Language use in different situations in the mathematics classroom: Everyday academic language and mathematical discourse

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During the last decades, the role of language in mathematics and mathematics education has increasingly caught the attention of many researchers in the field of education, teaching and linguistics as well. Within this context, a frequent use of the term "Academic Language" (AL) is noticed to label a variety of instances of language. However, today there is no universal or agreed definition for a possible exact meaning of AL in educational research. The present study in mathematics education investigates learners' discourse competences within different situations of classroom practice, and addresses the following question: How does the use of language and discourse change during different situations in the mathematics classroom?

Keywords: Academic language, discourse, language register, interactional analysis.

The importance of language for (mathematics) learning

The role of language in the mathematics classroom is controversially discussed relative to the underlying traditions and purposes of research works in this field of research. This paper gives a short overview of the importance of language for learning in a (mathematics) classroom and shows that especially language competences in *Academic Language* (AL) seem to have significant influence in the learners' mathematical achievements. But while lexical and semantical aspects of AL attract attention in many studies, discursive aspects have only received the necessary attention in more recent studies (e.g., Moschkovich, 2007/2018; Sfard, 2012; Erath, 2016; Quasthoff & Morek, 2017; Schütte & Krummheuer, 2017; but not only). A closer look at specific discursive phenomena within the mathematics classroom could clarify how crucial the situation for the learners' use of language might be as well as in which degree their use of language changes during different situations of interaction.

Many investigations proved the close connection of language-based and subject-based learning during different classroom activities and the concomitant educational success (e.g., Townsend et al., 2012). Three meaningful aspects of language within the classroom could be identified: It is the central *medium* for teaching and learning processes. To actively participate in school, pupils need to hold special language-based competences in order to, for example, read and understand mathematical texts, to follow explanations of the teacher, or to give an explanation to classmates. But not all learners bring the same language skills into the mathematics classroom, with the result that not all of them are able to equally participate. Language, according to that, is not just a *medium* to negotiate specialized mathematical contents, but an essential *precondition* for learning (often taken for granted) and a *learning target* as well. Indeed, several researchers in the field of mathematics education and migration research argue that worse school achievements cannot solely be explained with language-based competences in *Everyday Language* (e.g., Schütte, 2014). Especially these linguistic competences that play a role in educational contexts seem to be relevant – this is closely related to the term *Academic Language*.

Academic language

Closely linked to the focus on language in the context of school and mathematics education, the term *Academic Language* (AL) is frequently used. Despite many academic examinations, there exists a variety of synonymously used terms. At the moment, (in Germany) an empirically-based specification of the characteristics of AL as well as models to describe the AL competences of the learners are not available (Heppt, 2016). Additionally, normative views and considerations lead the discussion and open up dichotomous distinctions such as Everyday versus Academic Language or formal versus informal. Frequently, AL is seen as a language register that is used in the context of school and education in order to impart knowledge, and that orients itself by written language with its higher degree of complexity and explicitness (Gogolin & Lange, 2011). Moreover, in a normative way AL is seen as „that linguistic register, whose mastery is expected from a 'successful pupil'" (Gogolin & Lange, 2011, p. 111, translated by the authors). Schütte (2014) has shown that educators and teachers in kindergarten and primary school do not act as linguistic role models. AL often is not a learning target, since in his examination he could hardly find any situation in which linguistic learning was being made explicit and oral communication was mostly implemented in Everyday Language. "The children are therefore unable to learn linguistic skills [in AL] related to the mathematical concepts" (Schütte, 2014, p. 936). Nevertheless, AL remains to be a central and meaningful precondition for learning, in mathematical texts and achievement tests as well. Students are expected to communicate in an appropriate way during lessons. For example, they have to explain and justify mathematical solutions or to answer the teachers' questions in a correct manner. "All these activities are accomplished not only by using certain syntactical constructions and academic vocabulary but within situated communicative practices …" (Heller, 2015, p. 1)

