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How the role of the preschool teacher affects the communication of mathematics

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The purpose of this article is to study and analyse how two teachers implement an outdoor situation for children aged 4–5 in a Swedish preschool. The analysis and interpretation of the data in this paper has been influenced by situation theory and by the use of the didactic contract as a key concept. The term didactic contract is seen as a metaphor; consequently, I use a broader definition of the didactic contract to illustrate how the role of the teacher affects the communication of mathematics with children. Most of the text in this paper is adapted from my thesis (Delacour, 2013) and articles (Delacour, 2014a, b).

Keywords: Kindergarten, teacher, didactic contract, mathematics.

INTRODUCTION

During recent years, preschool mathematics has been on the national agenda. In 2011, a revised preschool curriculum was introduced in Sweden (National Agency for Education, 2011), in which the goals for children's mathematical development were made clearer both in scope and in content. How children are to create, explore, and use mathematics is not specified in the curriculum, however, as it is a goal-oriented document and is not concerned with teaching methods that can lead to different ways of communicating mathematics (Delacour, 2013).

In this study, two preschool teachers implement a situation in which the children investigate properties and what belongs together. I describe the situation, and compare the roles of the preschool teachers to analyse how they affect the communication of mathematics with the children. The following research question has been formulated: how do preschool teachers' implicit expectations affect children's motivation to participate in mathematical activities?

THEORETICAL FRAMEWORK

First, I take up the didactic perspective of the study, highlighting the theory of didactic situations. The key concept here is the didactic contract.

Theory of didactic situations

According to Brousseau (2000), it is common to see teaching as a transfer of a special knowledge to children, and to see the didactic relation as a communication of information. Teachers try to plan their lessons so that the children get as much out of them as possible. Brousseau states that in order to succeed, it is necessary to consider the factors that may contribute to the teaching of mathematics. Brousseau (1998) developed the *theory of didactical situations* (TDS) to highlight the didactic relation between the teacher, the children, and the mathematical content. This relation is termed the *didactic triangle*. The theory of didactical situations offers a model of knowledge, teaching situations, and the roles of the teachers and children in the classroom. Knowledge cannot be transmitted merely through explanation but, according to Brousseau, the teacher orchestrates learning and teaching in order to increase the child's knowledge. Knowledge needs to be learned through different contexts, and teachers can organize specific situations that lead to children's learning of a particular piece of knowledge (Perrin-Glorian, 2008). Teachers often try to find activities to introduce a new item of mathematical knowledge to children. When a teacher focuses on the "why" aspect of teaching, he/she will see a problem or a situation, not as a simple reformulation of knowledge, but as an environment that offers answers to the children, according to certain rules. What information do children need from the "milieu" to make choices, and to use one specific piece of knowledge rather than another? (Brousseau, 2000).

The didactic contract

Brousseau (1988) introduced the concept of the didactic contract as part of his work in the theory of didactical situations, and defined it as the teacher's behaviour (as expected by the child) and the child's behaviour (as expected by the teacher). Brousseau studied how the didactic contract affects mathematical learning. Teachers usually develop different practices to give children the exact assistance they need, while children try to meet their teachers' requirements by interpreting the teachers' signals. However, teachers should not provide detailed instructions on how to solve mathematical problems, because this practice results in children not learning what the teacher expect them to learn (Delacour, 2014b). Brousseau's famous example shows how teachers can arrange a situation to help children gain a greater understanding of numbers. The teacher takes up five tanks (more or less depending on the child's number perception) and ask the children to pick up as many brushes as there are containers. The child should collect all the brushes at one time. The teacher does not tell children what to do but it is the children who must find a strategy to solve the problem. Some children will use their fingers, others draw on paper, others use blocks. How the teacher is planning the "milieu" is important. How far brushes are from the containers, for instance, will affect how the children act. Eventually, the children will understand that counting is a useful strategy.

During a situation, the preschool teacher repeats, clarifies, or asks questions that allow the didactic contract to progress in a direction that the teacher has in mind. Sometimes it is the children engaged in the contract who influence the change, when they make a discovery or get an understanding of something and share it with the group (Garcion-Vautour, 2002). My interpretation of the preschoolers' expectations is that these are connected to the procedures related to the situation (Delacour, 2014a). The didactic contract is often invisible until one breaks it. A child may break the contract when he or she accepts learning or playing the game, as Chevallard (1998) called it, but does not fulfill the teacher's expectations. Learning is only obtained under the breach of the didactic contract according to Brousseau (1998). When children sit around a table and play memory game for the first time for instance, they turn upside down on the pictures without really understanding what will happen. They turn on the pictures they can access from their seats. Children believe that the teacher expects them

to remain in their seats as they usually do when they eat, for instance. When a child breaks the didactic contract, getting up from his chair to reach the pictures that are further away and manage to get a couple, an individual learning occurs which then becomes collective.

