Talking about standardized units in preschool – supporting language and mathematical learning

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Today, the important role of language use for successful (early) mathematical learning processes is widely accepted and researched. Starting from the preschool teacher as an influencing variable for language learning and the mathematical content of measuring, this paper reconstructs opportunities for supporting conceptual as well as language learning in small group interactions planned for mathematical learning in preschool. The way preschool teachers talk about units ranges between a linguistically rich 'language bath' and an action-oriented 'activity bath' and thus offers different learning opportunities.

Keywords: Early mathematics education, measuring, linguistic competence, oral language.

Introduction

Despite the fact that large-scale studies have shown the impact language has on mathematical learning processes, the German school system is still in need of concepts to support children with disadvantageous starting conditions, for example migration background, low socio-economic background or developmental speech disorders. These children are still not provided with equal chances to take part in (mathematical) educational processes (Gogolin & Lange, 2011). Ensuing from these observations, for example, Prediger (2015) claims that academic language education processes should start as early as possible. While most research on language-sensitive teaching in Germany focusses on primary or secondary schools (Gogolin & Lange, 2011; Leisen, 2015), fostering academic language in preschool could contribute to improving educational injustices. Further, academic language education processes should be designed age-appropriately and oriented towards a specific content. Prediger and Zindel (2017) ask for more topic specific research in order to specify the concrete linguistic demands for mathematical contexts. Studies show that preschool teachers possess only insufficient knowledge concerning basic linguistic terminology, language acquisition and effective interventions (Michel, Ofner, & Thoma, 2014). These results are especially alarming if one takes into account that even preschool children who speak only one language are still language learners (Volmert, 2005). Hence, there is not only a lack of concrete concepts for integrated mathematical and language learning, but also for professionalizing preschool teachers in order to be able to implement such concepts. With the analysis of language usage in interactions during mathematical activities, we try to address this gap.

Our overall aim is to raise preschool teachers' language awareness and practical knowledge for fostering academic language proficiency (Isler, Künzli, & Wiesner, 2014) and mathematical learning. In a first step, we specify this aim by looking at the use of language in kindergarten interactions concerning magnitudes. On a linguistic as well as mathematical level, units are a crucial part of measuring. Since we found measuring of children's body length and the accompanying measured values as a recurring theme, we take a deeper look at the verbalization of units and

indications of size. After elaborating on linear measuring, the topic of our content-specific research, we present the empirical data, some results and a preliminary discussion.

Linear measuring in preschool

Measuring is not only one of Bishop's (1988) six basic mathematical activities, but is also seen as a basis for the development of mathematics as a science in all cultures and many curricula for early mathematics education in Germany put emphasis on measuring. Further, it represents a link between mathematically abstract concepts and everyday life, and comprises multiple inner-mathematical relations, especially with numbers and geometry. Beyond, the concept of measuring can be seen as a basis for further concepts, for example fractions and rational numbers (Barrett et al., 2011). While we take research on children's acquisition of a (geometric) concept of magnitudes, milestones and difficulties (Sarama, Clements, Barrett, van Dine, & McDonel, 2011) as a background for our linguistic analysis, we will not discuss it in detail. Although an integrated approach for different spatial magnitudes, especially in early education, is seen as reasonable in order to understand the differences and the fundamental idea of measuring as comparison with a unit (Barrett et al., 2011), here we only concentrate our linguistic analysis on length. Length and area are more easily perceivable and accessible for young children than other magnitudes, although they might be difficult to distinguish (Skoumpourdi, 2015). The activity of measuring length concentrates on the determination of a linear expansion. Therefore, you have to distinguish between objects with a rather clear linear characteristic, for example sticks or distances, and those objects with more than one dimension that can be measured (width, height, depth) (Nührenbörger, 2002; Skoumpourdi, 2015). Consequently, it becomes obvious that speaking about length comes along with specific linguistic challenges, for example concerning the characteristic of linearity and the differentiation from area. In order to obtain a profound concept of measuring, children need to understand the act of *iteration*. In order to obtain a measure, a subdivision of a certain length is translated. Each of these subdivisions has to be equal, the concept of *identical unit.* With these identical units, you fill out a certain space, the so-called *tiling*. In order to fill out a space completely, it might be necessary to *partition* units. Lastly, measures can be added so that a measure of eight units can be thought of as a composition of five and three suggests the concept of *additivity* (Lehrer, Jaslow, & Curtis, 2003). While some research suggests starting with non-standardized units and only introducing units like centimeter and meter later in the process, this rarely meets the children's reality. Based on this theoretical background, we focus on the following research questions:

- Which linguistic resources are at preschool teachers' disposal when talking about standard linear units?
- How are the acquisition of (academic) language and mathematical application supported in these interactions?

