The situational factors on the learners' language – the existence of different language styles in different mathematics classroom situations

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Abstract
In the last decades, the role of language in mathematics and mathematics education has increasingly caught attention of many researchers in the field of education, teaching and linguistics. Within this context, a frequent use of the term 'Academic Language' (AL) is noticed. However, there is no universal definition of the exact meaning of AL. The presented research investigates the learners' discourse competences within different situations and asks the following: How does the use of language and discourse change during different situations in the mathematics classroom? For this purpose, mathematics lessons of several classes have been video-recorded and selected passages have been analyzed by means of interactional analysis. Within the frame of this paper, some initial results of a grade one classroom will illuminate that the situation and visual aids play an important role in the use of (academic) language.

Keywords*: academic language, discourse, language register, interactional analysis, interpretative classroom research*

Fundamental theoretical considerations

The role of language in the mathematics classroom is inconsistent discussed relative to the underlying traditions and purposes of research works. The paper gives a short overview of the importance of language for learning in a (mathematics) classroom and shows that 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). A closer look at specific discursive phenomena and special contextual circumstances within the mathematics classroom could clarify how crucial the situation for the learners' use of language might be and in which degree their use of language changes during these different situations. After some theoretical basics about the importance of language in educational settings and the existence of different language registers within mathematical classroom situations, some research examples and findings of a dissertation project will illuminate how the situation affects the learners' language and what this could mean for their learning processes.

The importance of language for (mathematics) learning

Many investigations have proven 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 (and in this regard maybe even four) meaningful aspects of language within the classroom could be identified: First, it is the central *medium* for teaching and learning processes as verbal as well as written language is the central tool to transport information (Prediger 2013). To actively participate in school, pupils need to hold special language-based competences in order to, for example, read and understand subject-specific texts, to follow the explanation of the teacher, or to give a description 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 (Prediger 2013). 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. The aspect that (academic) language could be seen as a central precondition and target for learning and active participation in all school subjects underlines, that 'successful' students are expected to hold good (academic) language-based competences (Gogolin & Lange 2011). If not, language could become a learning *obstacle,* in case students do not hold enough competences in language production and reception which seem necessary in educational settings (Prediger 2013).

Here, a distinction between different language registers seems useful, since several researchers in the field of mathematics education and migration research for example argue that worse school achievements cannot solely be explained with language-based competences in *Everyday Language* (e.g., Schütte 2014). On the contrary, the competences of (second-language) learners in Everyday Language are often well developed and their language skills are estimated as 'good' (Gogolin 2013). However, this often disguises their worse linguistic competences in the educational/classroom context, which seem to be more important for educational success. Linguistic competences of this kind are closely linked 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 – in the German as well as in the English context – there exists a variety of synonymously used terms like Bildungssprache (Academic Language), Schulsprache (Language of Schooling) or Standardsprache (Standard Language). 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: 111, translated by the author).

In this regard, especially students with lower socioeconomical backgrounds, migration backgrounds, or a different mother tongue seem to need more time and greater effort to acquire competences in AL (e.g., Butler, Bailey, Stevens, Huang, & Lord 2004, Heppt 2016). But educators and teachers in kindergarten and primary school often do not act as linguistic role models: AL often is not a learning target, since in his examination Schütte (2014) 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: 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: 1). In this regard, it also seems important to consider the fact that students have to use AL in many different educational settings in different ways and become more and more familiar with AL.

Everyday academic language

If we consider the fact that learners are confronted with AL in many (or even all) mathematical contents and classes, we could contemplate 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" (Moschkovich 2018: 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).

Many publications in the field of language and education or language and mathematics use the term *Discourse* to underline relationships between language, the social and situational context in which this (special form of) language is used, and the produced meanings in this context. But just like for AL, many different definitions for Discourse as well as different analytic approaches to study (mathematical) discourses (Morgan 2016) exist.

