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Building with focus on stability and construction: using a story as inspiration when teaching technology and design in preschool

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ABSTRACT

In this study children's learning of the concept, *stability*, during some building activities were investigated. It was also examined how a story can create meaning, having the children build *for* some animals in the story. Two preschool teachers and 10 children participated. Data consisted of video-recordings from activities with the children and was analysed through thematic coding. The findings showed that the children enjoyed to build and showed an understanding of how to build stable constructions, however without using the word *stable*. There were connections to the story and new stories were also made by the children during building activities.

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Introduction

Earlier studies have investigated how children build with different materials in preschool, for instance, to study children's spatial development, geometry knowledge, or problem-solving (e.g. Clements and Sarama 2009; Davis and Hyun 2005; Shiakalli, Zacharos, and Markopoulos 2015). Some have focused on different aspects of building when children use blocks (e.g. Kamii, Miyakawa, and Kato 2004; Ness and Farenga 2007). In the study by Kamii, Miyakawa, and Kato (2004), children were supposed to build something tall, but with a limited number of blocks. They found a regular increase by age in the vertical use of 'flat' blocks, avoidance of triangular blocks, and horizontal use of triangular blocks. Hence, the shape of the materials seemed to be of importance and use varied with age.

Building and construction is the overall theme in a well-known Swedish preschool (*Trollet*), and has been for many years (Mylesand 2007). Therefore, teachers from this particular preschool have reflected on different perspectives and are aware of the significance of their own role. Two factors seem to play a crucial role in making children's building and construction successful: the role of the teachers and the choice and supply of different materials. These aspects have also been emphasised in the Swedish preschool curriculum:

Each child should develop its ability to build, create and construct with the help of different techniques, materials and learning should be based on the interaction between adults and children as well as children's learning from each other. Children will receive stimulation and guidance from adults to increase their skills and develop new knowledge and insights through their own activities. (Skolverket 2010)

It is therefore important that preschool teachers encourage the children to develop their constructions to stimulate learning. The children are supposed to be able to build small, large and high

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structures with different materials. Questions from the preschool teachers such as, ‘What kind of materials are useful if you want to build high constructions?’ or, ‘What kind of materials are stable?’ are of importance to stimulate the children’s development. Another perspective noticed among preschool teachers is that it seems important that building and construction have a purpose. The children want to build *for* something, like a home for a pet, a toy, or a doll (Mylesand 2007). This conclusion was also drawn by Stables (1993) who found parallels in how professional designers work and children work with technology and design. She notes that the children are driven by a strong motivation that is due to the desire to achieve a certain purpose, such as designing and making a house for a teddy bear or something to keep their ‘treasures’ in.

In this study, we take a closer look at children’s learning of a particular concept, *stability*, during some building activities but we also investigate how a story can create meaning through the building process, having the children build *for* some animals in the story. The research questions are:

1. What kind of content can be identified in relation to the children’s ability to build and construct with different techniques and materials?
2. What kinds of connections are made to the story during the building activities?

This will be studied in relation to building stable towers for the characters Mother Moo and the Crow, from a Swedish children’s story (see below under Research context).

Experiences of building and construction at preschool level

Fleer (2000) states that there is little knowledge about how young children work in a context of learning technology and design. She conducted a survey in Australia and analysed children’s (3–5 years) planning, making, and appraisal of technology education. The study indicates that children as young as 3-year-olds can use oral and visual planning as part of the process of constructing things in different materials. The context was presented by the teacher in the form of a story about a mysterious creature she had found in her garden. The story ended with the children being invited to create a friend for the creature. The teacher also gave the children a presentation of what materials they could use to solve the task. The children in the study found it easy to decide what they wanted to do and Fleer argues that a majority of them managed to make 2D-designed objects based on oral planning. On the other hand, a majority of them had difficulty making constructions using sketches, which indicates that children need to be introduced to different kinds of image creation in order to cope with this part of the task.

Another study that has explored how young children have worked with technology and design was conducted by Siraj-Blatchford and Siraj-Blatchford (1998). In their study, five-year-old children’s ability to design and construct was investigated. The children designed with play puzzles that could be joined in up to 450 different constellations. After some weeks it turned out that children in some groups developed their constructions with additional material and more details than the other groups. The differences between these groups seemed to depend on how active educators had been. The researchers concluded that a well-planned activity where the educators were involved and active close to the children resulted in a broader and deeper understanding of technology and design.