In order to answer the research questions, we follow methods from interactional linguistics (Couper-Kuhlen & Selting, 2000). Interactional linguistics takes an interdisciplinary and cross-linguistic perspective on language. It looks at the structure and use of language, capturing it in its natural environment, the social interaction. Based on the linguistic element used in the utterance, we

look at their role in the conversation. In our context, these linguistic elements are utterances containing standardized units to describe or accompany measuring processes. We are interested in situations in which units are used in ways which might lead to meanings within the child's and the kindergarten teacher's mind. Apart from that, we are interested in structures that deviate from a normatively correct way and which might therefore inhibit the construction of measuring concepts or at least make it harder for children to understand the concept of length. If applicable, the central concepts in linear measuring that might be transmitted through the preschool teachers' utterances are pointed out. These questions are part of a larger project which also looks at the language used with other magnitudes, older children at primary school and syntactical, lexical and semantic aspects, because "developing measurement sense can be conceptualized as learning the language of measurement, with attention paid to the semantics, syntax, grammar and pragmatics of measurement" (Joram, 2003, p. 65).

Empirical data and results

The data basis for our analysis consists of videotaped mathematical situations designed by preschool teachers from the project erStMaL (early Steps in Mathematical Learning) (Acar Bayraktar, Hümmer, Huth, & Münz, 2011). From this data basis, seventeen situations are concerned with magnitude and measuring, which are the corpus of our project (for detailed information on these situations see Brandt and Keuch (2017)). These small group interactions with one preschool teacher and two to five children were transcribed and annotated using the transcription and annotation tool EXMARALDA (Schmidt, 2002). Ten of these seventeen situations deal with the magnitude length. In order to be included into the following analysis, the utterance has to include some kind of standardized linear unit. In a first step, we differentiated between units that accompany numbers (indication of size) or that appear on their own. Indications of size are further analyzed according to which units are used and how they are combined with the respective number(s). The following utterance by one of our preschool teachers serves as an illustration for the different types of using units in indications of size:

Sabine: You are one meter and nineteen centimeters. Look, that's what the number looks like. One hundred nineteen centimeters are one meter nineteen.

For the first indication of size in her utterance, Sabine uses a number (one), then the unit (meter), the conjunction 'and', then another number (nineteen) and another unit (centimeter). So this part of her utterance is annotated as 'x m and y cm'. In the second part of her utterance she uses centimeters only, so this would be coded as 'x cm', and then she uses a shortened, colloquial form without 'and' and without 'centimeters'. This would count as 'x m y'. Preschool teachers use units more than four times more often than children (see Table 1) do. Moreover, only three children produced utterances containing units. In most cases, preschool teachers use units within indications of size. Teachers talk four times more often about centimeters than about meters. If they use mixed forms, they tend to use a shortened, colloquial version. In contrast, children never use mixed forms (but they use numbers without units to indicate size, which are not included in this analysis). Preschool teachers use units without numbers to list the different units that exist in different countries, but without giving further explanations as in the following example: "You can measure in

meter or in centimeter and in America I think you measure with inch. We measure here with meter and centimeter". The following table shows how numbers and units are combined within indications of size and how often each variation is used in all ten situations dealing with length:

	Units total	*without numbers*	*x cm*	*x m*	*x m and y cm*	*x m y*	*x inch*
Preschool Teacher	88	13	41	10	4	19	1
Children	19	5	11	3	0	0	0
Total	107	19	52	13	4	19	1

Table 1: Use of units in all ten situations dealing with length

After this global view on the general usage of units, we now look at explanations that preschool teachers give for the meaning of units. Only two of them, Berna and Sabine[1], try to explain what a unit (in their cases centimeter) is, hence we concentrate our following analysis on them.

Sabine: Every number is a centimeter. That means such a small piece is a centimeter. You see that also on the ruler, don't you?

Berna: From one long line to the next, so just this little box yes? That's a ... that's a centimeter there.

