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Sociomathematical norms in peer-cultures in free play situations in kindergarten

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Interactions between peers in play take up much of children's time in kindergarten. It can be assumed that the norms that children establish in the interactive negotiations during play are just as crucial for them as the norms that they re-construct in their interplay with parents and professionals. While the interactions between adults and children and the (sociomathematical) norms they negotiate in kindergarten discourses have increasingly become the focus of research in mathematics education, the emerging norms between peers and their peer culture of doing mathematics in play have gone largely unnoticed. Taking this as its starting point, it is identified in the article how such a play culture of doing mathematics is established in free block play situations in kindergarten and which norms emerge in this culture. The analyses show that the shared norms for the construction of buildings in play are central to the establishment of sociomathematical norms.

Keywords: Childrens' play, interaction analysis, early childhood education, mathematics education.

Introduction

For young learners, kindergarten discourses are often the first discourses of socialisation into an institutionally shaped microculture of doing mathematics (van Oers, 2019). When their utterances are reinforced or rejected in these discourses, children experience for the first time that their actions correspond, or do not correspond, with the expectations within the interactional process with adults or professionals. If these expectations persist in the long term, so-called social and sociomathematical norms can be established in this interactive interplay (Vogler, 2023, submitted). However, most of the interaction time in kindergarten does not involve negotiations with adults; rather, it is the interactions among children, with peers, which determine everyday life in kindergarten (Henschen et al., 2022). These interactions also involve the negotiation of specific (mathematical) rules between peers and the rejection or reinforcement of utterances by fellow group members (Henschen et al., 2022). It can therefore be assumed that a peer-specific micro- or subculture is established in these peer interactions in kindergarten. Works by Tomasello (2009) and Köymen and colleagues (2014) in this field suggest that the norms established in peer subcultures can make just as great a contribution to the children's norm system as the norms of microcultures between adults and children. Accordingly, the subculture of peers can be significant for learning and developmental processes that cannot be dismissed – especially with regard to the early learning of mathematics. Mottier Lopez and Allal (2007), for example, identified how the regulatory processes resulting from teacher-student interactions engage and orchestrate the regulatory processes resulting from peer interactions and thus contribute to the progress of students' problem-solving activities. While there are already qualitative reconstructive studies in mathematics education on different microcultures of doing mathematics between professionals and children (Vogler, 2023, submitted), there are still no concrete findings on

the microculture of peers of kindergarten age. The following contribution provides initial analyses in this field of norm establishment in peer cultures and is thus intended to close the outlined research gap. The focus is on the questions of which efforts to establish norms and which persisting expectations can be reconstructed in peer interactions in kindergarten as well as how these emerge. The special interest is on norms which seem to be relevant for the further learning path in mathematics from the perspective of mathematics and mathematics education. In reconstructing the microcultures, the theoretical perspective of the article draws on concepts from the work of Voigt (1998), Yackel and Cobb (1996) and Cobb and Bauersfeld (1995) as well as more recent work by Sfard (2008) and Mottier Lopez and Allal (2007). These concepts are presented in the following.

Mathematical learning from an interactionist perspective

The further explanations in this article are based on an interactionist perspective on (early) mathematical learning, as conceptualised in the anthology by Cobb and Bauersfeld (1995). From this interactionist perspective on mathematical learning, mathematics is understood as the product of social processes. Cultural and social aspects are consequently not peripheral conditions of mathematics learning, but essential characteristics (Voigt, 1998). In this context, mathematical meanings or the rules of their use are constructed through processes of negotiation of (mathematical) meanings between participants in interactions. Thus, the interaction between learners and teachers becomes the focus of research interest. As a result, the product "mathematics" can also vary depending on the social context in which it is negotiated among the participants. Mathematics no longer appears as unchanged transferable or reproducible objective knowledge (Voigt, 1998).

Emergence of mathematical meaning in peer interactions

Various studies in the field of early mathematical learning (Henschen et al. 2022; Vogler, 2019) show that such negotiations of mathematical meanings are not only emergent at school age and in the context of teaching, but they are also realised among children of kindergarten age. In addition to interactions between adults and children, interactions among peers play a special role, as peers are characterised by their special proximity and equality. During negotiation processes, they use similar sign systems for understanding (Ellis & Rogoff, 1982) and can use similar "domains of subjective experience" (Bauersfeld, 1983 as cited in Vogler, 2023). Furthermore, interactions between peers in play situations take up a large part of the time in kindergarten. In the play, children negotiate a variety of topics that are relevant to them. They develop a certain peer or play culture in which they imitate social rules from other contexts they know as well as develop them further, adapt them or even parody them (Klaas et al., 2011). They frequently make mathematical discoveries and negotiate mathematics-related meanings in that process. The assumption of the article is that in the context of these mathematical explorations, children negotiate certain expectations about what is considered mathematically relevant and socially desired.