Besides the importance of the role of the educators Trageton (1996) argues that a prerequisite for children’s ability to create three-dimensional constructions is that they have access to different types of material. He points out that quantity is crucial for the shape and variation. Hence, children should have access to a large number of wooden blocks, but it is also possible to use cans, milk packaging, toilet-paper rolls, boards and more when building. Mylesand (2007) stresses that she does not believe that there are any restrictions on what material the children can use. Furthermore, it is necessary to plan a building and construction environment that contains materials challenging children at different levels to meet the needs and interests of the individual child. It is also important that the

material appears in different shapes and structures where it is not always a matter of course what it should be used for (Mylesand 2007).

At the preschool *Trollet*, with many years of experience working with building and construction and considering aspects discussed above, such as the role of the educators and access to different kind of materials several outcomes have been identified. Building includes aesthetics, geometry, mathematics, language and social aspects as the children learn to cooperate. From a mathematical point of view, it is, for instance, common that comparisons are made: longer, shorter, higher, lower, heavier, easier and so forth. The children also develop knowledge about different materials and they make choices, try and retry and learn from their experiences in an inquiry process. Mylesand (2007) also presents an example from when the children built a copy of a water-tower situated close to the preschool. During the process, the children seemed to develop their knowledge about the concept of stability. The children started to build quite unstable towers, but when they saw a picture of the water tower they noticed that the tower had several legs, so they rebuilt it and finally their construction was stable (Mylesand 2007).

Stories serving as a context for learning

Stories have been told to children for ages and have the potential to stimulate learning (Egan 1986). Different kinds of stories have been used to stimulate learning in science (e.g. Boström 2006; Banister and Ryan 2001; Millar and Osborne 1998). When Walan (2017) investigated the outcomes of combining stories and hands-on activities in science from a preschool perspective the results varied. Some preschool teachers argued that the stories were essential to create a context for the hands-on activities in science. Others argued that the stories were not important at all. It was also claimed that the quality of the stories was significant. However, few studies seem to have investigated the use of stories connected to learning in the subject technology and design.

One of few examples of combining storytelling with technology and design was presented by Kilbrink et al. (2014) who used the folktale about *The Three Billy Goats Gruff* to frame an activity when preschool children were supposed to construct bridges. The study was a so-called Learning study (which will be explained later on) and the idea was that the children would learn how to build strong and framed structures. Some of the results showed that in the first cycle of the Learning study the children were focused on building bridges *for* the goats. During the pre-test, the children compared their constructions with bridges from real life that they were familiar with. Some of the children were really focused on the goats and explained that they had built a roof for them so they would not get wet if it started to rain. In the post-test, the children referred to what they had done in the pre-test and they wanted to build in a similar way. Changes were made in the learning activities to be able to move the focus more to the object of learning and in the third cycle of the study, the focus had moved from the story about the goats to the strength of the constructions and how they were framed. Conclusions made were that there were difficulties in delimiting a learning object using hands-on material, but also that it was hard to find a balance between the learning content and the context. It was also concluded that the teachers' role was of importance to clarify critical aspects of the learning objective.

In even more recent studies exploring the combination of storytelling and technology and design activities (e.g. Axell 2015; Svensson, Dahlbäck, and Von Otter 2019), it is argued that stories motivate the children when working with this kind of activities. The results from the study conducted by Svensson, Dahlbäck, and Von Otter (2019) showed that the story served as an introduction to a task with practical problem-solving and that it contributed to the children's interest in technical solutions. The story invited creativity, gave the children a context and inspired them with solutions since everything is possible in the world of stories.

Even though some examples have been presented above that have explored outcomes of combining storytelling and hands-on activities related to technology and design, studies within this field seem to be few. Hence, in this study, we wanted to make a contribution and design the study based

on earlier experiences. Based on the arguments by Mylesand (2007) and Stables (1993) that children want to build *for* something, or someone, the idea in this study was to inspire children in their building of high towers by asking them to build this *for* the cow and the crow in the story they were reading. Hence, the story was intended to serve as an inspiration, providing the children with a context for the construction as in the case presented by, for instance, Svensson, Dahlbäck, and Von Otter (2019). The story book included pictures of the huts made by the cow and the crow, as well as a picture with many details from the building process, including the materials and tools used.