In the first part of her utterance, Sabine compares the numbers on the folding stick with centimeters, the numbers equal the centimeters. With this explanation, she might want to address the concept of identical units. Barrett, Jones, Thornton, and Dickson (2003) warn that focusing on the numbers or marks on a measuring device might impede seeing length as an aggregation of segments or units. Berna, however, hints at the distance between two-centimeter marks on a tape measure, which she calls 'little box'. This expression can be (mis-)interpreted as a two-dimensional square (for example on graph paper) or as a three-dimensional object. In any case, defining linear units by using two- or three-dimensional objects like 'piece' or 'little box' might lead to confusions with area measuring (Keuch & Brandt, 2018). Starting from the former defined centimeter, Sabine tries to explain the need for other units like meter and hint to the concept of partitioning: "But when we now uhm calculate everything in centimeters, then the numbers must be much too big". Sabine hints to the inverse relationship between the number of units and the size of the unit (Grant & Kline, 2003). However, she never explains what exactly a meter is (or its relationship with centimeters), but puts a folding rule on the floor, folded in a way that it is one meter long, claims that 'that' is a meter and goes on with the next activity: "Look! And that's a meeeter! Do you now want to know how tall you are?"

Berna explains the relationship between meter and centimeter (partition) in two steps. First, she elaborates on ten centimeters and finally she draws the link to one meter, hinting at the decadal structure. However, the children's job in the second step is simply to read out the number hundred:

[1] The children in these two situations are 6;0 – 6;2 (Berna) and 4;11 – 5;11 (Sabine) years old.

Berna: That's a meter. And in one meter, from the beginning to the end are? Which number is this?

Friedel: Mhm hundred.

Berna: Hundred centimeters. So that means that in such a meter are hundred … little boxes.

Berna tries to initiate a number of tasks that hint at the idea of iteration, identical units and tiling while referring to different measuring devises: "So, from the beginning to the seven are how many centimeters then Can?"[2] When she notices the children's difficulties, she refers back to her explanation of *little boxes* and rather focuses on counting discrete little boxes (although there are no clear visible boxes on the folding stick) instead of continuous units:

Berna: One little box is always one centimeter and now count the little boxes up to seven.

Berna: Look, it is … the numbers don't play any role now. From one to the other mark, only one little box, is always one centimeter. Yes?

With this statement, she indirectly hints to the concept of identical units and also to the fact that every point on a measuring device can be used as a zero point. No such utterances that contain the idea of identical units, iteration or tiling were found in any other situation. Moreover, one has to consider that the children in the interaction with Berna are the oldest children in the corpus of our project. Sabine as well as Berna hint to the concept of additivity. While Sabine, in an indirect way, puts emphasis on the difference between the heights of two children, Berna takes two measuring results and adds them up in order to get a result, which equals one of the children's height.

Sabine: And you are one meter twelve tall (…) one centimeter bigger than Theresa!

Berna: So we have now twenty-five and hundred centimeters. So, one meter are hundred centimeter, plus the twenty-five to that. Then now I can tell you that Can is one meter and twenty-five centimeters long.

Interestingly, Berna first transfers one meter into hundred centimeters and then adds more centimeters. Her result however is a mixed indication of size consisting of meter and centimeter. Sabine seems to immerse the children in a kind of 'language bath' to offer them a linguistically rich environment and she might hint to the concept of partitioning and additivity. In this situation, units accompany the measuring process. She never asks the children questions about units but rather integrates them as 'silent' participants into the measuring process. When measuring the children's body length, Sabine uses units in various ways to express their size, also using adjectives or reading out the single digits to make those numbers that exceed the children's actively mastered number range more comprehensible:

[2] In German ("So, vom Anfang bis zu der sieben sind wie viele Zentimeter dann, Can?") the utterance is not completely grammatical and the author tried to stay as close as possible to the original.

Sabine: Oh you've got a funny number. You are one meter eleven tall. Look! One meter eleven is a one, a one and another one.

Berna makes the children participate mentally and physically by posing different questions or asking the children to show her a centimeter with their fingers on a measuring device but also limits her talk on units to these devices. When she determines the children's body length, mainly non-standardized units like building blocks are used, except when she calculates Can's body length. However, she asks many questions concerning units so that the children get a chance to test and apply their mathematical and language knowledge:

Berna: From one long to the other long mark it's a…?

Friedel: Meter!

Berna: Noo one centimeter, but you were really close. Well done Friedel!

