wird. Gleichzeitig legen sie nahe zu vermuten, dass der Unterricht selbst dem Anspruch, seine Sprache zu vermitteln, nicht genügt. Im weiteren wird im Sinne eines Werkstattberichts eine empirische Studie vorgestellt, in der der Versuch unternommen wird, die Zusammenhänge zwischen dem Lernen und Begreifen der Sprache und der Sache am Beispiel des Mathematikunterrichts in mehrsprachigen Klassen weiter zu erhellen.

1. Pupils' language abilities and mastery

The recently published results of the OECD study *Programme for International Student Assessment (PISA)* (Baumert et al. 2000, OECD 2001) point out the central role of language in subject-related learning. As with the *Third International Mathematics and Science Study (TIMSS)* German pupils again showed average to below-average mathematical performance. Therefore, in public discussion it is questioned more and more what are the basic abilities obviously not transmitted in the same quality to pupils in Germany as elsewhere.

While searching for answers, the design and the measurement instruments of PISA leads to focussing on the prominent role language plays for learning success. One part of the tested learning areas is explicitly language concerned: 'literacy', regarded as the ability

of a reasonable handling of complex, multilayered texts, restricted to reading literacy in PISA. However, the two other tested areas, ‘Mathematical and Science Literacy’, are also highly language-based. Neither knowledge of mathematical or science rules and formulae nor basic application of mathematical or science methods have been tested, but the ability to pervade conceptually the role and function of mathematics or science in the world.

Therefore, within this research the linguistic capacities of pupils have gained a basic interdisciplinary role penetrating all aspects of school. Following the PISA results, high mathematical and scientific performance is unlikely without a far-reaching, at least receptive competence for understanding complex and abstract texts.

The above described results relate to the research interest and background of our study in so far that pupils from immigrant families show significantly worse performance than pupils from non-immigrant families, by the way this results did not come up for the first time (see e.g. Schwippert/Schnabel 2000). The highest explanatory factor for these results arises from the area of literacy. Certainly, the factors ‘social situation’ and ‘cultural distance’ have influence on low performance too, but they are not decisive factors, while the mastering of the school language German is a decisive factor. Insufficient ‘reading literacy’ in this language reduces the competence acquisition in all academic areas.

From a pedagogical perspective, dealing with the effects of migration on education, the results of PISA are not surprising. The main line of argumentation based on research results about the impact of growing linguistic and cultural diversity among pupils, is that school systematically fails in imparting specific language competences which are a *conditio sine qua non* for educational success. School language is a special variant of the main *lingua franca* of a region. This special variant a child can acquire only under particularly fortunate circumstances without the help of the school. Such fortunate circumstances are a well educated family, which is coping with the school’s demand, practicing specific text types systematically. All other pupils, ergo most of them, are more or less strongly dependent on the introduction into the school’s specific variants of speaking and writing by the school itself, meaning consequently: to the specific language of each school subject.

The more distinct the living situation – in the meaning of education and socialisation - of a child from the historical developed conception of a ‘normal pupil’ is, the higher the dependence on the performance of the schools concerning school language teaching. In German (common) understanding a pupil is monolingual, not only meaning that it lives in and learns just one language. However, this concludes the imagination that the standard variant of the German language from which school language is a derivative, comes up naturally in a child born on German land (see e.g. Gogolin 1994). Consequently, teaching the school’s language is not part of the common habits. This can be seen quite impressively from the abstinence that is practised in subject lessons, where the linguistic capacities a pupil must have for being able to understand the

lessons' contents are not considered. Due to the lacking identification of this situation as a problem, it is therefore still far from being taken into account under which linguistic educational conditions pupils are tackling to acquire the contents of the subject.

The disastrous consequences of this tradition became obvious with the results of PISA – and not only in connection with the situation of marginalised groups of pupils who's educational fate is not a broad public's subject of interest – but became clear as a general problem of all pupils as a whole.