Social and sociomathematical norms in free play among peers

Depending on the context in which the expectations are re-constructed, they may differ. For example, what seems relevant and desired in mathematical conversations between children in free play may lose relevance in interactions between children and adults. If expectations are taken as shared and persistent in the long term, they can be considered norms. As Yackel and colleagues (2000) describe,

it is not the presence or absence of norms that distinguish microcultures from one another. Rather, it is the nature of the emergent norms that differ from discourse to discourse of the various microcultures. Following previous findings concerning classroom microcultures and norms (Yackel et al., 2000), a distinction can be made between two types of norms: social and sociomathematical norms. Social norms are rules whose implementation does not initially require reference to mathematical content. They could therefore apply to any discourse. In the context of negotiation processes in kindergarten, such social norms can be constructed, for example, in play situations or play cultures such as those analysed here. A discourse corresponding to established sociomathematical norms presupposes that the interactants are aware of the (desired) use of the specific mathematical rules. Vogler (2023, submitted) explained that such sociomathematical norms already emerge in kindergarten in interactions between professionals and children. Such norms emerge primarily as rules in the field of the coordination of counting or in the context of concept formation processes of mathematical objects. The re-constructed norms could be identified as quite significant for further learning in mathematics. In the context of these findings from research in mathematics education and approaches from peer and play culture research, the question arises: Which expectations and efforts to establish norms emerge in peer interactions or in a specific "play culture" of peers in block play situations in kindergarten, and how do these norms emerge?

Data and methodology

To answer this question, ethnographic video data collected in the context of Henschen's dissertation project (2020) has been utilised. The analysed interactions originate from an approximately 80-minute spontaneous play situation (completely videotaped) of four children (4;8, 4;10, 5;3, and 6;0 years old) with freely available wooden building blocks. The type of building blocks corresponds to the materials of the so-called "construction wagon" developed by Uhl in the 1940s (Uhl & Stoevesandt, 1991). Because Uhl's material set has diverse potentials for establishing norms in the process of construction buildings, which are already described by the author in her explanations of building with cuboids following Froebel, these descriptions of the author and additional remarks on the use of the set formulated by Stoevesandt (1979) are briefly outlined in the following.

Data: free play situations with the set of building blocks

In the analysed play situation, the children use simple cuboid wooden blocks. According to Uhl, this is a further development of Froebel's building gifts 3 and 4 (Uhl & Stoevesandt, 1991). The majority of the cuboid building blocks have the proportions 1:2:4 (basic element), additionally, there is a kit with rods of the length of 2, 3, 4, 5 and 6 basic elements as well as building blocks with the proportion 1:2:2. It is noteworthy that certain building and development tasks are connected with the use of this construction set. For example, "finding the staggered joint" (Uhl & Stoevesandt, 1991, p. 28, translation by the authors) is pointed out as a building task. Furthermore, according to Stoevesandt (1979), the building in a round construction is typical for block play in kindergarten. "Statically, this is easily explained: each stone is held fairly evenly from below and from above, and initially at both ends" (Stoevesandt 1979, p.45, translation by the authors).

Methodology

The comparative analysis of the data is carried out with the help of interaction analysis (Krummheuer, 2018). This allows the reconstruction of the negotiation of mathematical meaning. The presented scenes were selected with a focus on the re-construction of norms: Efforts to establish social as well as sociomathematical norms are often only explicated in moments in which these norms are violated by members of a microculture (Sfard, 2008). Especially in kindergarten contexts, indicating a violation of the norm in interactions can not only be done by explaining the violation, but also by ignoring it or by correcting it, for example, by asking questions (Vogler, 2023, submitted).

Analyses of empirical examples

In the following, two scenes will be presented below to illustrate to which expectations the children refer in their play and how efforts to establish norms become meaningful for the children's play.

Analysis of scene I – the bottom row of the tower

The first scene, which is analysed here, represents the starting point of the children's block play.