Theoretical framework – learning study and variation theory

Besides the connection to the subject technology and design and the use of a story as a context to inspire children in building and constructing, this study is based on a model of teaching development called Learning study. In this model teachers systematically and iteratively plan and then implement and analyse learning situations (Marton 2005). In a typical Learning study, the focus is on content and there is some form of revision of the performed lesson after each learning cycle in a direction guided from new knowledge on how to process content in the best way for children's learning (Holmqvist Olander 2013).

This model has been tested for several years in Swedish compulsory schools with positive effects on pupils' learning. Researchers then tried the Learning study model at preschool level to investigate whether it could contribute to younger children's learning (Holmqvist Olander 2013) and came to the conclusion that it is a useful tool also at this level.

The first step in the Learning study model is to identify what kind of learning will be in focus which is called the learning object. The second step is a pre-test to find out what the children already know about the chosen learning object. The third step is to plan and conduct a teaching activity that will stimulate learning. The fourth step is a post-test to find out what the children have learnt. This is the first cycle in a learning study. After the post-test teachers analyse and discuss the results from the first cycle and decide what they need to revise in the teaching activity in the next cycle. The second cycle is conducted and the process is repeated. Several cycles may follow (Holmqvist Olander 2013).

In a learning study, variation theory is the theoretical framework. Variation theory has a strict focus on the object of learning. In the theory, there is an assumption that learning is brought about by means of variation. To understand something, the learners also need to understand what it is not. In a learning situation, aspects of the object of learning can be made clear to the learners by using different patterns of variation. In variation theory, there are four patterns of variation: contrasting, generalisation, separation and fusion. *Contrasting* is when something is compared to something it is not, e.g. a cat is not a dog, or the number four is not five. The next pattern is *generalisation*, where different appearances of the aspects of the object of learning are made visible in the learning situation, e.g. there are different kinds of dogs; four pens and four books are both examples of the number four. *Separation* is when one of the critical aspects is highlighted and varied while the others remain constant, and *fusion* is when all critical aspects are varied at the same time (Marton and Tsui 2004). When working with specific content in teaching, for example in a Learning study, those patterns of variation can help the students discern what they are supposed to discern (Kilbrink et al. 2014).

When designing this study, we were inspired by the learning study method and the use of variation theory, but had to adapt the method to the ordinary activities at the preschool. In this study, the preschool teachers focused on using *contrasting* or *generalisation* as the pattern of variation when planning the activities. The implementation of our study, inspired by the learning study method, is described below.

Method

In this section, we describe the research context, the participants, the research implementation, and finally, data collection and analysis.

Research context

This study was conducted at a preschool in a medium-sized city in Sweden. The preschool had earlier worked for many years with stories connected to hands-on activities in science and technology and design in a project in cooperation with the municipality and the nearby university. Because of this experience, the preschool teachers were asked if they wanted to participate in a study using a story as inspiration to stimulate children's learning about a chosen learning object related to technology and design. The reason for choosing the subject technology and design was that this subject is quite new in the curriculum for Swedish preschools (Skolverket 2010) and there is a lack of research within this field.

The research team consisted of the three authors and they visited the preschool in total four times during a period of four months. Each meeting lasted for about 2 h. At the first visit, the preschool teachers told the researchers that they already had started to work with a children's book about a cow and a crow and their building of huts, called *Mamma Mu och Kråkan bygger koja* (in English: Mother Moo and the Crow build huts). Therefore we (researchers and preschool teachers) decided to base the study on the use of this book. Besides the meetings at the preschool, the preschool teachers were provided with support from one of the researchers via telephone and email. This researcher also participated in the first pre-test.

Participants

Ten children aged 4–5 and two preschool teachers participated in the study. All of the participants have been anonymised. The preschool teachers are referred to as preschool teacher one (PT1) and two (PT2). The children have been given pseudonyms as child 1–10 (C1–C10).

Research implementation

This research was inspired by a learning study in two iterative cycles (we aimed for three, but one of the preschool teachers moved during the process so it was not possible to implement the last cycle). The idea was that the preschool teachers would get more support in the beginning, and work more independently as the project progressed (cf. Kilbrink et al. 2014). The meetings between researchers and the different steps conducted are described below.

