STUDYING PRESCHOOL CHILDREN’S REASONING THROUGH EPISTEMOLOGICAL MOVE ANALYSIS

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In this paper, we propose a theoretical tool for analysing mathematical reasoning using Epistemological Move Analysis (EMA) in combination with a framework focusing on arguments and the foundation of these. We also suggest the addition of evaluative arguments when talking about different types of arguments besides predictive and verifying arguments. The tool was applied on data of preschool children’s mathematical reasoning. The results indicate that different types of epistemological moves are connected to the different types of or the lack of arguments, and will fill (or not fill) gaps that occurs in the reasoning.

INTRODUCTION

Research focusing on young children’s mathematical thinking indicates that young children are more capable than previously has been reported when it comes to develop and demonstrate mathematical thinking including processes such as mathematical reasoning (Mulligan & Vergnaud, 2006; Säfström, 2013). Recent studies show that children can not only use different competencies in their reasoning (Sumpter & Hedefalk, 2015) but also that other skills do not have to be developed in beforehand (Säfström, 2013). However, looking at the development of mathematical thinking, there is evidence that children do not develop these competencies without someone providing the learning opportunity (Bobis et al, 2005). Mathematical reasoning is such a competence (Bergqvist & Lithner, 2012). Also, it has been indicated that if children have access to a guide, they are more likely go further in their mathematical thinking (Björklund, 2008) especially if that person is asking key questions (van Oers, 1996).

With regard to mathematical reasoning, one of the goals that Swedish preschools should aim for is that children “develop their mathematical skill in putting forward and following reasoning” (School Agency, 2011, p. 10). In order to so, following the idea of learning opportunity, teachers need to be able to pick up children’s mathematical ideas (Bergqvist & Lithner, 2012; van Oers, 1996; Shimizu, 1999). This should happen independent of the activity is planned or informal since the key thing of Swedish preschool education (children age 1-5) is the emphasis of play and should not be formal schooling (School Agency, 2011). Previous research looking at education of mathematical reasoning, although on secondary level, reports that in Swedish teachers’ presentations, most task solutions are based on algorithms with only rare opportunities to see aspects of creative mathematical reasoning (Bergqvist
At present moment, we don’t know how such results are translated to preschool level especially with informal settings as an important learning opportunity. Our future aim is to study the opportunities to develop different types of mathematical reasoning presented to children at preschool level, which would be a similar aim to Bergqvist and Lithner (2012). However, at preschool level such opportunities are most likely to occur in a play based education. Therefore, other theoretical tools are needed compared to Bergqvist and Lithner (2012). This is the aim of this paper: to propose and discuss a theoretical tool that would allow us to perform such an analysis. The tool needs to allow us to look at the conversations, interactions, between teachers and children and in particular the role of the teachers in these conversations, but at the same time focus on the mathematical reasoning and the different types of arguments in the reasoning. Here, we will test this theoretical tool on a subset of a data set to show different types of arguments in mathematical reasoning and teachers’ role in these situations.

THEORETICAL BACKGROUND

We propose the parallel use of two theoretical frameworks. One framework helps us to study mathematical reasoning, in particular the different arguments in mathematical reasoning, that take place in conversations in play based activities. In order to study the conversations and the teacher’s input, we use a method called Epistemological Move Analysis (EMA). The starting point for this study is, just as Bergqvist and Lithner (2012), an ecological perspective meaning that the teachers’ choices or actions are not seen from a right/wrong dichotomy.

Mathematical reasoning

Young children’s mathematical reasoning is getting more attention in research (Sumpter & Hedefalk, 2015), but a general problem in mathematical reasoning research is that mathematical reasoning is used to denote a ‘higher quality’ thinking without defining what this would encompass (Lithner, 2008). To avoid this, we use a framework that has a clear definition of mathematical reasoning and also allow different types of reasoning including those that are not based on deductive logic. Reasoning is defined as the line of thought adopted to generate assertions and conclusions when solving mathematical tasks (Lithner, 2008). This is a product and we see it as a sequence or several sequences that starts with the tasks and ends with an answer, where the answer could be no conclusion at all. When organizing the data, we use the following four step structure: (1) A task situation is met (TS); (2) A strategy choice is made (SC); (3) The strategy is implemented (SI); and, (4) A conclusion is obtained (C). Lithner (2008) has attached two types of arguments to two of these steps. The strategy choice can be supported with predictive arguments and the implementation with verifying arguments. The first type of arguments aims to answer the question ‘Why will the strategy solve the task?’. The second type aims to answer the question ‘Why did the strategy solve the task?’. While these two types of
arguments focus on the strategy, no arguments focus on the conclusion and the evaluation of it: how and in what way is this an answer to the initial question? Inspired by the argumentation research in the field of artificial intelligence, we would like to add evaluative arguments to the different types of arguments. Evaluative arguments serve the purpose to persuade that something is right or wrong (Carenini & Moore, 2006). We suggest that evaluative arguments fill the void that occurs in the conclusion step answering the question ‘How do the conclusion answer the TS?’ We argue that evaluative arguments could function as part of control (Schoenfeld, 1985) or review (Polya, 1945) in problem solving. This is yet to be tested in this paper.

