# COLLECTIVE MATHEMATICAL REASONING IN CLASSROOMS WITH A MULTILINGUAL BODY OF PUPILS

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The students of German schools are affected by multilingualism and various cultural backgrounds due to continual immigration in the recent decades. Currently, almost one-third of the students in German schools have a migration background. This circumstance would not be worth considering if each student had equal prospects for a successful school career. However, this is not the case (cf. Beauftragte der Bundesregierung für Migration, Flüchtlinge und Integration 2005 PISA)[i]. Against this socially relevant background, we will present a research project in progress, which ought to investigate possibilities to tie in with the adaptive potential of language within teaching mathematics in primary schools. Thereby, we will combine two different theoretical considerations concerning a) learning by participating in collective mathematical reasoning (Krummheuer, 2007; Brandt & Tatsis 2009) and b) the linguistic accomplishment of mathematic learning processes in multilingual classroom settings (Bernstein 1996; Schütte 2006).

The basic idea is that especially in classrooms with a multilingual body of pupils, the teaching of mathematics must focus on encouraging collective mathematical argumentations and supporting mathematical expressiveness (which is beyond learning mathematical vocabulary). It is crucial that the pupils verbalize their ideas and thoughts and address dialogue partners. There is a close connection between cooperative learning opportunities and the significance of verbalization within mathematical learning processes. Thus, in our project we will systematically realize different types of collaboration in classes with a multilingual body of pupils (3rd and 4th grade classes). Thereby, the question of adaptive effectiveness of different collaborative scripts is examined with respect to the pupils' language-related participation in collective mathematical reasoning. Given the fact that this empirical design-based study occurs during everyday teaching, instantaneous moments of teaching methods can be attained which render the possibility to support a multilingual body of pupils. But in this paper we will focus on our theoretical backgrounds and the combination of them for theoretical purposes.

## PARTICIPATING IN COLLECTIVE MATHEMATICAL REASONINGS

Our perspective on the classroom processes is an interactionistic one (f.e. Cobb & Bauersfeld 1995). In this approach, the interaction serves as a place for joint negotiation. From this perspective, we have developed a model for learning mathematics in everyday classroom situations (Krummheuer, 2007; Brandt &

[i] Commissioner of the federal government for migration, refugees and integration

Tatsis 2009). According to this model, the way students are involved in explaining, reasoning and justifying content-related actions is crucial to their learning. Within our conception, tuition is a meshing of "smooth periods of interaction" (SPI) (Krummheuer, 2007, 64), and "condensed periods of interaction" (CPI) (ibid., 68). Whereas SPI are undemanding and superficial and reduce the risk of conflict, the CPI optimise the conditions for content-oriented learning by deepening the requirements for participation in the productive aspects as well as in the receptive aspects.

In particular, CPI differ from SPI with regard to the following modes of interaction: (a) in terms of the complexity and explicitness of the argumentation, (b) in terms of the chaining of the utterances of different speakers, (c) in terms of the involvement of the listeners in this argumentation and (d) the requirements for a change from a listening to a speaking form of participation. Thus, we see the CPI as optimization of social conditions for content-related learning by participating: Hence, relatively elaborated forms of argumentation were produced with distributed responsibilities amongst the participants. Beyond this optimization for content related learning through an active participation, on the one hand CPI can enhance the opportunity for learning through listening. The speaking participants must thereby take the "audience" into consideration by the choice of words and the degree of contextualization and indexicality (s. a. Brandt & Tatsis, 2009). On the other hand, the speaking persons of a CPI could exclude listening persons by using an inaccessible language code and thus hinder learning by listening.