First cycle

During the first meeting at the preschool, the learning object for the study was decided to be stability, based on the content in a story about Mother Moo and the Crow which the preschool teachers had read together with the children in the preschool. This also relates to the curriculum requirement that children are supposed to be able to build and construct, expressed as follows:

Each child should develop its ability to build, create and construct with the help of different techniques, materials and learning should be based on the interaction between adults and children as well as children's learning from each other. Children will receive stimulation and guidance from adults to increase their skills and develop new knowledge and insights through their own activities. (Skolverket 2010, 7, 10)

To be even more specific about what the children were supposed to learn from the building activities, comments from Utbildningsdepartementet (In English: Ministry of Education) on the curriculum (2010) served as guidance:

Through construction and building the children gain experience of balance and strength of different designs and materials as well as experience of height, depth and width. (Utbildningsdepartementet 2010)

There was a joint discussion between the researchers and the participating preschool teachers on how the preschool teachers could work with stability in relation to the story together with the children and how different patterns of variation (contrasting and generalisation) could be used to emphasise critical aspects of the object of learning (e.g. choice of material).

The next step was to decide how the pre-test with the children would be designed. To be able to document what the children were doing it was decided that they were going to build in pairs and an iPad would be used to film the children during the test. To be able to compare different materials in relation to stability, the children were going to be provided with the material in the form of cans, wooden blocks, toilet-paper rolls, plastic or paper cups, CDs and beanbags. The children would be instructed to build a tower, as high as possible for the cow and the crow. The children had never before used these kinds of materials at the preschool, but only used Lego bricks and wooden blocks during free play.

At the second meeting at the preschool, the films from the pre-tests were analysed by the preschool teachers and the research team. After the analysis, it was discussed how the teaching activity would be designed and decided that the post-test would be conducted shortly after the teaching activity.

At the third meeting, the teaching activity was discussed as well as an analysis of the documented post-test. Discussions were held about changes to be made for the second cycle.

Second cycle

During the second cycle, the preschool teachers worked independently with only some support from one of the researchers via telephone and email. Documentations of the pre- and post-test from the second cycle were also made by filming with an iPad. A fourth meeting was held after the second cycle. During this meeting, only one of the preschool teachers was able to participate together with one of the researchers. The meeting served as a follow-up to the second cycle and the preschool teacher was interviewed. The second preschool teacher had moved to another preschool and was not able to follow up the project. The interview and the discussions with the preschool teachers are not included in this study since those data focused on the preschool teachers' perspective, while this manuscript only focuses on the observations based on the filmed activities in the study.

Data collection and analysis

The collected data consisted of 15 video-recordings from activities with the children. The recordings covered in total about 120 min of activities with the children in different settings (pre- and post-tests and the learning activities).

Even though this study was inspired by the Learning study perspective we chose to conduct the analysis based on the research questions from a holistic perspective with a focus on the content that emerged from the empiricism as a whole, rather than from the specific learning object (stability). This was decided by the researchers during the process as the activities did not keep the focus on the learning object *stability* and the whole process of construction turned out to be of interest. Hence, data were analysed using thematic coding as described by Robson (2011, 474–488). First, the video-recordings were watched repeatedly/iteratively by each of the researchers individually familiarising themselves with the data, noting inductively initial themes (main categories) that could be identified based on the research questions. Then the three researchers joined to discuss and agree on the generation of initial codes, both in terms of main categories and sub-themes. The next step was to sort the data into the identified themes that emerged based on a thematic map. Finally, all three researchers individually checked the sorting of the data and agreed on consensus.

Findings

Analysis of data resulted in a thematic coding map sorting answers to the research questions as presented in Figures 1 and 2. Examples of how children showed signs of knowledge about the importance of techniques and properties of the materials to make the construction stable were shown in video-sequences capturing comments made by the children.

Children's ability to build, create and construct with different techniques and materials

Analysis of the data responding to the first research question about children's ability to build, create and construct with different techniques and materials resulted in three main categories: construction, aesthetics and limitations. From these categories, some sub-themes were identified (e.g. attitudes to constructing, heavy or light, symmetry and lack of use of concepts). All of the categories and sub-themes are presented in [Figure 1](#) and examples from the data are further described as follows.

Construction – attitudes to construction

In all of the video clips, except one (when one child had to build alone because lack of a partner on that occasion) the children always showed enthusiasm when the preschool teachers told them that they were going to build.

A typical situation was when the preschool teacher (PT1) put the box with the material on a table in front of two children. When they (C8 and C9) saw the material they both shouted: Yes! (with a lot of enthusiasm).