While we were able to show that Berna tends to correct lexical mistakes very often and very directly (Brandt & Keuch, 2018), she seems to have a quite relaxed attitude towards the difference between meter and centimeter. While from a linguistic perspective, there really is just one prefix that differentiates the two words, mathematically there are ninety-nine centimeters in between.

Conclusion

In this paper, we looked at the use of standard units in small group interactions in preschool. It became obvious that preschool teachers used units more often than children did. The children rarely spoke about units. This might have to do with limited elicitations by the preschool teachers. They, on the contrary, used units and indications of size in various ways, with the latter most often expressed in mixed and incomplete structures. When the context is clear, leaving out units in everyday settings would not inhibit the understanding, but it contradicts the idea of fostering academic language. Focusing on Berna and Sabine, both preschool teachers seem to possess pedagogical as well as didactical knowledge. Yet, we could only observe limited language awareness regarding the introduction of standard units. Central concepts of linear measuring like iteration, identical units, tiling, partition, and additivity are addressed rarely and mostly indirectly. In both situations, it is not clear which (if any) conceptual understanding of units and scale values the children develop beyond the actual context. The negotiation process related to the mathematical content stayed at the surface especially for linguistically less competent children since some explanations might not have been accessible for them and therefore they did not get a chance to improve their mathematical and (active) linguistic competences. Berna almost completely restricted units to the scales of measuring devices. Nevertheless, the children might have gotten a better idea of the actual size of a centimeter (although it might interfere with area) because of her multiple questions and tasks. It remains unclear how far the children were able to transfer their knowledge to the actual measuring activities in the situation and beyond. Because of Sabine's lack of questions and tasks concerning units, the actual concept and size might have stayed unclear. Following her rich 'language bath' concerning body sizes, the children in this situation might get a feel for expressing indications of size, even beyond this situation. This 'language bath' was integrated in the cultural practice of measuring with standard units. Through this subjective-bodily involvement, she

might enable more indirect learning which can leave marks and offer connectivity options for later (direct) mathematical and language learning opportunities.

References

Acar Bayraktar, E., Hümmer, A.-M., Huth, M., & Münz, M. (2011). Forschungsmethodischer Rahmen der Projekte erStMaL und MaKreKi [Research methodological framework of the projects erStMaL and MaKreKi]. In B. Brandt, R. Vogel, & G. Krummheuer (Eds.), *Die Projekte erStMaL und MaKreKi: Mathematikdidaktische Forschung am Center for Individual Development (IDeA)* (pp. 11–24). Münster, Germany: Waxmann.

Barrett, J., Cullen, C., Sarama, J., Clements, D., Klanderman, D., Miller, A., & Rumsey, C. (2011). Children's unit concepts in measurement: A teaching experiment spanning grades 2 through 5. *ZDM*, *43*(5), 637–650.

Barrett, J., Jones, G., Thornton, C., & Dickson, S. (2003). Understanding children's developing strategies and concepts for length. In D. Clements & G. Bright (Eds.), *Learning and teaching measurement: 2003 yearbook* (pp. 17–30). Reston, VA: NCTM.

Bishop, A. J. (1988). *Mathematical enculturation: A cultural perspective on mathematics education*. Dordrecht, Netherlands: Kluwer Academic Publishers.

Brandt, B., & Keuch, S. (2017). The duck is the biggest – kindergartners talking about measurement and magnitudes. In Dooley, T. & Gueudet, G. (Eds.), *Proceedings of the Tenth Congress of the European Society for Research in Mathematics Education* (pp. 1243–1251). Dublin, Ireland: Dublin City University and ERME.

Brandt, B., & Keuch, S. (2018). Talking about measurement in the kindergarten - linguistic means in small group interactions. In C. Benz, A. Steinweg, H. Gasteiger, P. Schöner, H. Vollmuth, & J. Zöllner (Eds.), *Mathematics education in the early years - Results from the POEM3 Conference 2016* (pp. 207–230). New York, NY: Springer.

Couper-Kuhlen, E., & Selting, M. (2000). Argumente für die Entwicklung einer ‚interaktionalen Linguistik' [Arguments for the development of 'interactional linguistics']. *Gesprächsforschung – Online-Zeitschrift Zur Verbalen Interaktion*, *1*, 76–95.

Gogolin, I., & Lange, I. (2011). Bildungssprache und durchgängige Sprachbildung [Academic language and continuous language education]. In S. Fürstenau & M. Gomolla (Eds.), *Migration und schulischer Wandel: Mehrsprachigkeit.* Wiesbaden, Germany: Verlag für Sozial-wissenschaften Springer Fachmedien.