To be able to analyse the arguments, Lithner (2008) introduce the notion of anchoring. It is important to note that anchoring does not refer to the logical value of the argument since it allows us to talk about reasoning that is incorrect. This helps us to look at the foundation and how it is used (Sumpter & Hedefalk, 2015). Anchoring is seen as the fastening of the relevant mathematical properties, or what is the replacement of it, of the components that you are reasoning about. These components are objects, transformations, and concepts (Lithner, 2008). Certain mathematical properties will be surface and other intrinsic depending on the task such as when comparing fractions, the size of the numerator and denominator is a surface property whereas the quotient is the intrinsic property. In Lithner’s (2008) framework, different types of reasoning can be classified. Here, we will only focus on the different types of arguments and their foundation and connect these to the teachers’ input, the role of the teacher.

**Epistemological Move Analysis (EMA)**

EMA is an analytical method that aim to generates knowledge about the role the teacher plays in children’s meaning making. The focus of the analysis is on how the teacher directs the children’s meaning making in different ways (Lidar, Lundqvist & Östman, 2006; Lundqvist, Almqvist & Östman, 2012). When the children respond, verbally or non-verbally, to the teacher’s direction, we call it an epistemological move. The epistemological moves from the teacher show the children both what counts as knowledge and appropriate ways of obtaining knowledge. The following moves have been identified in science and technology education in primary school and secondary school (Lidar et al., 2006): confirming, reconstructing, instructional, generative, and reorienting moves. In the confirming move, the teacher confirms that the children are recognizing the correct phenomenon, or confirms that the children are undertaking a valid process, by agreeing with what the children say or do. The reconstructing move makes the children pay attention to the “facts” they have already noticed but have not yet perceived as valid. The instructional move gives the child a direct and concrete instruction for how to act, to discover what is worth noticing. In the generative move, the teacher enables the children to generate explanations by
summarizing the important facts in the context of the activity. Finally, the reorienting move indicates that other properties may be worth investigating and encourages the children to take another, alternative direction.

How the teaching affects the meaning making process is studied by analysis of practical epistemologies. Practical epistemology is used as a tool for describing the route that meaning making takes, and the meaning making processes involved. Four concepts are used in a practical epistemology analysis, namely: encounter, stand fast, gap and relations (Wickman & Östman 2002). An encounter is a specific situation in terms of what the participators interact with and here we will focus on encounters between children and teachers. What stands fast for the participator is identified in their actual use of words within the practice. When the participator uses a word without hesitation or questioning, such words are said to stand fast in the particular situation. Standing fast is a situational description of the meaning that words have in action (Wittgenstein, 1969/1992). When the participator hesitates, when what is happening cannot be taken for granted, there is a gap. When a gap is noticed it can, according to Wickman and Östman (2002), be filled through establishing relations to what stands fast in the encounter. Then it is possible for the participators to proceed in their meaning making again.

APPLYING THE TWO FRAMEWORKS

The data comes from a larger set that was used to study children’s collective mathematical reasoning. For more information of how data was collected, see Hedefalk and Sumpter (2015). Here, we have chosen a part of a longer episode, divided into three parts, to apply the proposed theoretical model. As a first step, the encounter and its goal is described. This is related to TS. In this encounter, Kasper and Karolina is playing in the woods. They have found a rock that they are trying to climb. Teacher Kristina, marked with [T], sees this and interacts with the children. The main TS for this encounter is: what is rock’s height in relation to other objects/people? In the next step, we identify what epistemological moves the teacher uses with the children in the encounter and if the actions (the practical epistemology) is changed. We also analyze the arguments using the four step structure to identify the different types of arguments and the foundation of these. The last step is to connect the results from the two analysis.
In the first part of this episode, the teacher initiated the TS by first a confirming move and then, the actual initiation, with an instructional move. When Kasper suggests a SC with no predictive arguments, it is not challenged by the teacher but instead the SC is confirmed. This confirming move agrees that the SC is correct and/or relevant however do not encourage further arguments such as predictive arguments.