There were also typical episodes when the children were building and the construction became too high for them while sitting on chairs and building on a table. In these situations, the children spontaneously climbed on their chairs and continued to build now standing on the chairs.

In another situation, it was shown that the children had been building for more than 15 min and the preschool teacher wanted them to finish and told the children that they should quit. The children (C6 and C7) did not want to quit and the process went on for another 10 min.

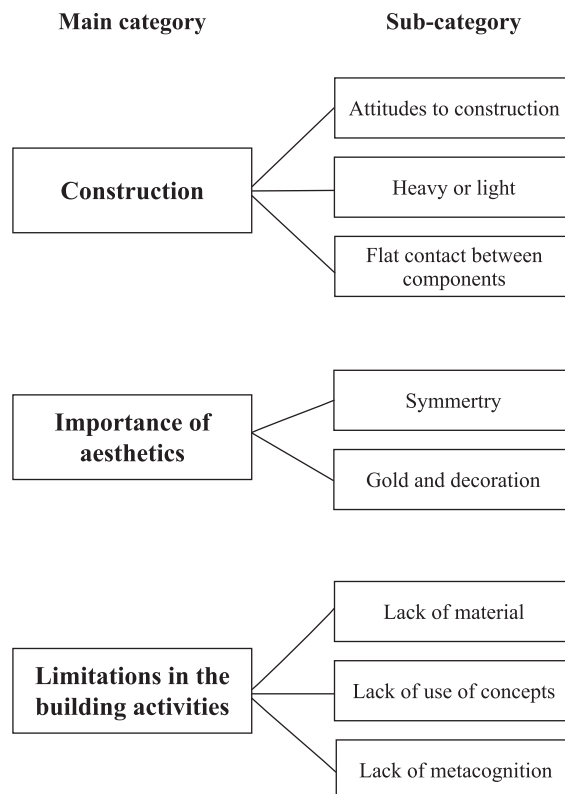


Figure 1. The thematic coding map responding to the first research question about what kind of content can be identified in relation to the children's ability to build and construct with different techniques and materials.

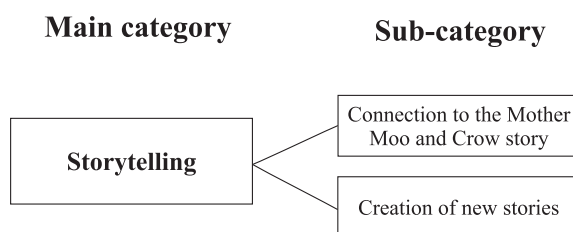


Figure 2. The thematic coding map responding to the second research question about what kinds of connections are made to the story during the building activities.

A typical situation was when children had built a high tower that did not fall and they seemed proud of what they had achieved, the following comments were made to the preschool teacher:

- C8 I have built a really high tower! [Claps hands and laughs].
 C10 Look what I have done! [Pointing at the tower].

The only situation when this enthusiasm was not shown was when one child was building alone. The preschool teacher asked the child to make a tower for the cow and the crow, but the child did not want to build. The preschool teacher several times tried to encourage the child to build and during a couple of minutes the child was building, however, without any enthusiasm. After 4 min the child did not want to do the activity anymore and the preschool teacher accepted.

- C8 I have finished now. Now we can leave and join the others.

There were no explanations found from the conversation between the preschool teacher and the child that showed why the child did not want to build.

Construction – heavy or light

There were examples when the children showed that they were constructing by putting more heavy materials at the bottom of their buildings and that they thought this was important. The children did not say by words that the construction would be more *stable*, but argued that the heaviest must be at the bottom, otherwise it would fall.

- C2 Ok, these must be at the bottom, because they are heavy. [The child was holding a wooden block in its hand].
 PT1 Heaviest at the bottom. [A typical response from the preschool teacher, repeating what the child just said].

Another example was a child who held a plastic cup in one hand and a wooden block in the other (Figure 3) and said:

- C4 You know, you cannot put this one [the wooden block] on top of this one [the plastic cup], because it is too heavy. It will crash.

Construction – the importance of a flat contact between components

During the activities children also showed awareness that materials needed to have a flat surface to keep the buildings stable, examples are shown in Figure 4. The most typical example was that the children did not want to use the beanbags. While constructing the following conversation took place:

- C2 This one is not good. [Holding a beanbag].
 C3 No.
 PT1 Why isn't it good?
 C2 Because there are peas inside and they roll.



Figure 3. Child showing that you need to consider the weight of the material when constructing.

