“IT’S NOTHING ELSE THAN A TERM” - THE EPISTEMIC ROLE OF LANGUAGE WHILE GENERALIZING NUMERICAL PATTERNS
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The development of algebraic skills in earlier grades is said to be a gatekeeper for higher mathematical skills. To gain a deeper understanding of the underlying structure of mathematics, expressing generalities is important. But primary students often lack the language and a shared language base to discuss such generalities. This paper gives an insight in a design research project in which German primary students are fostered to gain access to this topic in a content- and language-integrated learning arrangement. The empirical analysis of the videotaped teaching-learning processes especially shows the epistemic role of the language of schooling, a register that many primary students have limited access to.

THEORETICAL BACKGROUND

Many empirical studies have repeatedly shown that middle school students often conceptualize variables as meaningless symbols (e.g., Kieran, 2007). The reason for this might be that the transition from arithmetic to algebra is difficult even for those students who are quite proficient in arithmetic (Kieran, 2007). So it is demanded to support students’ development of algebraic thinking already in the early grades because analyzing, structuring, generalization and abstraction are elementary mathematical activities that can not only support an understanding of mathematical relationship but also an understanding of the deeper underlying structure of mathematics (Cai & Knut, 2011; Kieran, 2007; Radford, 2006; Steinweg, 2013). Consequently in recent years, the question, ‘How is it possible in the elementary grades to prepare students for algebra?’ has received a great deal of attention. Many studies show that young children are able to formulate generalizations by using individual phrases and deictic gestures (e.g., Carpenter et al., 2003). But the role of promoting language proficiency to support young children competences in generalization has rarely been addressed – although algebra and language proficiencies count as a gatekeeper in students’ middle school success (Moses & Cobb, 2001). Some empirical studies show a strong connection between language and algebraic skills (MacGregor & Price, 1999) and that promoting the proficiencies in “language of schooling” and “technical language of mathematics” of socially underprivileged mono- or multilingual eighth graders have positive effects (Prediger & Krägeloh, 2015).

“Language of schooling” (Schleppergrell, 2004) and “technical language” are sociolinguistically classified as a special register of language. “A register can be defined as the configuration of semantic resources that a member of a culture typically associates with the situation type. It is the meaning potential that is accessible in a given social context” (Halliday, 1978, p. 111). In this sense, the language of schooling can be seen as a register, that is “situated between, but overlapping with, both the everyday register and the technical register” (Prediger & Krägeloh, 2015). Many empirical studies show that the proficiency especially in the language of schooling might be a key skill for
mathematical learning especially for higher order thinking practices such as abstracting and generalizing (Schleppergrell, 2004).

Consequently the design research project presented in this paper focuses the following research questions:

Q1 How does fourth graders’ increased language proficiency influence the individual learning pathways in generalizing growing patterns for shapes and/or number sequences?

Q2 How can the reconstructed language-determined problems of the fourth graders in expressing (and understanding) verbally given generalizations be overcome by suitable language- and content-integrated learning arrangements?

**METHODOLOGICAL FRAMEWORK**

The aim of the project was the simultaneous support of language and algebraic skills according to the competences of generalizing growing patterns for shapes and/or number sequences. Both skills were promoted in partner learning arrangements with fourth graders in a laboratory setting. In sum, 142 fourth graders were interviewed in four sessions about 20-30 minutes.

The tasks were constructed against the background of the “scaffolding”-concept of Hammond and Gibbons (2005). In the idea of this concept language support is conducted in consideration of the individual language learning preconditions of the children. Consequently support measures carefully initiate the transition from the informal everyday register to the formal school register and the technical register of mathematics. Thereby the transition must be seen as a dynamical move between the three registers and not as a move to the technical register with no return to the other registers (Prediger & Krägeloh, 2015).

Hammond and Gibbons (2005) describe two levels of scaffolding: the micro and the macro level. While the support on the micro level is situational and interactional without pre-planning, on the macro level learning arrangements are pre-planed. In the present study 10 pre-service teachers were trained to conduct the interviews according to the micro scaffolding. Additionally on the macro level special support measures were planed. In this interview project the following support measures were included:

- a list of words and sentence structures to use in oral and written productions (in German so called “Wortspeicher”, e.g., Götze, 2014).
- linguistic examples on a worksheet, children have to find the correct patterns of shapes/numbers, they describe own patterns to a partner.
- analyzing three descriptions of three fictive children (instructional meta-level discourse (Kieran, 2012), see Fig. 1).

Fig. 1: An instructional meta-level discourse task
EMPIRICAL SNAPSHOT FROM THE INTERVIEW PROJECT

In the following transcript the fourth-graders discuss an instructional meta-level discourse task (Fig. 1). It is a sequence from the fourth interview. In the interviews before, the children, assisted by the pre-service teacher, have collected words and phrases to describe the patterns in the sequence of shapes and numbers. Furthermore, they had to find a sequence of shapes on the basis of a written description and had to describe each other own sequences of shapes by using the words from the poster. They have learned how to find a general rule for calculating the numbers of dots in the shape at the x-th position by using an algebraic thought term or the expression “x-arbitrary”. So in the whole interview setting the children had to switch between different mathematical representations – specially focused on verbal representation – and between recursive and explicit described pattern rules.

First snapshot

12 Mia: I don’t understand what Till and Oender wanted to express: We are thinking of a term number... I don’t understand this.

13 I.: Do you understand, Romy?

14 Romy: No. I don’t understand, too, cause a term number? You don’t know which term number exactly.

15 I.: Try any term!

16 Romy: Okay, we take 2. (...)

27 Mia: 8. I would say, the description is quite good. Look, you can see 2 multiply by 4.

28 Romy: Yes.

29 Mia: ... results in 8 plus 2.

30 Romy: Yes, I would also say, it’s quite good, cause it’s nothing else than a term, so to say.

First Mia and Romy are confused about the generalized sentence “We are thinking of a term number” (12 and 14). But after the pre-service teacher suggests inserting a special term (15), Mia notices that the description can help to calculate the number of shapes in the 2nd term (29). While Mia might mentally remain in the numerical example by using 8, Romy makes a connection between the written text and the term (30).

Second snapshot

27 Sandro: We have taken a x-arbitrary term. So 2 plus… the term multiplied …

28 Furkan: For example 8. For the 8th term.

29 Sandro: …by 4.

30 I.: Mhm. Exactly. And what have Till and Oender done?

31 Sandro: The same.

Before this transcript starts Sandro and Furkan have described the sequence of shapes on their own. It is Sandro who recognizes the direct connection between their own description and the description of Till and Oender (27 and 31). For him it seems to be clear that you can express the rule for
calculating the number of dots in the shape at the x-th term either with ‘x-arbitrary’ or with ‘I’m thinking of a term number’. By the way the two boys use phrases and words of the school and technical register (27, 28 and 29) for the transfer of knowledge.

What the snapshots show (more detailed results are going to be reported at ICME 2016) is that the simultaneously support of algebraic and linguistic competences may support:

- children to express linguistic generalized numerical patterns with a new natural language (Radford 2006),
- the transition to the school and technical register that might be valuable for further mathematical generalizations,
- a shared language base that might help to overcome a language barrier,
- a propaedeutic understanding of variable as generalizer.

References


Prediger, S., & Krägeloh, N. (2015). “x-arbitrary means any number, but you do not know which one” The epistemic role of languages while constructing meaning for the variable as generalizers. In A. Halail & P. Clarkson (Eds.), Teaching & Learning Mathematics in Multilingual Classrooms. Issues for policy, practice and teacher education. Sense Publisher, Rotterdam.