In this part, there is a solution to a sub-task of the main task. There is one move from the teacher, a confirming move, to Karolina’s conclusion. This confirming move
Hedefalk and Sumpter

could function as an evaluative argument: since a teacher agrees to the conclusion, this is a correct answer to the sub-TS. In line 2452, it could have been a reorienting move but since there is no change in practice, this move doesn’t occur.

<table>
<thead>
<tr>
<th>Line</th>
<th>Person</th>
<th>Data</th>
<th>Argument</th>
<th>EMA</th>
</tr>
</thead>
<tbody>
<tr>
<td>2453</td>
<td>Kasper:</td>
<td>But you are as big. [meaning as tall]</td>
<td>Different C: Disagreeing with previous statement with a comparison: teacher as big as rock. Teacher’s height = rock’s height</td>
<td></td>
</tr>
<tr>
<td>2454</td>
<td>Kristina [T]:</td>
<td>This stone is a bit smaller than me. Isn’t?</td>
<td>C: Teacher’s height &gt; rocks height.</td>
<td></td>
</tr>
<tr>
<td>2455</td>
<td>Kasper:</td>
<td>It is bigger, a little bit bigger.</td>
<td>C: Rock’s height &gt; teacher’s height.</td>
<td></td>
</tr>
<tr>
<td>2456</td>
<td>Kristina [T]:</td>
<td>Yes, yes…no, I am a bit bigger.</td>
<td>C: No argument provided. Teacher’s height &gt; rock’s height.</td>
<td></td>
</tr>
<tr>
<td>[…]</td>
<td></td>
<td>[The children climb the rock and are now sitting on the rock]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2501</td>
<td>Kasper:</td>
<td>Yes, but the house is bigger than the rock.</td>
<td>Final C. New TS and C. Argument not provided. House’s height &gt; rock’s height.</td>
<td></td>
</tr>
<tr>
<td>2502</td>
<td>Kristina [T]:</td>
<td>Where?</td>
<td>House’s height &gt; rock’s height.</td>
<td></td>
</tr>
<tr>
<td>2503</td>
<td>Kasper:</td>
<td>The house is bigger than the rock.</td>
<td>Agreeing to C: provides argument using transitivity: Since House &gt; Teacher, and Teacher &gt; Rock, therefore House &gt; Rock.</td>
<td>Confirming move</td>
</tr>
<tr>
<td>2504</td>
<td>Kristina [T]:</td>
<td>The house? Yes, definitely. Because the house, I can step in [the house], right?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Part 3 of TS.

In this part, there are two incidents where a gap occurs. When the teacher argues that the rock is up to her nose, Kasper disagrees as he says that “you are as big” (line 2453). The gap occurs as the participants in the encounter show hesitation about the size of the rock in comparison with the teacher’s body. The comment from the teacher does not result in a change of epistemology, i.e. a move, as the children does not change their arguments in line with the teacher’s argument. The gap is visible again in line 2454 and line 2455. In these situations, no further arguments are given. When Kasper says that the house is bigger than the rock (line 2501) the teacher confirms that it is a valid statement (line 2502) but she also gives arguments for her conclusion. Since they are related to the TS and not SC and SI, they are evaluative arguments functioning as control. In this chain of interactions, the gap is not filled.
The relations they create to what stands fast is that the rock is smaller than the house which is the final C to the TS.

**DISCUSSION**

The purpose of this paper was to find a theoretical tool to study mathematical reasoning in settings including both formal and informal learning. The choice was to combine EMA and Lithner’s (2008) framework. EMA allowed us to identify different moves and using the four step structure, we could see when these moves occur but also when gaps occurs and if these gaps were filled. It is important to stress that gaps are not seen as needed to be filled using an ecological perspective. In this episode, an instructional move initiated the task situation which could be compared to hatsumon, the asking of a key question (Shimizu, 1999). This main TS were addressed by several sub-tasks initiated by the children. There were also confirming moves connected to evaluative arguments meaning that these arguments came from the teacher instead of the teacher initiated these types of arguments from the children. Such a situation would have been a generative move. EMA helped us to distinguish between these two different situations. Here, there were no arguments based on mathematical properties but instead a repeated statement of conclusions and the gap was not filled. If we were to use the concepts provided by Shimizu (1999), there was no ‘polishing up’ (neriage). Compared to Bergqvist & Lithner (2012), the proposed analysis stresses the role of the teacher but at the same time allowing a focus on reasoning. We see this as contribution to mathematical reasoning research theories besides the addition of evaluative arguments.

**References**