## MATHEMATICAL LEARNING PROCESSES UNDER THE TERMS OF LINGUISTIC AND CULTURAL PLURALITY

Tracing back to concepts of Bernstein (1996) and Gogolin (2006), Schütte (2009) analyzed the linguistic accomplishment of mathematic lessons in primary city-schools ($4^{th}$ grade classes) that contain a high percentage of pupils from educationally disadvantaged families with a low socioeconomic status and/or migration background. As a result of his analyses, Schütte reconstructed that tuition in these classes is predominated by a language usage that significantly depends on colloquial everyday language and in spite of introducing new mathematical terms does not achieve a formal linguistic status. Furthermore, the interaction structure of instruction is characterised by the phenomenon of implicitness concerning statements and proceedings of the teacher during the introduction of new mathematical terms. Concerning the linguistic realisation of instruction, Bernstein (1996) develops a differentiation between two forms of discourse. The common knowledge is expressed by "horizontal discourse", whereas the communication about specialised knowledge happens in terms of "vertical discourse" (ibid., p. 171). With regard to this distinction the analyzed discourse features characteristics of a horizontal discourse.

According to Gogolin (2006), pupils in German schools are submitted to the normative standard, that they are receptively and productively in command of

the cultivated linguistic variations in class. This language of higher school education – described by Gogolin as "Bildungssprache" *(formal educational language)* (ibid, p.82 ff.) – has on a structural level more in common with the rules of written linguistic communication. It is in large part inconsistent with the characteristics of the everyday verbal communication of many pupils (cf. "CALP" by Cummins 2000, p. 57 ff.).

Hence, the children who require a linguistic introduction to the *formal educational language* of a vertical instructional language within class are not satisfied by a kind of linguistic accomplishment and interaction structure which resembles a horizontal discourse. Consequently, especially those children are disadvantaged by primary school classes in terms of their future educational success within secondary schools who require an introduction to a formal educational language.

## THE COMBINATION OF BOTH THEORETICAL APPROACHES

Concerning learning by participating in collective mathematical reasoning, the reconstructed linguistic accomplishment seems to hinder the emergence of CPI sequences because of its orientation towards a horizontal discourse. In fact, the implicit instruction of new terms in connection with an everyday language is rather consistent with the SPI that stays at an argumentative surface with low chaining of the utterances. With regard to the interaction theory of mathematical learning processes, the reconstructed teaching praxis in classrooms with a multilingual body of pupils does consequently not benefit sequences of interaction which provide optimal requirements of facilitation for learning mathematics.

Pupils from educationally advantaged families apparently possess the abilities to compensate the deficits that are located in the linguistic accomplishment of instruction due to the competences that they acquired at their homes. They not only possess greater competences in the domain of a formal educational language but they are also already familiar with interaction patterns of teaching due to their family environment. This might effectuate that they are more likely involved actively into the moments of CPI, that selectively occur during lessons. In opposition, the opportunities to learn about new technical terminology seem to be limited for those pupils who do not possess these abilities by virtue of family socialization. They are reduced to the prevalent form of argumentative-superficial as well as conceptual-informal discourse of the SPI where mathematical terms can be acquired as "vocable-knowledge" but the potential of formal linguistic elements is neither accessible nor identifiable in terms of a profound as well as argumentative consideration. They therefore seem to be excluded from the optimised moments which make learning possible within CPI-sequences. This kind of teaching method has a double selective effect due to the early selection within the German school system as well as the interaction during lessons simultaneously representing a "learning area" just as it is applied to appraise the pupils' performances.

## DISCUSSION

The question that arises is how can the instruction support all pupils in order to learn a *formal educational language* and how can it suitably be applied to collective argumentations for the purpose of learning mathematics via an (active) participation. We believe that an approach is given by the use of special collaborative modes of learning which focus on equal inclusion of pupils with differing linguistic and professional knowledge. According to our learning theory that was posed above, the initial priority is to increase the emergence of CPI-sequences within the interaction processes. Furthermore, we will provide linguistic support to the pupils that functions as frames structuring the interaction. The linguistic support is oriented towards the approaches of second language acquisition and aims at the subjacent aspects of argumentation. Thus, the design of learning environments within our study targeted on the deficits that we analysed in the linguistic accomplishment.

Concluding, we expect an improvement of the possibilities to participate in CPI-sequences for all pupils and consequently optimised facilitational requirements to professional learning. We assume that the adaptive effect accumulates if the pupils' scope of participation simultaneously grows along. It will be crucial that they use the expansion of scope options not only to upgrade their formal linguistic competences but also to make cumulative contributions to the collective mathematical argumentation.

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