Everyday academic language and mathematical discourse

If we consider the fact that learners are confronted with AL in many (or even all) mathematical contents and classes, we could consider that AL in the mathematics classroom could be seen as an *Everyday Academic Language*, since students get familiar with AL and its norms when participating in lessons every day for many years. Also following Moschkovich (2018) research on language and learning mathematics needs to "move away from simplified views of language as vocabulary [...] [and instead] recognize language as a complex meaning making system" (p. 38). Through the perspective that meaning is negotiated in social interactions, learning is seen as a social and co-constructive process. In this regard, language can no longer be seen solely as medium, precondition and learning target but also acquires a central significance, if not *the* central significance in the building of mathematical knowledge and the development of mathematical thought (Schütte, 2018). During classroom activities, students use multiple resources from their experiences inside and outside of school. Therefore, it is important to avoid the construction of Academic and Everyday Language as a dichotomous distinction, because it depends on how we define these two types of language, respectively discourse (Moschkovich, 2007). In this regard, the term *Everyday Academic Language* seems to underline the fact that students (and teachers as well) do not solely use "the" AL but rather a mix of multiple resources from different language registers (e.g., Schütte & Krummheuer, 2017).

"Since there are multiple mathematical Discourse practices, rather than one monolithic mathematical Discourse, we should clarify the differences among multiple ways of talking mathematically […]" (Moschkovich, 2007, p. 28). That is why this study aims to consider the use of the learners' language during different situations within the mathematics classroom. Moving away from such dichotomies could help to suggest mathematical (classroom) discourses as a hybrid of different discourses with co-existing registers. As already mentioned, lexical and semantical characteristics of AL have been explored in many studies and research projects (e.g.,

Townsend et al., 2012; Uccelli et al., 2015) and discursive characteristics are less common at the center of attention. Some research efforts focusing on aspects of discourse are Quasthoff and Morek (2015) or Erath (2017). The former were able to show, regarding the discourse practices explanation and argumentation, that many learners do not gather enough language-based experience in family and peer groups prior to entering school. But often, such language competences in explaining and arguing are assumed (Quasthoff & Morek, 2015). Erath (2017) could show, that the discursive practice of explaining varies regarding different micro cultures, respectively classes. Depending on the class, different expressions are considered suitable. Most studies on discourse in mathematics define "discourse practices" or "discursive norms" with the focus on selected linguistic activities like explanations and arguments. However, it is differently discussed which linguistic features rank among discursive ones. Mostly it is stated that the construction and organization of such texts, which are used for the realization of specific school-based language actions (like report, presentation, discussion), has to fulfil specific conditions. Language-based actions like descriptions, explanations, comparisons, and argumentations are frequently listed (e.g., Bailey, Butler, LaFramenta & Ong, 2004; Vollmer, 2010).

The presented study takes up a broader view on mathematical discourse and the learners' language (like Moschkovich, 2018; Sfard, 2012; and Gee, 2005), as well as on the term *Everyday Academic Language*, instead of opening up the dichotomy between Everyday versus Academic Language. It should not be self-evident that AL is used in all situations or by all learners in the same way to share meaning and knowledge. A more elaborate language does not necessarily have to result in a greater learning success; and even if the situation could be characterized as an educational or mathematical discourse, the learner's language might occur as Everyday Language or less explicit, elaborate and decontextualized, but with a high impact on the learning success for the learners. In this sense, it is not enough to know what a (mathematical) word means. Learners should be able to make sense of ways in which the word is used or put together with other meaningful words and phrases to constitute a mathematical meaning and to express conceptual understanding (Moschkovich 2018). The events in the mathematics classroom present different and manifold language-based challenges to pupils and it often depends on the situation and the participants itself, if a given statement is seen as appropriate and suitable or not.

For this research project, the underlying concept of D/discourse is the one of Gee (2005; 2015). Following Gee, "language is a tool for three things: saying, doing, being. When we speak or write we simultaneously say something (inform), do something (act), and are something (be)." (2015, p. 1). In order to be recognized as a member of a community or a Discourse, it is not enough to "talk the talk" – somebody also has to "walk the walk" (Gee, 2015, p. 1). For example, being recognized as a high-achieving student in mathematics depends on the situation itself, because what works in one setting does not work in other settings. It is not enough to speak in an appropriate manner and use a prepared list of vocabulary. One also needs to behave in an adequate way. Different situations create different opportunities to behave and the classroom participants themselves could be seen as an own micro-culture that generates special ways of "doing mathematics". Closely related to this, Gee (2005) distinguishes between discourse (with small-d) and Discourse (with capital D). The former he defines as language-in-use among people. In this sense, we are interested in "how the flow of language-in-use across time and the patterns and connections across this flow of language make sense and guide in interpretation" (Gee, 2015, p. 2) to build identities. However, such identities or activities are rarely enacted only through language as with non-language aspects. In this way, Discourse (with capital D) is defined as language plus other "stuff" (Gee, 2005, p. 7), by what he means things like gestures, bodies, interactions and beliefs. Every situation creates specific language-based requirements as well as appropriate/inappropriate and suitable/unsuitable possibilities to use language. The analysis of

