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The role of the teacher in the development of structure-based argumentations

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Motivation

It is a desideratum that mathematical argumentation should be integrated into today's mathematics teaching. In reality, opportunities for learning mathematical argumentation are infrequent. Algebraic language is often understood only as a series of signs that can be transformed according to certain rules and the same applies to algebraic argumentation (Pedemonte, 2008). Such argumentations present an epistemological challenge for students because they are detached from concrete examples. The integration of mathematical argumentation into teaching and the appreciation of different types of arguments is therefore of crucial relevance. The role of the teacher in this needs to be clarified.

The aim of my PhD project is to investigate the role of the teacher in the development of structure-based argumentations in classroom practice. What kind of support can teachers in mathematics education give their students in order to guide their argumentation from concrete examples to general structures? How does this support influence the students' argumentation and their conception of algebraic language? For this purpose, a learning environment at the transition from arithmetic to algebra was designed and implemented in three eighth-grade classes in Germany. The main ideas of my teaching design and learning environment will be presented in this poster.

Theoretical framework

Sfard (1991) distinguishes between an operational and a structural conception of mathematical objects. In an operational conception, mathematical objects are perceived as a process. In a structural conception mathematical objects are conceived as static constructs, objects. Reification is necessary to conceive mathematical objects structurally. There are different types of mathematical arguments. Structure-based arguments use properties of the involved objects instead of only calculation-oriented transformations of algebraic expressions without relation to the content. Mason (1996) describes that, as a first step, learners should investigate examples and their structure in order to be able to develop general arguments using symbolic language. This idea guided the construction of the learning environment in my project. Connections between the conception of algebraic language and the development of structure-based argumentations are examined as well.

All in all, the teacher has an important role in mathematical argumentation. Conner, Singletary, Smith, Wagner and Francisco (2014) describe three different types of support for collective argumentation by teachers: "Direct contributions to arguments", "Asking questions" and "Other supportive actions" (e.g., evaluating, repeating). In addition to that, it is interesting how teachers enact written tasks in classrooms. This can lead students to an interpretation of tasks that can provide rich opportunities for argumentation or create obstacles. Whether and how this support can affect the arguments of pupils has been researched little so far and is a focus of this study.

Research project and methodology

First, tasks for eighth-grade classes and teacher prompts are theoretically constructed, which are supposed to stimulate a structure orientation and provide opportunities for mathematical argumentation. Then, a learning environment is designed and empirically enacted. Two interviews with teachers are conducted to get insights into the teachers' understanding of mathematical argumentation and into their experiences with the designed learning environment. Then, from transcripts of the lessons, argumentation processes and students' conceptions are reconstructed and analysed with a focus on the prompts of the teacher that promote a structure orientation. All this will inform a revision of the learning environment. The following research questions guide my study: How can teachers constructively support their students in developing structure-based argumentations? How do a teaching design and a learning environment for the development of structure-based argumentations in mathematics lessons look?

Structure of the learning environment

An intervention of four lessons (90 min each) was designed and performed. All tasks provide opportunities for mathematical argumentation. The teaching environment and tasks are designed in a way that allows students to build on concrete examples, examine the structure of these examples, and finally develop structure-based arguments. All tasks support this strategic approach to argumentation: 1. Observe; 2. Assume; 3. Analyse and check; 4. Justify. Learners are not simply asked to do calculations in the tasks, but to observe and reflect the mathematical structures of the numbers to support structure orientation (see Wittmann, 1985; Mason, 1996). In the first two lessons, the students get to know four different types of arguments (explanatory arguments in form of a dot pattern; generic examples; algebraic and narrative arguments) and have to solve conjecture-and-proving tasks. In the third and fourth lesson, the students learn to argue in a new format and more sophisticated arguments are demanded in context of "arithmogons": the sum of two corners is a side (Wittmann, 1985).

All in all, this learning environment should provide students opportunities to learn mathematical argumentation and to establish a structure orientation. How teachers enact this learning environment, support their students and which impact this support has will be analysed in my study.

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