Grant, T., & Kline, K. (2003). Developing the building blocks of measurement with young children. In D. Clements & G. Bright (Eds.), *Learning and teaching measurement: 2003 yearbook* (pp. 46–56). Reston, VA: NCTM.

Isler, D., Künzli, S., & Wiesner, E. (2014). Alltagsgespräche im Kindergarten: Gelegenheitsstrukturen für den Erwerb bildungssprachlicher Fähigkeiten [Everyday talks in kindergarten: Opportunity structures for the acquisition of academic language skills]. *Schweizerische Zeitschrift Für Bildungswissenschaften*, *36*(3), 459–479.

Joram, E. (2003). Benchmarks as tools for developing measurement sense. In D. Clements & G. Bright (Eds.), *Learning and teaching measurement: 2003 yearbook* (pp. 57–67). Reston, VA: NCTM.

Keuch, S., & Brandt, B. (2018). Language hurdles on the way to an understanding of length in early mathematics education. In N. Planas & M. Schütte (Eds.), *Proceedings of the Fourth ERME Topic Conference 'Classroom-based research on mathematics and language'* (pp. 89–95). Dresden, Germany: Technical University of Dresden and ERME.

Lehrer, R., Jaslow, L., & Curtis, C. (2003). Developing an understanding of measurement in the elementary grades. In D. Clements & G. Bright (Eds.), *Learning and teaching measurement: 2003 yearbook* (pp. 100–121). Reston, VA: NCTM.

Leisen, J. (2015). *Handbuch Sprachförderung im Fach - Sprachsensibler Fachunterricht in der Praxis* [Manual for subject specific language support – practical language sensitive subject teaching]. Stuttgart, Germany: Klett.

Michel, M., Ofner, D., & Thoma, D. (2014). Early childhood educators' competences for supporting children's academic language skills in Germany. *Language Awareness*, *23*(1–2), 138–156.

Nührenbörger, M. (2002). *Denk- und Lernwege von Kindern beim Messen von Längen: Theoretische Grundlegung und Fallstudien kindlicher Längenkonzepte im Laufe des 2. Schuljahres. Texte zur mathematischen Forschung & Lehre: Vol. 17* [Thinking and learning paths of children measuring lengths: Theoretical foundations and case studies of childlike length concepts during the second school year. Texts for mathematical research and teaching]. Hildesheim, Germany: Franzbecker.

Prediger, S. (2015). „Die Aufgaben sind leicht, weil … die leicht sind." Sprachbildung im Fachunterricht – am Beispiel Mathematikunterricht ["The tasks are easy, because ... they are easy." Language education in subject-based education - using mathematics as an example]. In W. Ostermann, T. Helmig, N. Schadt, & J. Boesten (Eds.), *Sprache bildet! Auf dem Weg zu einer durchgängigen Sprachbildung in der Metropole Ruhr* (pp. 185–196). Mühlheim, Germany: Verlag an der Ruhr.

Prediger, S., & Zindel, C. (2017). School academic language demands for understanding functional relationships - A design research project on the role of language in reading and learning. *Eurasia Journal of Mathematics Science and Technology Education*, *13*(7), 4157–4188.

Sarama, J., Clements, D., Barrett, J., van Dine, D., & McDonel, J. (2011). Evaluating of a learning trajectory for length in the early years. *ZDM*, *43*(5), 617–620.

Schmidt, T. (2002). Gesprächstranskription auf dem Computer: Das System EXMARaLDA. [Talk transcription on the computer: the system EXMARaLDA] *Gesprächsforschung, 3*, 1–23.

Skoumpourdi, C. (2015). Kindergartners measuring length. In K. Krainer & N. Vondrová (Eds.), *Proceedings of the Ninth Congress of the European Society for Research in Mathematics Education* (pp. 1989–1995). Prague, Czech Republic: Charles University of Prague and ERME.

Volmert, J. (2005). Primärer Spracherwerb: Wie der Mensch zur Sprache kommt [Primary language acquisition: how the human being comes to speech]. In J. Volmert (Ed.), *Grundkurs Sprachwissenschaft: Eine Einführung in die Sprachwissenschaft für Lehramtsstudiengänge* (pp. 207–232). Stuttgart, Germany: UTB.