This paper presents a study on conversations in kindergarten and how young children have conversations with each other and with kindergarten teachers and other adults. These conversations are about mathematics and the participants use their mathematical knowledge. The aim for this paper is to illuminate what mathematical conversations in kindergarten are and their characteristics. Data was collected from one kindergarten, with audio recording and field notes from observation of children and adults’ conversations outdoors and indoors the kindergarten. Excerpts from the material are used to illustrate how one can interpret a conversation as mathematical. The analysis of the data is an ongoing process, and preliminary results are presented. In order to examine mathematical conversations the paper is based upon theory on inquiry and orchestrating.

BACKGROUND AND PROBLEM

My emphasis is on how kindergarten teachers and student teachers can develop language as a tool to create communities where children use mathematics and talk about mathematics, for the purpose of learning and developing mathematical knowledge. This issue is of significance to me after working with mathematics in teacher training in Norway since it was initially introduced in kindergarten teacher education, as a separate subject in 1995. Over the years I have met many kindergarten teachers and student teachers. They get inspired by my talk about mathematical conversations in kindergarten and ask me: How can I know if I have had a mathematical conversation and what characterises them? In this paper I will explore the possibility to label some properties of mathematical conversations.

The basis for the work with mathematics in kindergarten in Norway is The Norwegian Framework Plan. In 2006 mathematics was introduced as a learning area in the Framework Plan under the title “Number, space and form”. The Norwegian Framework Plan for the content and task of kindergartens (Kunnskapsdepartementet, 2006, 2011) states:

Learning takes place in everyday interaction with other people and with the community, and is closely related to play, care, and formation. Children can learn from everything they experience in all areas of life. Children’s questions must be responded to in a challenging and investigative manner, to form the basis for an active and developmentally pedagogical environment at the kindergarten. The children’s own interests and questions should form the basis for learning processes and themes at kindergartens. The way in which staff responds to children's expressions in terms of body language, verbal language, feelings, and social relationships will affect how they learn (Kunnskapsdepartementet, 2011, p. 29).
This quote emphasises the importance of communication in learning in kindergartens, the way children should learn mathematics, and that children learn when they participate in everyday activity in cooperation with adults. Due to the emphasis on language, communications and participation, this framework is, as I see it, positioned in a sociocultural perspective on learning (Wells, 1999a, 1999b).

In The Norwegian Framework Plan (Kunnskapsdepartementet, 2006, 2011), emphasis is on how staff should respond to children’s questions and expressions. I find this interesting because it tells the kindergarten teachers and the rest of the staff how they should behave as communication partners for the children. The Norwegian Framework Plan states that language and social relationships have impact on children’s learning and development.

The way The Norwegian Framework Plan (Kunnskapsdepartementet, 2006, 2011) expresses how learning mathematics in kindergarten should be taught is in contrast to other countries that emphasise more direct methods for preparing kindergarten children for mathematics in school, for instance USA (cf. Nunes and Bryant, 1996).

This paper presents preliminary results from a larger project where my goal is to help develop a conceptual framework around how to communicate about mathematics in kindergarten – to talk about mathematics. My goal is to gain insight into how kindergarten teachers can use or initiate mathematical conversations as tools in their practice. Such conversations can be related to children’s field of interest in daily activities.

Through focusing on conversations in kindergarten, what mathematics they contain and their structure, this study is concerned with how conversations can promote mathematical learning. In this paper my emphasis is on how we can determine whether a conversation in kindergarten is a mathematical conversation.

PREVIOUS RESEARCH ON CONVERSATION AND MATHEMATICS IN KINDERGARTEN

Mathematics in kindergarten

It is necessary to define what mathematics in kindergarten might be. The subject of mathematics is taught in school; however mathematical knowledge is something children already have experienced at home and in kindergarten before they start school (Nunes & Bryant, 1996). Alan J. Bishop (1988) emphasises six universal mathematical activities such as counting, playing, designing, measuring, locating and explaining, as fundamental to all in dealing with mathematics in different cultures. This way of looking at mathematics widens our understanding of what mathematics is and can be, and is of more use in the kindergarten than definitions such as “mathematics is the science of quantity and space” (Davis, Hersch and Marchisotto, 2012, p. 6).