Figure 1



Figure 2



Figure 3



Figure 4



Figure 5



Figure 6



Figure 7

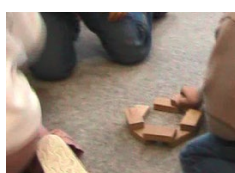


Figure 8



Figure 9

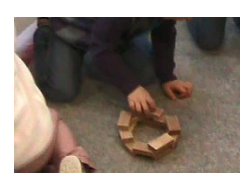


Figure 10

- 1.01 Anna: *aligns 4 building blocks so that they form a square (Figure 1)*
1.02 *n'round*
1.03 Ron: *(not in the camera view) but for the tower*
1.04 Max: *looks at Anna, moves building blocks apart slightly, holds a fifth building block in his right hand (Figure 2)*
1.05 *no not that small\ (...)*
1.07 Anna: *put the blocks back that Max has moved apart (Figure 3)*
1.08 *not so wide*
1.09 Max: *moves two blocks apart a little and puts a fifth block between (Figure 4)*
1.10 *like that*
1.11 Anna: *not so wide*
1.12 Max: *yes, like that*
1.13 Ron: *so it looks like a square anyway*
1.14 *kneels down, arranges the 5 blocks more symmetrically (Figure 5)*
1.15 Max: *also arranges the blocks more symmetrically on his side now (Figure 6)*
1.16 *like that*
1.17 Anna: *looks at the activities of Max and Ron (Figure 7)*
1.18 *< must be small otherwise we can't use the ladder*
1.19 *< Turns away, towards the building block box, turns back again with block in hand (...)* Children continue to build the tower (Figure 8-10)

In line <1.01>, Anna places four building blocks in a way so that a rhombus is formed in the area between the building blocks. The statement "n'round" can refer to the arrangement of the building blocks. Anna could indicate with this statement that she has placed the building blocks in a "round." In this case, her use of the word "round" could be interpreted as an attribute for a closed circle and thus primarily in a topological sense. It could also refer to a process "to put in a round." In line <1.03> Ron addresses a tower. Scene I can be interpreted as a negotiation of the shape of the tower. It becomes obvious in this first scene that the children have a specific idea of what a tower should look like. Their negotiation seems to be influenced by a shared social norm or special convention for the construction of buildings in play (hereafter referred to as "building norm") that a tower is "round" <1.02> or at least should not look asymmetrical or like a square <1.13>. Furthermore, a further building norm could be identified here: A high tower that is built from wooden blocks in the kindergarten must be built in a round construction (Fig. 7-10). These building norms seem to result in different ideas regarding the appropriate shape for the tower. From the children's negotiations over the course of the scene, an effort to establish a common sociomathematical norm - regarding the circumference of the tower (<1.05>, <1.08>, <1.11>, <1.18>) and the shape or arrangement of the building blocks in the bottom row of the tower (<1.02>, <1.09-1.10>, <1.13>) - can be reconstructed. For example, in line <1.13> Ron determines that a square shape is not useful for the building project. He then arranges the five building blocks so they are symmetrical and almost form an equilateral pentagon between the building blocks. In line <1.15> Max picks up the idea of the symmetrical shape of the bottom row by also adjusting it. It seems that for both boys, the sociomathematical as well as building norm for their actions is that a tower must have a symmetrical shape. The circumference also seems to be important, since Max, for example in row <1.05>, vehemently opposes a downsizing. Concerning the pattern that is necessary for building the tower in a round construction, different norms seem to have already been established. The children place one block after the other as a routine without any verbal communication (<1.19> and Figure 7-10). However, it is interesting in this context that in the progress of building the tower (in tower rows 8 and 9), Anna nevertheless demonstrates to Emma how the building blocks are (supposed to be) placed round by round or row by row. Other expectations concerning the building process that emerge in the scene are related to the categorisation of the building as a tower. In relation to the rule that a tower must have a certain height, there seems to be a rule (in the kindergarten group) that ladders may only be used when it is indispensable (something is high enough) <1.06>. In her statement in line <1.18> Anna seems to refer to this expectation. In Anna's statement "not so wide" and as well as in the statement "must be small otherwise we cannot use the ladder," from a mathematical perspective, the idea can be recognised that the circumference of the tower, the number of available blocks and the height of the tower depend on each other. It can be interpreted that a sociomathematical norm is being referenced here, which from the researchers' perspective is based on the mathematical idea of functional relationship.