2. Learning mathematics within the context of linguistic and cultural diversity

2.1. The mathematics didactical background of the study and main research questions

The study described below aims to contribute to a revised understanding of learning mathematics and language. Furthermore it is pursuing the hypothesis that for achieving 'Mathematical Literacy' the linguistic and cultural conditions pupils bring with them into the classroom are highly relevant or even decisive. On the one side this hypothesis is legitimised by a didactics of mathematics perspective, and on the other side by a perspective from intercultural research of education.

Starting point is the assumption that for acquiring 'Mathematical Literacy' in German classrooms it is most likely that children from immigrant families experience in their world outside school 'dialects' of mathematical belief systems (i.e. mathematical world-view) which are also influenced by traditions of their familiar origin. We ask if and how these various mathematical belief systems influence the learning approaches and results of children with different familiar background, who receive the same mathematics education.

From intercultural research on education we already got some partial answers: Studies on teaching from an intercultural perspective show that for teaching in multilingual classes the specific linguistic and cultural conditions (for education) of immigrant children are not reflected systematically. In the contrary, the methods of initiating learning processes or transmission of subject-specific knowledge rely on the assumption that all pupils bring with them automatically from their general learning and living experiences the linguistic and cultural knowledge and abilities they require for being able to capture the teaching contents. For this reason it is not the rule that in school lessons children are introduced to the linguistic preconditions they need for the subjects to be learned. At the most linguistic-cultural instruction happens eclectically, often in the form of recipes. Following our observations children are offered only special technical terms of a subject, which they have to learn by heart as vocabulary. The stereotype reproduction of these terms by pupils are interpreted by teachers as evidence for the contents labelled by a term have been understood. On the contrary, the complex structures of subject-related language - not existing in everyday life - are not

transmitted continuously to pupils in an adequate way considering the language experience of the pupils. The demand to teach language as a tool for interaction and communication in school is not yet (at all) regarded as an original task of subject-teaching.

From the perspective of mathematics education it is meaningful that the epistemological attempt of Platonism now is put into question. This Platonism, which was undisputed until the eighties of the last century, comprehends practicing mathematics as discovery of timeless and culturally independent truth and therefore regards mathematics as a 'value-free' discipline. That learning and mathematical practice are dependent on the context or the situation in which mathematics knowledge is acquired or applied, was out of view (see e.g. Vergnaud, 1990). However, since the beginning of the eighties in the fields of didactics of mathematics there developed attempts which regard mathematics as a cultural phenomenon (e.g. approach of ethno-mathematics, see d'Ambrosio, 1985, Bishop 1991). Here culture is understood as the totality of conventionalised modes of expression, ways of reception, attitudes of a group, including their opinions about mathematics and the way it is practiced. Ergo mathematics is a cultural product with universal aspects that finds its manifold expressions in various cultures, traditions and living situations.

Bishop (1988) shows in his conception of 'Mathematical Enculturation' the relevance of these attempts for learning mathematics in different cultures: he distinguishes different fundamental mathematical activities, such as Counting and Measuring, which have led to the central mathematical ideas like Numbers, Pattern, Chance. On the basis of these ideas, from his point of view, the internationally accepted mathematics developed, as the so-called 'Western mathematical knowledge'. This Western mathematical knowledge is characterised by the central role of symbolically conceptual structures which are typical for the Western mathematical and technical culture. Starting from an anthropological point of view which defines education of mathematics as part of the descendants' introduction into 'culture', this has crucial consequences: While children with a Western background would be introduced into a home culture, for children with a non-Western background this would mean that with learning mathematics they are introduced into a strange culture. Following Bishop the negative consequences might be that this would lead to a meaningless, rote-learning syndrome, the general attitude of irrelevance and purposelessness. Therefore he appeals to create a construction of a 'culturally-fair mathematics curriculum' (1991: 38). In more recent studies Bishop together with Abreu and Pompeu, sets the so-called canonical-structuralist approach of teaching mathematics in contrast to the ethno-mathematical approach. The latter he describes as being practice-oriented, discovering, specific (in contrast to universal), related to a socio-cultural basis, taking into account the children's knowledge from outside of school, developing mathematical knowledge from children's individual situations - with emphasis on the analysis of the children's problems and of their understanding -, as well as supporting children's abilities to judge (e.g. Abreu /Bishop /Pompeu, 1997).