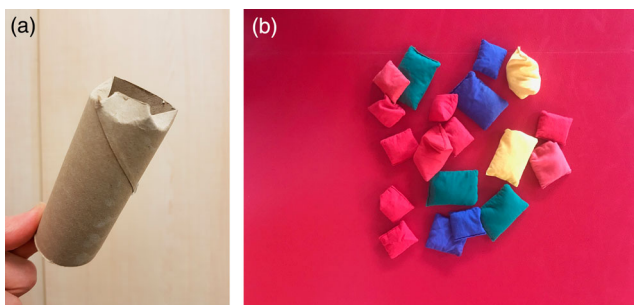


Figure 4. Examples of situations when children emphasised that surfaces need to be flat. (A) An episode with toilet-paper rolls. (B) A child explaining the problem with using the beanbags.

A similar conversation was held with some other children and the other preschool teacher.

- PT2 What about these? [The teacher is picking up a beanbag and trying to give it to the children].
 C4 No, they are slippery and if you put something on top of them, it will slip and fall.
 C5 No, they are not slippery. It's because there are peas inside and they roll around and that's why it will fall.
 PT2 Ok, so, they are not stable.

Another situation that showed how a child was thinking about the importance of contacts between components to be flat was when a child was holding a toilet-paper roll and tried to make the edges flat because they had been bent.

- PT1 Why are you doing like that?
 C1 Because it needs to be flat.
 PT1 Why is that important?
 C1 Because, otherwise, if it's bent, then it's not possible to build.

In yet another situation two children were building together and one of them picked up a toilet-paper roll and wanted to put it on top of their construction.

C4 No! It will crash.

C5 No, it will work. It's flat on both sides [The child showed this on the toilet-paper roll].

The importance of aesthetics – symmetry

In many of the constructions (not all) the children built symmetrically. This was not something they talked about, but when they were building together in pairs, or groups, there were children that corrected if a new component was not placed on the right spot in relation to symmetry. An example was when one child put a pile of plastic cups on the construction. The other child then started to move cups putting them into three piles and trying to arrange so there would be the same number of cups in each of the piles. This is shown in [Figure 5](#). Another example is shown in [Figure 6](#). In this case, the children had chosen to only use two of the materials (CDs and cans).

The importance of aesthetics – gold and decoration

Most of the material that was used during the building activities did not have any particular colours except for the beanbag. This did not seem to matter during the building activities. However, the CDs were of particular interest for the children, especially those that had a gold colour on one side. Some examples:

C3 Wow, it's gold. That's nice. [Holding a CD].

C2 Wow, where did you get these? [Question posed to PT2].

Some minutes later the same children talked about the CDs again.

C2 Let's use the gold CDs.

C3 Yes!

C2 We can build a golden balcony on the tower!

And so they did, ([Figure 7](#)).



Figure 5. Trying to get symmetry.



Figure 6. Another example of symmetry.



Figure 7. The importance of aesthetics – gold.

Besides making the constructions symmetrical, or nice-looking by adding CDs, the children also wanted the surroundings of their constructions to look nice. In the examples observed they used beanbags for this purpose. These were used as grass, or as water.

In one situation two children had built two cities (instead of towers). The cities were next to each other. The following conversation took place:

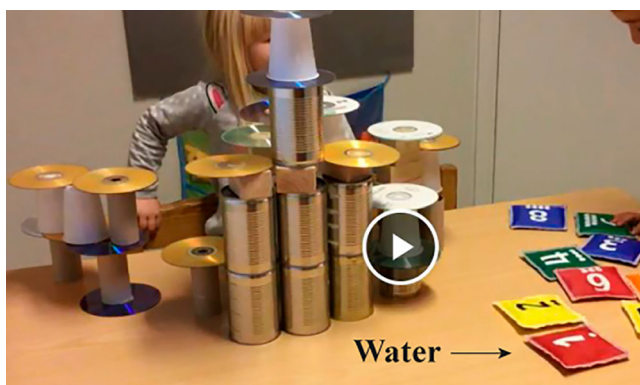


Figure 8. The use of beanbags as decoration, serving as water next to the construction.

C4 Let's connect our two cities.

C5 Yes, I can make some grass with the CDs.

In another situation, the children had finished building a tower and they had used all the material except for the beanbags. This is shown in Figure 8.

C5 Let's use the beanbags, they can be water.