Analysis of scene II – length of the roof rods

In the second scene sociomathematical norms can also be reconstructed that have a close connection to fundamental ideas of mathematics. The second scene begins after Anna and Emma have completed the tenth row of the tower. In the meantime, Max and Ron have collected rods of various lengths from the building block boxes and placed them next to the tower construction (Figure 11); as they had

previously said, these are to be used for a roof. After the rods have been collected, Ron holds one of the rods (rod 1, Figure 11) over the unfinished tower, this interrupts Anna and Emma's building activity. Ron is possibly checking whether the rod is suitable for building the roof of the tower. This interpretation is supported by the following negotiations among the children:



Figure 11



Figure 12



Figure 13



Figure 14

- 3.07 Ron *picks up another rod (rod 6, figure 12) from the floor*
 3.08 *as a roof I would rather have these small narrow ones*
 3.09 *takes another rod (not visible), holds it together with the rod taken earlier*
 3.10 *these small narrow ones-*
 3.11 Emma *places a building block (basic element) in the 12th row*
 3.12 Max *holds a rod (5, Figure 12) over the tower (Figure 13) (...)*
 3.19 Max *(loud) we are just trying to see how long they need to be*

Ron picks up another rod from the floor (line <3.07>). He comments on his action with the words: "as a roof, I would rather have these small narrow ones" (<3.08>). It is interesting that Ron formulates a highly elaborate sentence here, which could also be copied from a conversation between adults in which they discuss the conditions for a building. Ron may have a specific design in mind. He seems to be focusing not only on functional aspects of the tower construction, such as the rods covering the top of the tower opening, but also on a certain building aesthetic. A certain normative idea of roofs can be identified in this building aesthetic. Ron may be following the idea that the roof should not overlap too much. Ron and Max test which of the rods have the right length by holding them over the tower or placing them on it (<3.12> and <3.26> and Figure 14). This appears to disturb Anna's tower building, and she seems to assume that Max and Ron want to build the roof at this moment. She considers the time inappropriate, which she makes clear by repeatedly pushing the blocks away and making defensive remarks (not part of the transcript shown) (Figure 14). Max then explains that it is not yet a matter of building the roof, but of trying it out: "we are just trying to see how long they need to be" (<3.19>). Based on the already shared building norm that buildings in general, and thus also towers, need a roof, the idea of building a tower roof is pursued here in the block play. The idea that a roof bridges a structure from one side to the other at the top probably plays a role here. In Max's statement in line <3.19> as well as in the further negotiation process, the idea of measuring or estimating the appropriate length of the required rods for the roof emerges. The expectation that a roof tile has to bridge a building consequently leads to efforts concerning the establishment of the sociomathematical norm that the fit of the length (of building components) can be found out by direct comparison. At the same time, the sentence "we're just trying" (<3.19>) contains an idea typical of role-play among children, that of trying things out or pretending.

Concluding Remarks

This article aimed to identify which efforts to establish norms in peer interactions or the "play culture" of the peers in the kindergarten can be reconstructed, which also appear relevant from a mathematics

didactic perspective, and how expectations and subsequent norms emerge. The negotiation process of the children in the two analysed scenes initially seems to be characterised by three so-called building norms: round construction of towers, a tower is a high building and buildings need a roof at the top. These building norms seem to be special social norms that emerge in block play situations: They refer to the construction of the tower and are already established or are being established in the microculture of block play. Furthermore, the children already use the convention that tower walls have to be built following a certain pattern. According to Uhl, they seem to have already mastered the building task of "finding the staggered joint" (Uhl & Stoevesandt, 1991, p. 28). In this context, the analyses show how the block play of the peers and the included building norms base the efforts to establish sociomathematical norms. The importance of block play for the establishing processes of highly relevant sociomathematical norms becomes obvious. This is especially reconstructable in the first scene, in which Anna references a functional relationship between the circumference and the height of the tower under the condition of a limited number of building blocks. From the perspective of mathematics education, this idea of functional relationship can be understood as part of the fundamental mathematical idea of *functions* and offers many links to concepts of school mathematics. In the second scene, it also becomes apparent how fundamental ideas are initiated through the establishment of norms in the block play: Here, it is the direct comparison of lengths as part of the fundamental idea of *measurement*. The play culture of peers thus makes a significant contribution to the development of sociomathematical norms, which provide the basis for further mathematical learning through participation in mathematical discourse. According to Mottier Lopez and Allal (2007), further analyses of established and establishing norms in interactions with professionals or parents need to clarify to what extent the norms established in the play culture are also found in other contexts.

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