Until the nineties of the last century these new approaches have not been adopted by the didactics of mathematics. Only within the last years international comparative studies on teaching of mathematics have substantiated its fundamental importance. Studies like the video-study on mathematics teaching in Japan, Germany and USA, carried out within the framework of the Third International Mathematics and Science Study (e.g. Stigler/ Hiebert 1999), the ‘Survey of Mathematics and Science Opportunities’ on teaching mathematics and science in 6 countries (e.g. Schmidt et al. 1997) as well as the study of Kaiser on English and German teaching of mathematics (1999) have shown that not only processes of teaching and learning are activities which are influenced by culture, but also ‘what’ is taught and learned. As such differences are of crucial importance, Cogan/ Schmidt (1999:77) argue that there exist various dialects of mathematics.

Therefore, probably the way how mathematical contents is presented linguistically is highly meaningful for whether a certain degree of ‘Mathematical Literacy’ can be achieved or not. Starting point for our research project is the hypothesis that pupils’ linguistic and cultural origin is not only significant for their learning chances, if they passed a part of their educational biography in another school system than the German one, but even with a complete educational biography in German schools the influence of culturally influenced familial practices and (general) opinions on pupils’ approaches to mathematics is probable. We know from research that the language of origin (in variants influenced by migration) is still used and still has a special function for immigrants, even if they already use the major language of their surrounding in many fields of life, or even if it has already become the dominant language for them. Therefore, we can presume that a multi-lingual living situation has impact on the approaches to the taught subject contents, even if a child from an immigrant family only attended German schools and the German language has a central function for its communicative practices.

In brief, our study deals with the ways of perceiving and processing mathematics by children from different linguistic and cultural origin who are taught together in German language at schools in Hamburg. We suppose that - both on the level of literacy in a narrower sense and on the level of habitual disposition in the meaning of ‘the ideas of what does it mean to be a pupil, what is learning and what one thinks is mathematics’ - there are discrepancies between pupils grown up in mono-cultural old-established families and those grown up in a multi-lingual immigrant families with a different cultural background. There is evidence to assume that culturally specific styles of interpretation are learned within the families. And that these cultural - and may be also linguistical - systems of interpretation which are influenced by the families, have an impact on the understanding of mathematics obtained in mathematics lessons (concerning these assumptions see also Demidow 1999).

2.2. Design of the study and first results

The study is qualitative-oriented and the collection and analysis of data and the development of theory follows methods of the Grounded Theory (e.g. Strauss /Corbin, 1996). Methodically we have proceeded as follows: The study was carried in year 7 (12-13 years-old), because we suppose that pupils at that age have developed (to a certain extent) a quite stable image of mathematics and mathematics teaching, and that for pupils at this age the decision concerning their future school career is provisionally finished. There had been chosen schools with linguistically and culturally manifold pupils: these are schools with great parts of children from resettled families (i.e. families from the former Soviet Union with a German background going back several hundred years), schools with a high share of children of Turkish origin and – as a certain type of ‘control group’ - schools whose pupils have predominantly a mono-cultural German background. At first, the reason for this selection was that by this way we got ‘relevant’ types who are mapping the nowadays’ linguistic and cultural structure of pupils (concerning this basic methodical decision see Bohnsack 2000:143ff). This project is concentrated on two groups of immigrants as comparison groups for the following reasons: Both chosen groups are representing different but for Germany’s situation relevant groups of immigrants. Moreover, there are indications that in the traditions of the pupils’ origin there exist clearly different ways of approaches to mathematics, especially concerning the appreciation of mathematics as established part of general education, as well as of its relevance for everyday life.