DATA PRODUCTION AND ANALYSIS METHOD

This article is based on data collected for my thesis (Delacour, 2013) between the spring of 2011 and the autumn of 2012. The preschool teachers in this study were videotaped while they implemented a mathematical situation outdoors. They have been previously interviewed about their interpretation of the curriculum which have influenced my analyses of the video.

The teachers in this study work in two different preschools in a group consisting of four-year-old and five-year-old children. The preschool teachers were videotaped while they implemented a mathematical situation outdoors. In this article, two of these mathematical situations (filmed material) were analysed in terms of a didactic contract. The selection of the first video is based on the richness of the material, and the selection of the second is due to its variation from the first.

The preschools included in this study are located in two small communities of the same municipality. The schools show no major differences in staff composition, group size, or children's socio-cultural and economic background.

To analyse and interpret the data, I made a reflexive interpretation of the preschool teachers' implementation of a situation, and used an abductive analytical method, which meant that the reflection moved between data and theoretical analysis (Alvesson & Sköldbberg, 2010). In the preschool teachers' implementation of the situation, my focus was on highlighting the relation between the teachers, the children, and the mathematical content. The analysis shows that the teachers had similar expectations about how the children should communicate, but obtained different reactions from the children.

ANALYSIS

In this part, I describe how two preschool teachers introduce a mathematical situation for the children, and

highlight how the communication between teacher, children, and learning object progressed. I describe in which situation the groups was engaged in before the situation I analyses in this paper because I believe it affect the outcome. As the objectives in the Swedish curriculum are formulated as goals that the preschool should strive towards and there are no specific goals for the children to achieve I will focus mostly on the participation of the children rather than on the knowledge they acquired.

The mathematics situation

The preschool teacher Lotta collects four children in the schoolyard. She tells the children that she has found a lot of garbage in the forest, and asks them what they think about this. The children propose to remove the garbage from the forest, and then want to sort the garbage items in different piles according to their characteristics. Now the children are sitting around a white cloth that Lotta has laid on the ground. Lotta's situation is based on a play in which children present four items individually. The video shows how Lotta makes a window out of sticks, and puts four items in it. She uses the garbage that the children have already sorted. She asks the children to point out one item that is not associated with the other three. Lotta introduces a new concept: *having something in common*. She lets the children tell each other which one of the four items they think does not have something in common with the other items. The children argue with each other about the items they have chosen, and about how they are thinking. Lotta follows the discussion and asks an occasional question. Once the children understand the rules of the game, they take turns to choose four items.

The preschool teacher Malin asks eight children to sit on two logs in the forest facing each other. Malin has laid a white cloth on the ground. The children had previously been working with patterns. During the work with patterns, Malin had sent the children to collect a leaf and a pinecone each. Then she asked each child to tell what he or she had collected, and to lay one leaf, one pinecone, one leaf, one pinecone, and so on, on the white cloth. For the next situation that I will analyse for this paper, Malin has collected materials from nature in a box. She picks up one item at a time, and asks the children to tell what it is, what color it is, which tree it comes from, etc. Then she asks the children to come, one at a time, and choose two things and tell why they think the two things belong together.

The rules of the didactic contract

There is a strong tradition of morning meetings in Swedish preschool, when the children and teacher sit in a circle and do different activities (Rubinstein Reich, 1993). The children have been instructed in the preschool's rules, and know what is expected of them in a meeting. When Lotta and Malin laid a white cloth on the ground, the children expected that what was about to happen would be different from the meetings that take place in the morning and indoors. The children knew that free play was over, and that a teaching situation was beginning. The white cloth also provided an indication to the children about what was expected, and where they were expected to turn their attention. These rules were implied, as the children have been through similar situations in the past and can now recognize the teacher's actions, body language, and voice.