Nunes and Bryant (1996) describe how mathematical activities and knowledge involve much more than what is currently viewed as mathematics in the school
Children have to be able to present mathematical knowledge in a way that solves problems. Nunes and Bryant further illustrate how children can be successful in mathematical activities outside school whereas they fail in similar activities in the classroom.

Magne (2003) emphasizes that there are three areas that is important for the learning of mathematics with young children: 1) Problem solving and language 2) Geometric understanding such as space, shapes and measurements and 3) Numbers or numeracy. He defines mathematical learning as our ability to detect mathematical patterns and calls it the mind principle.

**Inquiry**

The work of Carlsen (2010) studies how inquiry plays a role in orchestrating a mathematical activity in the kindergarten. This study is near my field of interest, as it points to how kindergarten teachers can work on mathematics with young children within the Framework Plan. Carlsen (2010) discusses inquiry (i.e. Jaworski, 2007b) as a method to work with kindergarten teachers and a researcher to improve the children’s learning in mathematics. The purpose of inquiry is not primarily the development of knowing, but of how the individual becomes disposed to and develops ability to apply the appropriated knowing in future situations. Inquiry is thus both a process used as a tool in concrete settings as well as a way of being – a profound and basic attitude when encountering challenges and problems (Jaworski, 2005, 2007a; Wells, 1999a). Lindfors (1999) points out that inquiry lives in the Zone of Proximal Development (Vygotsky, 1978).

Carlsen, Erfjord and Hundeland’s (2010) studied how a kindergarten teacher interacted with children about mathematics in a mathematical activity such as measuring. They revealed six different categories of questions that kindergarten teachers use in communication with children. The categories for the questions were suggesting actions, open, asking for argument, problem solving invitation, re-phrasing and concluding. They found that this kindergarten teacher used mostly open questions. This finding is different from the findings of Gjems (2013) who in her study found that children mostly were invited to answer closed questions in the conversations during everyday activities in the kindergarten and seldom were invited to work together with the kindergarten teacher to develop understanding.

Wells (1999a, 1999b) studied inquiry and how to develop a community where the participants can engage in activities that enable them to adopt the culture’s way of doing and to be able to act so they can reach their own potential and build a personal identity (Wells, 1999a). Inquiry is the process of which we approach mathematical challenges. It can be seen as a tool in problem-solving but also as a way of being in general (Jaworski, 2005; Wells, 1999a).

Research conducted by Matre (2000) shows that children care about each other and each other's thinking. When adults are not present, the older kids take a more active role in kindergarten, with playful and argumentative dialogs. They argue with each
other or they try out their hypotheses. Matre (id.) also shows that children give examples, explain and establish connections.

**Orchestrating**

Carlsen (2010) uses the concept of orchestrating, “coined by Kennewell (2001)” (p. 54) for describing the process in inquiry. Here it labels the kindergarten teacher’s process of planning and carrying out mathematical actions and activities. Orchestrating includes the preparations made ahead of the session as being part of the orchestration, in other words the planning of activities. But it also includes what the teacher is thinking, saying and doing with respect to the activity and in interaction with the children.

In Carlsen, Erfjord, Hundeland and Monaghan’s (in progress) they have put more emphasis on the orchestration of mathematical activities and the use of distributed agency and the role of teachers. In this work they argue that the kindergarten teachers’ orchestrating make different approaches to children with the use of digital tools. In this way they argue that the tools also are mediators like the teachers and the children. I see conversations as a tool for teaching and learning mathematics in kindergarten, and orchestrating can be a useful concept to work within studying kindergarten conversations with children.

**METHOD**

The data in this study stem from a three week period during which I observed one kindergarten. The data consists of audio recordings of conversations and field notes from observation of children and adults' play and conversations, outside and inside the kindergarten. It was an open observation since the participants knew why I was there: To observe everyday life in the kindergarten. The fact that I had focus on mathematics was known to the kindergarten teacher, but was not communicated to the children.