Big-D Discourse embeds the former type of discourse analysis (with small d) "into the ways in which language melds with bodies and things to create society and history." (Gee, 2015, p. 2)

Since the presented research takes up a micro-sociological perspective, I therefore use the term Discourse to signify both, language-in-use as well as some "other stuff" like gestures, actions and other context-sensitive aspects. The prime focus is on the language of students in use among different situations (discourse) but it seems also helpful to take into account other influencing factors (Discourse), like the social formation, the learning content or the existence of visual aids.

Main goals of the study

To clarify the importance of the situation for the learners' language, empirical evidence would be instrumental for educators, policy makers, and funding agencies alike. To modify the existing dichotomies of Everyday versus Academic Language, respectively a "worse" and a "better" way of speaking in an academic context, a wider perspective on language is necessary. To see language as a process rather than as an inflexible object, as posed by Moschkovich (2018):

> …. studies need to consider what mathematical knowledge and discourse practices learners use in different settings, what knowledge and discourse practices learners use across settings, and how to make visible the ways that learners reason mathematically across settings (p. 39).

Consequently, one main goal of this research project is to identify which mathematical Discourses exist during different situations and which special language-based discursive opportunities as well as requirements arise from this for the learners. This resembles the two sides of the same coin: on the one hand, the opportunities and possibilities to speak and behave could be very diverse, on the other hand, there could be limiting expectations as well as (implicit) rules and norms. Following Schütte (2014), demands regarding AL have seldom been made explicit by the teachers and are often being taken for granted. "It is certainly desirable for all participating children to be given an introduction to formal and mathematical linguistic aspects, and for the teacher to act as an explicit role model in this regard" (p. 936). Moreover, it is useful to bear in mind that specific classroom situations lead to the emergence of different ways of using language depending on, for example, the age of the learners or the learning content. A changed view on the use of language within the classroom would affect the production of more specific materials and methods to foster the learners' language competences.

Methods and research questions

Based on a social-constructivist view on learning, mathematical and linguistic learning is seen as a collective and interactional process as it is typical for symbolic interactionism (cf. Blumer, 1969). One main assumption of this approach is that mathematical and linguistic meaning emerges and develops during communicational processes (e.g., Cobb & Bauersfeld, 1995; Krummheuer, 2011). Learners participate in different manners during different situations. To achieve successful mathematical and discursive competences, they use diverse resources from different registers (Moschkovich, 2018; Schütte & Krummheuer 2017). Despite the high theoretical and practical emphasis on improving the learners' language skills (in AL) and despite several research efforts in this field, there are less investigations existing to describe AL, respectively discursive (Academic) Language requirements for different social formations, learning contents and class levels (Heppt, 2016).

However, opposite to previous and current research opening up dichotomous distinctions such as Everyday/Academic Language under a normative manner, I tend to describe the use of *Everyday Academic Language* during different situations in the mathematics classroom without passing judgement on "worse" and "better" ways of using language. These dichotomies are not consistent with the current assumption that "everyday and academic practices are intertwined and

dialectically connected" (Moschkovich, 2018, p. 39) and do not fit a social-constructivist view on learning. I suspect that one person uses language in different ways concerning the situation. By considering the interaction of the learners during different mathematics classroom situations, linguistic and discursive particularities should be identified. There are many influencing factors that may have an impact on the learners' language activities, such as the following: The social formation of the learners (whole class discussions in which the teacher mostly has an outstanding position of regulating, determining and moderating the discussion in both ways, language and organization; or phases of group or pair work which seem to be more intimate). The (non-)existence of the teaching person or another audience. The (non-)existence of illustrative learning material for visualization what could affect the explicitness and clarity of the learners' statements. To gain a broad impression of the learners' language use during different situations of the mathematics classroom and to call into play as many situations and micro cultures as possible, it is intended to contemplate different school types and class levels. Following these fundamental theoretical concepts and ideas, this study project aims to find answers to the following questions:

- How do the language-based contributions of the learners differ in varying situations of the mathematics classroom, respectively during different mathematical discourses?
- Which scope of action and opportunities for language use can be identified during different situations of the mathematics classroom?
- Which (academic-)language-based requirements, conditions and challenges go along with that and how do the learners fulfill them?