When Lotta introduces the situation, she does not need to tell them that they are allowed to talk, move, and exchange thoughts and ideas. There is an implicit understanding here of what mathematics is, as the teacher has previously communicated in this way to the children in this group. Mathematics in this preschool is something you do in groups, in which people help each other to solve various problems in a playful way related to the theme currently being worked on. This group has been working with environmental issues throughout the semester. When the preschool teacher asks questions, makes small comments, and calls for the children's attention on what is being said, the children are seen, and their actions are approved. They are encouraged to take the initiative and to listen to each other. The didactic contract is characterized partly by explicit rules but primarily by implicit rules. How the situation will proceed and what the children should do is not pronounced verbally. Lotta does not tell the children to come up with proposals of their own, or which garbage pieces they have to choose. In Lotta's group, once the children are involved in the situation, they introduce mathematical concepts, while noting properties of the items such as flat and thick, and different sizes, shapes, and materials. There may be concepts that some but not all of the children know. The children can then learn from each other. Lotta encourages the children to be active and investigative. She would rather offer realistic problem situations in which many solutions are possible according to Lotta. She encourages them to find their own way, to explore rather than to find an answer. The children's

responses and behaviour are valued and praised with words like “good” and “talented.” Both individual children and the entire group receive praise and encouragement.

David (5 years) puts three metal cans and a plastic bag in the window that Lotta (teacher) has made from sticks.

Olle (5 years): “This one, this one, this one.”
(pointing to the plastic bag)

Klara (5 years): “These two should be removed,”
(showing a can and a plastic bag) “for they are like that.” (showing two jars, turned upside down)

Olle: “This one, this one, this one, this one.”
(plastic bag)

Lotta: “How were you thinking, Olle?”

Olle: “For it is metal, this one is not!”

Klara: “I think like this,” (putting her hands on the plastic bag and showing a jar) “this one will be removed because they are the same thing,” (the other jars) “for they are so.” (showing that the two jars are upside down)

Olle takes a jar that was removed by Klara and turns it.

Olle: “But if you turn it right side up, what is it then? It will be the same, right?”

Klara: “But look, they are golden, so it should not be. It is silver.”

Lotta: “Mmm right, and you think this one. What do you think, Eric?”

Eric (5 years): “Plastic and not plastic, and this one will be removed.” (pointing to the plastic bag)

During the situation, the children reflect and draw their own conclusions. The children are given the opportunity to experiment with the items and discuss with each other.

This situation can be interpreted as the preschool teacher creating a situation in which the children can communicate. The children’s diverse knowledge of the materials offered creates a dynamic. When they express their thoughts verbally, the children reflect with the help of their fellow students and the preschool teacher’s questions.

Malin introduces her situation to the children by giving instructions on what they have to do. During the first part of the situation, in which the children work with patterns, they have to follow the teacher’s instructions step by step, and no individual proposals are expected of them. In the part I analyse, Malin starts by asking the children to tell the names of the items she picks up from the box. She also asks different questions about the qualities of the items. Again, no initiative or individual proposals are expected. The answers children give can only be right or wrong. Next, when Malin asks the children to come one by one, pick up two items in the box, and explain their choices, she is expecting them to take initiative and come up with individual proposals.

Malin (teacher) calls the first child, Richard (5 years).

Malin: “You can pick up two things.”

Malin: “You can stand there and tell what you chose.”

Richard: “A berry and a leaf.”

Malin: “A berry and a leaf. Why do you think the berry and the leaf belong together?”

Richard: “Because both are red.”

Malin: “Because both are red. Thank you very much, Richard.”

Six of the eight children use color to motivate their choice. Malin does not value or praise the children’s motivation. She thanks them for their participation.

According to Blomhøj (1995), the teacher usually develops different forms of work in order to give children precisely the assistance required, and the children try to meet the teacher’s expectations by interpreting the teacher’s signals. The teacher cannot give detailed instructions on how the children should solve mathematical problems, because under this circumstance, the children do not learn. Instead, Lotta uses different signals to confirm that the children are acting as expected: She uses linguistic signals, such as telling the children they are doing well, repeating what the children say, asking them if they hear what a child says, and telling them that it is exciting to see how many solutions they can find; or she uses body-language signals, such as putting her hand on a child’s arm, nodding, and looking satisfied. Lotta often uses the pronoun “we,” as in, “We have to think now!” to signal that they will reflect all together. She sits with the children around the white cloth.