Limitation – lack of material

The building processes often were naturally finished when the children had used all of the materials. In some occasions, they started all over again and made a new one. The children sometimes asked for more material, but the response was always the same from the preschool teachers, that this was what they had access to.

C2 We need more material to continue.

PT1 Sorry, this is all you can have.

Hence, there was no discussion on how to improve or develop the constructions, neither in relation to stability nor in any other way.

Limitation – lack of use of concepts

In most of the videos, the preschool teachers did not use concepts related to building and construction, such as the specific construct stability. They rather focused on practical issues, such as telling the children to back so they would have enough space for the constructions, or, encouraging them to cooperate. There were also situations when the preschool teacher recommended the children to make their constructions on another spot:

PT1 I think it's better if you build on the floor, not on the carpet, because it's not flat on the carpet.

Other examples of comments from the preschool teacher were when she wanted to support the child:

PT1 What will happen if you use the CDs?

PT1 Try without using the beanbags.

There were no situations recorded showing any comments about the properties of the materials from the preschool teachers.

However, even though there was a lack of use of concepts relating to building and constructing a few episodes included the use of the word *stable*.

- PT2 How can you build so it becomes stable?
 C4 You need to put things on each other very carefully.
 C2 I am building a stable tower.

This episode was the only one when any of the children used the word stable.

Limitation – lack of metacognition

In all of the cases when the constructions fell down the preschool teachers asked the children why it happened. This happened with all of the children that participated and they always responded in a similar way. A typical example:

- C5 Oh, no! It crashed!
 PT1 Why do you think that happened?
 C5 I don't know. I have to rebuild it.

The comment about rebuilding did not always occur, sometimes the children just continued and other times they quit building, only responding that they did not know why it crashed.

Summary of the kind of content that can be identified in relation to the children's ability to build, create and construct with different techniques and materials

The examples presented show how almost all of the children were enthusiastic when they were building. In some cases, they showed that materials need to have flat surfaces to connect to each other if their buildings would keep standing. In other episodes children explained that heavy materials needed to be at the bottom. There were also examples of how they wanted the constructions to be symmetrical. Furthermore, the children wanted their constructions to look nice, so they decorated the buildings and surroundings, often using the golden CDs. However, there were also limitations found in the building processes in terms of lack of material. There were only a few occasions when the concept stability (stable) was used, even though the children were supposed to learn this concept. Finally, even though the children managed to build stable constructions, and even though they showed understanding of the importance of properties of the materials none of the children were able to show any metacognition and explain why their buildings crashed.

Connections made to the story during the building activities

Connections to the story about Mother Moo and the Crow were made both by the preschool teachers and the children. The preschool teachers only referred to the original story, but some children also started to make up new stories during and especially at the end of the building activities. Some examples are presented below.

Connections to the original story

The most frequent comment that connected to the original story was made by the preschool teachers when they started building activities with the children. The comment was similar in all of the pre- and post-test videos.

- PT2 So, can you build a high tower for Mother Moo and the Crow? Maybe they can have a great view.

The children talked about the cow and the crow on several occasions. Often they pointed and showed how the animals would climb or jump in the tower, or where they would be sitting.

- C2 This is the place for Mother Moo, and this is the place for the Crow.
 C5 They [referring to the animals and pointing] walk here and then they climb here and then they climb and they are here and they can see far away.

These excerpts show examples from both teachers and children in the study. In both examples, it is visible that the connections were made to the characters of the story, rather than to any other content of the study.

Connections to new stories made by the children

Some videos show how the children do not respond to the comment from the preschool teacher about building a tower for Mother Moo and the Crow; this was, for instance, the situation when two children (C9 and C10) were building together. They did not try to build a tower, but their building only consisted of one floor.

- PT1 Aren't you going to build a tower for Mother Moo and the Crow?
C9 No, we are building a home for people.

The children then talked about the home and how the CDs were beautiful to use in their home, because there was a rainbow showing up when they were holding the CD.

In another situation the response from the child was:

- C1 Well, I am going to build a city. And there will be a wall so the people can defend themselves.

The child continued by telling how people would be safe in the city. The children had earlier built a city together in a group of five children (C1–C5), so the city theme then occurred in yet another situation with two of the children.

- C4 We are building a city. It's Africa.
C5 No, we are building Star Wars.

They went on talking about how different characters would act and how they lived next to each other.