Discourse

In the context of the presented study it is important to find an underlying concept for the term Discourse that fits to the goals and methods of the study on the one hand and that is compatible with already existing studies in the field of mathematics education. As already stated above, it is differently discussed which linguistic features rank among discursive ones. Most studies on discourse in mathematics education define *discourse practices* or *discursive norms* with the focus on selected linguistic activities like explanations and arguments. 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. Especially language-based actions like descriptions, explanations, comparisons, and argumentations were 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. "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: 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 many co-existing registers. 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 (Prediger 2013, 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)." (Gee 2015: 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: 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 necessarily 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: 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 and 'other stuff'" (Gee 2005: 7), by what he means things like gestures, bodies, interactions and beliefs. Every situation creates specific language-based requirements as well as (in)appropriate and (un)suitable 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: 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 consider 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, the existence of 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, 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 (Moschkovich 2018: 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" (Schütte 2014: 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 (e.g., Blumer 1969, Miller 1986). 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 resources from different registers (Moschkovich 2018, Schütte & Krummheuer 2017). Despite the high theoretical and practical emphasis on improving the learners' language skills and 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: 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 different 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:

- In what extent 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 in Germany have been video-recorded during the period from 2017 to 2018. The duration of the recordings in each class varies from two to four weeks. To underline differences and similarities different school types and grade levels were observed. 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 in speaking could be characterized and if mathematical and linguistic meaning emerges.

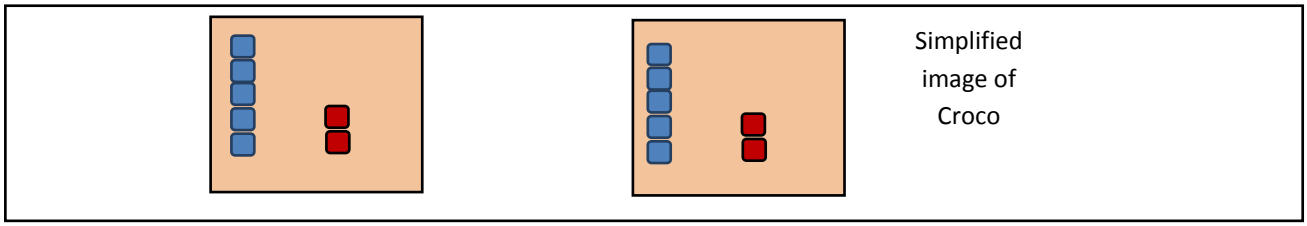
Initial results

Until now, the database of mathematics lessons encompassed recordings from several German classes in primary school (year one to four), a multi-graded high school class 7 and 8 with children between 12 and 15, and one 12th class of a mathematics intensified course (students are between 17 and 18 years old). Many obviously interesting and meaningful scenes are already transcribed. In the following, different classroom situations of a grade one mathematics class about relational terms will illuminate language and discursive particularities of the different scenes. Due to the shortness of this paper, it is not possible to answer all research questions, but these initial results will show, how important the situation and the existence of visual aids could be for the learner's (academic) language output.

Scene 1 – Class discussion at the start of the mathematics lesson: *What does Croco like to eat?*

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 with an open mouth named *Croco* and towers of cubes in red and blue on the board (Figure 1).

Figure 1: The towers of cubes on the board in front of the class before and after the class discussion.



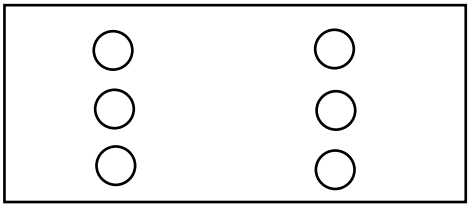
T: Our little Croco always wants to eat a lot. That's why its mouth is open that wide. And now he comes and thinks about. Shall I eat the red ones or the blue ones? What do you think, Ina?
Ina: I think red.
T: You think red [*turns Croco with the open mouth to the two red cubes*]. Why?
Ina: Red is like 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 might be 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 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 fixated on 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.

Scene 2 – Assistance during individual work on the tasks in the workbook: *Do you need help, Nabil?*

Directly after this class discussion the students were asked to complete some exercises about this topic in their workbooks. After four tasks in the style comparable to those on the board – two towers of cubes and in between the students had to place the correct sign – in number two there is no visual support (Figure 2).

Figure 2: The first tasks of number two in the children's workbooks.