To answer these questions, mathematics lessons of the several classes were video-recorded from 2017 to 2018. The duration of the recordings in each class varies from two to four weeks. To underline differences and similarities it is planned to observe different school types and grade levels. Afterwards, selected lessons and passages were transcribed and analyzed via a linguistic analysis on selected language-based aspects and via interactional analysis (Krummheuer, 2011) to illuminate how the situation and its opportunities and requirements in speaking and behaving could be characterized and if mathematical and linguistic meaning emerges.

Initial results

Until now, the database of mathematics lessons encompassed recordings from a 1st, 2nd, 3rd and 4th class in primary school, a multi-graded high school class 7 and 8 with children between 12 and 15, and one 12th class of a mathematics intensified course (between 17 and 18 years old). Many obviously interesting and meaningful scenes are already transcribed. The following excerpt is from a class discussion in grade one and the topic is about the relation terms "greater than" (>) and "less than" (<). The students already know some tasks and the teacher (T) is now initiating a discussion about the formal expression of the terms with the help of a narrative about a crocodile named "croco" and cubes on the board.

T: Our little croco always want to eat a lot. That's why is mouth is open that wide. And now he comes and thinks about 'Shall I eat the red ones or the blue ones?'. What do you think, Ina?

Ina: I think red.

T: You think red [*turns croco with the open mouth to the two red cubes*]. Why?

Ina: Red is like meat.

T: Aha. That would be a consideration. Nabil, what do you think he wants to eat?

Nabil: Blue?

T: You say blue is what he wants to eat, why? … [*Nabil does not say anything for 4 seconds*]. Simply because blue is beautiful. Okay. Rich, what do you think?

Rich: Ehm. He wants to eat red because it is like meat and fish.

T: [*turns croco to the red cubes*] Because meat and fish. Mhm. Nagi, what do you think.

Nagi: Blue. Because that is more.

T: That is our little croco who always wants to eat the most and that's why he looks here [*turns the crocodile between the towers and cubes that it looks to the four blue ones, writes a ">" between the four blue and the red cubes and again places croco between them*]. Can you see this? Because he always wants to eat what is more.

First of all, we can see that the first two children, Ina and Nabil, were asked by the teacher for an explanation of their given answer. In contrast, the last two children who gave answers, Rich and Nagi, gave these explanations by themselves. We could imagine-that they recognized the specific demands and requirements of the situation, that giving an answer is not enough and instead, some remarks about the "Why" are necessary. In addition, this is typical for educational contexts.

Second, the extract shows that the teacher packs the mathematical content into a narrative, what seems to lead to student answers which are centrally oriented towards the story and less towards the mathematical content. This typical IRE-pattern (Initiation, Response, Evaluation) continues until Nagi gives a satisfactory answer with a short justification about the mathematical insight which is less oriented to the story. Ina and Rich, instead, seem to be "caught up" in the narrative and try to argue for "red" as it is similar to the color of raw meat and fish. Although it is visible that there are more blue cubes on the board, two children argue for red, what leads to the assumption that they are too much fixated to the story about croco. However, it remains unclear whether the children could see the mathematical concept behind the story, since only Nagi contributed something mathematical to the situation and the rest of the students' utterances were superficially oriented toward the story of croco and the colors of the cubes. The teacher did not guide the children in one direction and the idea of color is seen as one possible way to answer the question of what croco wants to eat. These results are comparable to Schütte and Krummheuer (2017) who found that if the (mathematical) content is "packed" in a narrative, the interpretations of the learners and their verbal utterances could be bound to the story. This could hinder them to gain mathematical-based interpretations and to understand the underlying mathematical construct.

In sum, it can be stated that in the presented transcript it was reconstructed that the learners' language is affected by the situation, especially the existence of visual aids and the "packing" of the learning content into a narrative. In this view, interaction could be seen as a "discursive practice, primarily structured by the social action it forms, rather than by its content" (Barwell, 2003, p. 201). Telling the story about croco seems more important than the mathematical structure of "less-than" and "greater-than" that goes beyond the story. In this regard, we can identify a central challenge for early childhood educators: On the one hand, it seems necessary to "build up" a story about a mathematical content. On the other hand, this story could be an obstacle for the children, preventing them from to "seeing" the mathematical content behind.

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