It was challenging to have the role of the observer in the kindergarten. There is still material that is not transcribed yet. In the audio recordings where children are playing there is a lot of noise and sometimes it is difficult to hear exactly what is going on, and the nonverbal communication is not fully described in the field notes.

The analysis of the data is an ongoing process which is not concluded yet. The goal of the analysis is to develop categories for the conversations. The first stage is creating categories to suit the individual conversations. The categories are sustained by comparison and through constant analytic process – a cyclical process. One goes in and out of the different conversation and attempt to fit the categories to them. Categories are modifies, renamed, deleted and added. The analysis work is finished when the new data fit into existing categories (Charmaz, 2000, in Drageset, 2012). It is in this process I am now. My analysis of the material have been inspired by grounded theory, which is a qualitative method developed by Glaser and Strauss (1967).
CONVERSATIONS AROUND LEGO CONSTRUCTIONS

The kindergarten teacher has planned an activity which some of the children have done before. The children will be divided into groups and build Lego figures. Here the kindergarten teacher has orchestrated a learning situation which the children consider playful. Four children, Ina, Chi, Dan and Jil are around five years, and are going to build a Lego airplane together. Inside the Lego-box there is an instruction booklet. Inside the box, there are also several bags of Lego pieces to keep track of. The kindergarten teacher assigns Ina the task of managing the group work since she has built a similar airplane before. The kindergarten teacher wants to observe and want the children to manage on their own. The adult in this excerpt is an assistant in the kindergarten. The children start opening the bags with Lego pieces.

DAN: Here is the plastic bag. Are we going to throw it in the bin?
INA: Is there anyone who has seen the head?
INA: We should open this afterwards. It's hair. All that belongs to humans is over here.
JIL: Are we good at building Lego? [She looks at the adult, who smiles back.]
DAN: It should be there.
Adult: Do you have the instruction book Ina? Here's the bag with the number 1 and here's one with the number 2. What number is that? [Asks the group] ... one. Then we must open this.
CHI: [Trying to open a bag.]
DAN: I can do it.
CHI: I'll do it.

There is a lot going on simultaneously among the participants. The children are in the beginning of the assignment which is to build an airplane. The children want to start the construction. There is an emerging coordination among the group members. In groups, members take or are given different roles as they attempt to engage in the group through meaningful activities. Ina has already started to sort the Lego pieces, and is trying to find out what pieces belong together. Dan and Chi disagree about who should open the bag. Chi is determined to do it. Ina has been told that she is the manager of this building project. Throughout the ensuing conversation Jil places herself a little to the side of the task. She does not take any verbal initiatives to join building process. She has a question aimed at the adult: “Are we good at building Lego?”, but this is not related to the actual construction process.

The conversation among the children gives them the opportunity to inquire into and use their mathematical knowledge. They use and develop their knowledge and become aware of their own and others knowledge in conversation with each other. It is significant for the learning process that children should be aware of their own knowledge. Reflection is supported by the group interaction and conversation structure.

Adult: It is probably a good idea to start with the bag with the number one.
CHI: What do we do now?
DAN: Now we need two greens.
Adult: Where do you think this piece should be, Ina? [Ina is sorting pieces and does not answer.]
Adult: Now we need to find pieces same as this [takes up a Lego piece and shows it around]. We need five. How many do we have Dan?
DAN: One, we need 1-2-3-4. [Counts the pieces in the instruction manual.]
DAN: Here are two more.
Adult: This ...
DAN: The tire is hard to stick on.
Adult: Wait a minute.
DAN: Now it should be two white on each side and a blue brick.
Adult: Which way should it be? .... It should be like all the others. Dan, press slightly on the piece in front, there. There you go.
DAN: There must be some kind of piece on top here.
Adult: Do you see that the green one should be up against the grey?
DAN: The grey should be in the middle. First this one and then the other one on the other side, there. Here we go.
Adult: Great.
DAN: I have put it on.

In this segment the adult is more involved and Dan is the active child. When Chi asks: “What do we do now?” Dan answer: “Now we need two greens”. Through his answers in this segment, Dan shows that he can count. Participating in group work creates opportunities for reflection and learning. Not all participants are equally involved in the building process. Jil, for example, does not participate actively in this segment. However, being present in the conversation in itself creates opportunities for further learning.