On the other hand, Malin gives complete instructions to the children, and tells them exactly what they have to do. She stands a bit back from the children, and calls one child forward at a time. It seems difficult for the children to suddenly start thinking by themselves. My interpretation is that the children are confused about what the teacher is expecting of them, and try to give a right answer, as they were previously required to do. Most of the children use the same motivation: "Because they are the same color." Malin uses signals and asks further questions to invite the children to talk, but the questions she asks require a right answer: Is it the same kind of leaf? What kind of leaf is it? What color is it? These questions may prevent the children from daring to come up with their own proposals. Malin does not involve the other children by asking them if they can see a different similarity than the one proposed by the child standing in front of them. Malin only involves all the children when she asks *right and wrong answer* questions. Her way of meeting the children does not seem to encourage discussion.

In Lotta's group, when the children do something other than what the preschool teacher has shown from the beginning, the situation evolves as the children want it to, and the teacher follows the children's behaviour. Lotta initially asks the children to point out one item that is not associated with the other three. After playing for a while, the children begin to point out two items that belong together. Lotta responds that it is true that the two items belong together, and the play continues with the new rules for the rest of the situation. Here, the children's actions govern the rules. Lotta's response can be interpreted as not wanting to inhibit the children's creativity by telling them to point out only one item, because she has designed the situation to get the children to explore, and not to judge their competency.

The didactic contract becomes visible

According to Brousseau (1998) and Blomhøj (1995), the didactic contract is not visible until it is broken. There is a difference between not following the didactic contract and breaking the didactic contract: The one who breaks the contract is involved and interested but does not act as expected, whereas the one who does not follow the contract loses concentration or is uninterested. When Lotta communicates mathematics with the children, she wants the children to discover that there may be many different solutions to the same

problem. However, she does not communicate this to the children before one of them breaks the contract:

Olle (5 years): "Yeah but what is this? This one should be removed; they are not the ones."

Lotta (teacher): "It is great thought. And you others have also found a solution. Great God, how good, oh, great. What do you say? Should we collect?"

Olle: "What did you think? Did you think it was a bit difficult? You thought it was easy, and it wasn't."

Lotta: (puts her hand on Olle) "There are several different solutions. It was great."

Olle: "Did someone guess the right solution?"

Lotta: "There are many right solutions. You had a great explanation of how you thought, Olle, and David, you too, you also thought very well. And Eric, you were thinking the same way, and Klara too. Really good."

Olle thinks that the other children may have had difficulty guessing what he was thinking.

Olle does not accept the rules. He does not accept that there can be many solutions to the same problem. He thinks that the others should try to guess what he was thinking. He breaks the didactic contract, and when Lotta explains that there are many right solutions, the contract becomes visible.

Lotta makes the didactic contract visible when she repeats that there is more than one solution.

CONCLUSION

Preschool teachers prepare for a situation with an intention in mind. In one of the types of situation above, the children control the content of the situation and introduce various concepts. It is in the children's interests for them to control the shape of the situation when mathematics is being communicated. According to Lange, Meaney, Riesbeck, and Wernberg (2014), the teacher should be able to listen very carefully in order to build her suggestions on the children's interest. The preschool teacher reinforces what the children say by repeating and by asking questions that challenge them to explain, listen to each other, and move on. The teacher's scaffolding by using different feedback strategies,

such as putting her hand on a child's arm, nodding, and looking satisfied; or by asking open-ended questions rather than giving instructions, will support children's learning (Bäckman, 2014). The preschool teacher's ability to follow the children's interest is critical in the establishment of a didactic contract by which both students and teacher are able to accept the rules of the game. The two videos examined here (and my previous interview) show a difference between the attitudes of the teachers and the responses they get from the children. Many factors can affect children's motivation to participate in a mathematical situation and it is difficult to know based on two observations how the "milieu" affects the children's motivation. In Malin's group, although the children did what they had to do, they were not motivated. My interpretation is that the kind of questions Malin ask confused the children about her expectation but I am aware that other factors can affect the outcome of the situation. The fact that eight children have to wait for their turn for instance, be quiet, sit still, and listen to each other can affect the communication in Malin's group. *Instruction*, which refers to experiences aligned primarily with the teacher's goals, and *construction*, which refers to processes young children actively engage in to acquire concepts and skills, should be integrated, according to Jie-Qi Chen (2012). However, this study shows that young children who are initially engaged with instruction may have difficulty then engaging with construction; and that the teacher needs to be clear about her expectations in order to help the children to break the didactic contract formed when instruction is used.

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