After several minutes, Nabil is still working on number two, while his seatmate Dani has already finished task three. When Dani sees that Nabil has not finished yet, the following conversation starts:
Dani: I am already done. I can help you.
Nabil: Why do you want to help me?

Dani: [*takes the pencil out of Nabils hand and signs on task* 6 O 5 *in his workbook*] Here. See here. Which he would like to eat? Six or five?
Nabil: … Six.
Dani: Yes. So you do it [*writes something in Nabils workbook*]
Nabil: [*takes his pencil from Dani*]
Baila: [*Comes to the desk of Nabil and Dani. Dani stands on Nabil's left. Baila stands to the right of him. Looks on Nabils workbook*] ehm … you are here. Think about it … [*shows three fingers with her left hand*] nine or three. Which is more?
Nabil: [*writes something in his workbook*]
Baila: That`s right.

In this scene, two students who have already finished the tasks in their own workbooks, Dani and Baila, seem to offer help to Nabil, without directly asking him if he wants it. Dani's explanation is similar to that of the teacher as it is bound to the story of Croco. It is more oriented towards the narrative and less towards the mathematical content. If Dani herself requires the story about Croco and his food to solve the tasks in her workbook is doubtful. The argumentation with Croco does not really fit the situation, thus it can be assumed that she might be aware of the underlying mathematical concept and is just using the narrative to visualize the task for Nabil. It seems possible that it becomes even more problematic for Nabil when Dani uses the story of Croco for her explanation of the tasks in number two: There are neither colors nor towers of cubes to be seen, which could be eaten by Croco. There are just numbers and a gap in which the correct relational sign (< or >) has to be filled in. The students seem to be supposed to identify the relationship between the numbers and the correct sign on their own. Nabil answers with 'Six', what could be an indication for his understanding of the mathematical concept. It remains questionable, if he requires the story of Croco to solve the tasks or if the narrative itself leads to the slow progress in the processing of tasks.

Directly after this, another student named Baila approaches Nabil and 'helps' him without asking, if he is in need of help. This could be seen as a typical discursive characteristic in educational settings or especially in this class: If there is someone who has not finished yet, students who already have finished help them to solve the tasks. Baila also offers an explanation, which, in comparison to Dani's, is more formal and oriented to the mathematical content. Since there are no visual aids in number two, she uses her fingers and shows the number 'three' to illustrate something for Nabil. Again, Nabil seems to know the right answer and it is questionable once more, if he needs the girls' help, if the story of Croco is helpful for his understanding of the mathematical concept, or if his slow progress is caused by the inappropriate and confusing use of the narrative. The connection between the story of Croco and the correct solution of the task (including the correct sign) is not verbalized until now and still remains implicit.

Concluding remarks – narratives could mask the mathematical content and affect the learners' language

The presented scenes illuminate two central aspects, which seem to be really important for (mathematics) teachers, for scientist in the area of language and education, as well as for educators designing schoolbooks.

First: If the mathematical content is bound to a narrative, this could hinder the students to see the mathematical structure in it since they might solely focus on the story. The analysis' results are comparable to those of 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 (Schütte & Krummheuer 2017). On the one hand, such narratives like the story about Croco seem to simplify the start of a new learning content as they "catch" the students' attention. On the other hand, educators who design work- and textbooks for school as well as teachers themselves should be aware of the risk that some students could lose themselves in the story and not 'see' the learning content just because of that.

Second: Visual aids could support the students' understanding of the mathematical content. They also could make it easier for students to follow the lesson and take part in it verbally, since verbal utterances

are also visualized. On the other hand, visual aids could reduce the learners' language explicitness, as it seems less important to verbalize all facts (Fetzer & Tiedemann 2015). Especially in scene one, the class discussion is more about the colors than on the number of cubes on the board, although this was the important aspect to answer the question "What does Croco like to eat?". Like the story-boundedness, visual aids have positive and negative aspects. Teachers and educators should be aware of these / both.

In sum, it can be stated that in the presented transcripts it was reconstructed that the learners' language is strongly 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: 201). In the presented situations, 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 and to use visual aids to support the learners' understanding and to reduce linguistic requirements. On the other hand, such a narrative could be an obstacle for the children, preventing them from 'seeing' the mathematical content behind it.

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