Since the kindergarten teacher is not there it is the assistant who orchestrates the conversation. The use of questions in the conversation varies from problem solving invitations like “Which way should it be?” to suggesting actions “What is the picture of there?” and concluding questions: “Do you see that the green one should be up against the grey?” (cf. Carlsen, Erfjord and Hundeland, 2010, see also previous section on Inquiry). In this way, one can see that the adult structures the conversation. Through the use of questions he nurtures the activity.

Adult: How will you build it? [Points to the instruction booklet.]
DAN: We need tires?
CHI: We can look in the booklet. [Turns page] That was many red squares.
JIL: [picks up a lot of things]
Adult: What are you thinking about Chi?
CHI: We need to have white and blue.
Adult: What is this picture of? [Points to the instruction booklet.]

CHI: The steering wheel.

Adult: Where should it be?

CHI: Right behind.

JIL: [Moving Lego pieces]

INA: Jil stop just taking ... [uses a high voice]

INA: Do you need a grey brick? You need a chair in between the steering wheel.

DAN: I have a white.

INA: We need many white pieces.

CHI: We have reached 10. [She shouts it out to another group. “10” refers to a stage in the booklet.]

[...] We have reached 9 ... [Says someone from another group].

DAN: We need more of these pieces.

In this excerpt the construction project has progressed further and the children are involved in different ways. The adult uses the question “How will you build it?” as a tool to further the conversation. It is an open question to all of the children, but by pointing to the instruction booklet there is a clear suggestion of action. The instruction booklet gives the children an opportunity to compare the plane they are building with the pictures in the booklet. It seems like the adult actively invites all the children into the conversation by using you (plural form of “you” in Norwegian), and thus addressing the question to everybody and not just to Dan.

The questions posed are an essential part of the conversation structure. Through questions and answers the participants are take initiative and are invited into the questions. Initiative is connected both to posing a question and to responding to one. The use of questions, and the wondering attitude they promote, is important in the development of communities of inquiry, and in creating communities that cultivate mathematical conversations.

The complexity in the material is illuminated by looking at the many areas of mathematics that appears. For instance, the children categorize the Lego pieces into different categories like tires, steering wheels and other pieces. Then they sort them into groups after different colours and length. In this process the children use counting and measurement. Counting is also used to keep track of where they are in the building process (“we have reached 10”). Other mathematical topics such as ordering (“first this one, then…”), spatial relationships (“right behind”) and shape (“wheel”) are also present in the conversation.

It is essential for children to have adults who give directions and advice to them. In my material I have seen that the children also use each other in this learning process. This can be illuminated by how Dan is using his knowledge so the other children can observe and be a part of a building process they could not do on their own. At the same time Dan is challenged by the adult. In this way the various interactions in the conversation increases the children’s benefit of the building process.
MATHEMATICAL CONVERSATIONS ARE CONVERSATIONS IN THE KINDERGARTEN

To sum up my preliminary findings I have come up with five initial categories for mathematical conversations in kindergarten. They are still general and overlapping in some areas since I am in the grounded theory process. My present categories are 1) being mathematical, 2) reflecting, 3) structuring, 4) interaction between participants and 5) aimed at further learning.

1. **Being mathematical.** By this I mean that the conversation is based around mathematics as described in the section *Mathematics in kindergarten*. This I believe is a central characteristic of what should be called a mathematical conversation. Every conversation I have observed that I wish to designate as a mathematical conversation, contains elements of mathematical areas such as problem solving, geometric understanding and/or numeracy (cf. Magne, 2003). Many of the conversations show that several mathematical areas are at work simultaneously such as in the Lego construction conversations. Lego is concerned with spatial geometry, but we see for example that numeracy is involved when Dan counts: “One, we need 1-2-3-4”. Even though being mathematical is at the core of mathematical conversations, I do not find this characteristic sufficient. The following characteristics express the other properties I find necessary in mathematical conversations.