The study included three schools from the upper type secondary school (so-called *Gymnasium*) and three schools from lower type secondary school (so-called *Hauptschule*). Thus we hope it will be possible to compare pupils who are relatively successful in education with relatively unsuccessful pupils. Decisive for this is our assumption that there exist different ways of perception of mathematical contents and of processing it – this is what we are inquiring - , even if a level of literacy and general school competence has been achieved, so that one does not suspect a pupil’s failure. Therefore we do not suppose that we are facing a problem of lack of competence which should be eliminated through a purely compensating kind of lesson. We rather assume that pupils’ educational preconditions concerning diversity in language, culture and habits endure even with so-called ‘well-performing pupils’ and therefore still produce different ways of access to subject matters and different ways of processing.

The project started in the middle of year 2001 and we are now in the process of data analyses. The study design is as follows: observations and recordings of mathematics lessons in six selected classes were used to record modes of perception and ways of processing mathematical concepts and methods in relation to the teaching procedures and its intentions. These data will give information about how the pupils’ multi-lingual situation is handled on the individual and on the institutional side as well. We will further get data from a questionnaire about the educational and linguistical biography of the pupils and also about the socio-economical situation of their families. Through open interviews with selected parents it is aimed to get access to the parental opinions about the role and function of school, about mathematics teaching and their

mathematical belief systems. By using data from comparative assessments of the linguistic proficiency, the grade of complexity of the pupils' competence in German and in their family languages shall be analysed. From this it should become clear which are the language obstacles that the probationers have already overcome or they still have to cope with in order to understand and learn the mathematical subjects. For this analysis there have already been taken subject-related oral language samples. Especially because of the central role language plays for learning mathematics and for the development of mathematical literacy – as briefly described above – the comparative assessments of linguistic proficiency are highly relevant and the development of adequate instruments, as being strongly connected with the pupils' performance in the special language, it is a great methodical challenge (e.g. Gogolin, 2001). Furthermore, there have been carried out case studies on mathematical solving processes with selected pupils: The probationers worked on special mathematical problems which promote individual solving strategies or which might be perceived differently in different cultures, and then they gave comments afterwards on it following the method of the so-called 'stimulated recall'. Through this the different approaches to mathematics and the applied problem solving strategies and the cognitive styles they are based on are to be reconstructed. The samples for the mathematical case studies like for all interviews were composed of groups of equal size coming from the classes participating in the study. Each third of the probationers should be grown up either monolingually German, or Turkish and German or Russian and German. Finally there shall be reconstructed mathematical belief systems of the pupils from questionnaires and open interviews. Thus - as for the whole project – it will be referred to the culturalistic-theoretical approach of Pierre Bourdieu with its central conception of *habitus*, where the forms of *habitus* are understood as systems of durable social and historical dependent dispositional systems (Bourdieu, 1987). Following Bourdieu *habitus* expresses itself in schemes of perception, thinking and acting. This gives reason for the assumption that the different linguistic and cultural backgrounds of the pupils participating in the study will find its expressions in various habitual ways of perceiving and processing mathematics.

The results received so far point out that there exists remarkable differences in the perception of the mathematical problems dealt with in the problem solving sessions as there were:

- alternative comprehension and understanding of different key concepts within the problem;
- different lingual comprehension of the problem solving situation;
- specific treatment of the context, especially gender differences could be observed concerning the seriousness of the context and the distance to it;
- differences in the ways of communicating the solution.

These differences are influenced by the context in which the pupils have embedded the task and by their lingual, cultural and social background.

In addition remarkable differences in the expectations of the parents towards school and the caring of the teachers between the different cultural groups became apparent: The parents with Russian-immigrant background saw a high relevance in education and expected an individual support of their children by the teachers, whereas in contrast the parents with Turkish-immigrant background assigned education a much lower importance and expected less promotion by the teachers.

On the whole we want to contribute with this study to an understanding of diversity as resource and not as an obstacle, and we hope that in future it will be more probable that children and youngsters will be offered adequate chances for education which are not depending on their linguistic and cultural background.

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