2. **Reflecting.** In mathematical conversations the participants reflect mathematically in their dialog. This may present itself in the use of questions children and adults express. However it is not only about using questions effectively, for example inquiry is an activity that fosters reflection from the participants. Lindfors (1999) examines two forms of inquiry acts: information-seeking and wondering. In the way I use reflecting it contains wondering. Conversations must engage the participants in mathematical reflection to be called mathematical conversations. For example in the conversation around Lego building, when the adult asks “How will you build it?” the adult tries to elicit reflection among the children.

3. **Structuring.** The structuring of the conversation in and around the activity influences the conversation itself. Every conversation follows a certain kind of pattern. Structure is an aspect of the conversation that keeps it on track. A conversation without clear structure will easily drift off track. A mathematical conversation should be structured such that the mathematics is not incidental, but such that the structure invites the participants to inquire further into the mathematics. This conversation is structured around the building of the airplane. In general, a conversation is always structured around the topic under discussion and the activity one engages in. The opportunities inherent in the topic to nourish a structure with potential for mathematical ways of thinking is essential for a conversation to be mathematical. The structure of the topic forms the way the children can act and participate in the conversation. The conversation among the participators is built up logically around the Lego construction: First there is an organising phase and then
there is a building phase. In each of these phases certain utterances become more relevant than others.

4. Interacting. In different conversations the participants interact with each other in various ways. We can detect interaction in their utterances, in their actions and their listening. I want to emphasise that learning is a social practice and for the conversation to be mathematical there has to be interaction between the participants in such a way that they are actively involved in it. Knowledge is constructed and reconstructed in conversations between people who do things together and talk together (Gjems, 2009, p.107). For example, dialogs contain this type of interaction in contrast to monologs (cf. Alrø & Skovsmose, 2002). In the Lego conversation, some aspects of the interaction become transparent through the utterances. For example, there is a clear interaction between Dan and the adult. The last excerpt contains a short sequence between Ina and Dan (“Do you need a grey brick? ...”) which shows how they through interaction negotiate which pieces they need.

5. Further learning. For a conversation in kindergarten to be mathematical there has to be an element that it is aimed at further learning. Children have an innate desire to learn and use their knowledge in conversations. From the excerpts it is possible to see that the participants have an ongoing conversation where they exchange and presumably create new knowledge. Especially one child, Dan, is very active and builds up the other group members’ knowledge. The group dynamic in the conversation makes it possible for them to together accomplish more than they could individually. In this sense, the children are in the Zone of Proximal Development (Vygotsky, 1978) and they are scaffolding (Wood, Bruner & Ross, 1976) for each other.

I want to illuminate these characteristics by presenting a metaphor about conversations as flowers in a garden. In this metaphor, every flower in the garden is a conversation, and flowers that represent mathematical conversation may look something like figure 1.
Every mathematical flower is unique since every mathematical conversation is different, but they are closely related and have some common characteristics. At the core of the mathematical flowers is the characteristic of “being mathematical”. The petals present other characteristics that have to be present for the flower to be termed mathematical: reflecting, structuring, interacting and further learning. A mathematical flower is thus seen to represent a conversation characterised by mathematical content where there is reflection about mathematics, the conversation is structured around mathematics, there is interaction between the participants and it is being aimed at further learning of mathematics. Working in the garden the kindergarten teacher must learn to plant and cultivate mathematical flowers. There are different seedlings or sprouts that grow into different flowers. This can be viewed as being aware of mathematical conversations as a didactic tool in the kindergarten, and how different ways of launching conversations lead to different potential mathematical conversations. By considering conversations as flowers the aspects which unite them in the community of inquiry become clearer. Every kindergarten develops its own way of cultivate and foster mathematical flowers (conversations). The kindergarten teacher becomes the gardener and gardening becomes a concept complementary to the concept of orchestrating. It is of great importance that the kindergarten teacher can cultivate conversations that are mathematically enriching and cultivate an environment for them to grow in. Such a garden should have room for both wild flowers, that arise more or less unplanned, and for the more rigid flower beds, where the carefully planned conversations are. Thus the metaphor puts emphasis on children meeting a variety of conversations and kindergarten teachers able to cultivate and foster conversations in a way that develops communities of inquiry that provide a dynamic environment for mathematical conversations.

REFERENCES