Summary of results on the kinds of connections made to the story during the building activities

The connections the children made to the story about Mother Moo and the Crow were in terms of talking about how the animals would act if they were placed in the constructions. The preschool teachers always referred to the characters when asking the children to build, but that was the only connection they made to the original story. There were also children who started to make up their own stories, especially in some cases when they wanted to build something else, not a tower for Mother Moo and the Crow. The stories were often about cities and how people lived there, or as in one case, about Star Wars. There were no connections to the original story by the children. In addition, the preschool teachers did not refer to the building process or any of the tools mentioned in the original story.

Discussion

In this study, a story was used to serve as a context to motivate children in building and constructing activities. The purpose of the activities was that the children would learn the concept *stability* and how different materials were useful in constructions depending on their properties. It is not shown how important the story was to create motivation for the children. They were almost always eager and happy when they were about to build. However, in most cases the preschool teachers were very clear with the children about the purpose of the building activities; the children should build a tower *for* Mother Moo and the Crow. This is in line with Mylesand (2007) and Stables (1993) who argued that the constructing should have a purpose, building *for* someone.

The results showed that the children seemed to have some kind of knowledge of how to connect different materials, for instance by putting heavy objects like wooden blocks at the bottom and plastic cups on top, or that surfaces needed to be flat. However, the children were not able to

explain why their constructions sometimes crashed. The videos did not show how the children had gained this knowledge, if it was something they learnt during the activities, or if it was because of earlier experiences. Information about how to place materials in a certain manner like heavier at the bottom, or that surfaces needed to be flat could not have been found in the story about Mother Moo and the Crow.

The significance of aesthetics, like symmetry, or the use of golden CDs, or decorations was often found among the children during the building process. This finding is also supported in the experiences presented by Mylesand (2007) who argues that building and constructing includes aesthetics. This aspect was not included in the aim of conducting this study, but emerged as an apparent result in the empirical material. In relation to this and to Mylesand (2007), aesthetics is something that could be taken into consideration in similar studies. Either this could be added as one object of learning, or the preschool teacher could help the children not to put focus on aesthetics, but on the critical aspects of the object of learning instead.

Mylesand (2007) and Trageton (1996) argue that the amount of material and enough space is important if children will be able to build three-dimensional constructions. In this study, there was one situation when the preschool teacher encouraged the children to back up so they would have enough space to construct, in this case on a floor. In other situations the children were supposed to build on a table. Building on a table could be considered as a spatial limitation, however, the task was to build a high tower and there was not any limitation because of height where the children were building. In other situations when the children could not reach the top of their towers they solved the problems themselves by standing up on a chair. However, the amount of material was limited and this became an obstacle for the children in their building process. This limitation was not related to the object of learning, but to the creativity process of building. When building with a specific focus on stability, there could have been more discussions made between the teachers and the children in relation to different materials and if their constructions could be rebuilt to be more stable and why, instead of building until there was an end of access to the material.

Connections to the story were made by the children, mainly to the characters in the story, Mother Moo and the Crow. The story is quite long and the preschool teachers did not refer to anything in the story when they were talking to the children during the building activities. One child was not interested in building and it did not matter that the preschool teacher repeatedly told the child to build something *for* Mother Moo and the Crow. Maybe the story was not motive enough for this child? Even though stories have been argued to serve as useful to create a context for activities (e.g. Walan 2017) they can sometimes not be interesting enough. However, the characters in the story can in themselves be of importance (ibid). This was possibly the case in this study. Svensson, Dahlbäck, and Von Otter (2019) found that the story they used connected to technology and design as it provided conditions for learning through languages and images. Furthermore, the tasks that followed were strongly connected to the story. This could have been developed even more in our study.

Discussing the study from the perspective of the research design, as a Learning study, there were several complications. An important factor in stimulating children's learning in technology and design is that the teachers are engaged (Siraj-Blatchford and Siraj-Blatchford 1998). Even though the preschool teachers in our study were committed, it was not possible for the researchers to discern many examples of teaching activities concerning the chosen object of learning. As researchers, we guided the preschool teachers through the different steps of a learning cycle. Hence, an object of learning was identified, the children were supposed to learn about the concept stability and how to gain this in their constructions. The pre-tests were conducted as planned. We could not identify how, or if the preschool teachers instructed the children during the learning activities by using contrasting, or generalisation. It seemed as if the children only were encouraged to build and to cooperate. One of the preschool teachers mentioned the word stability during the learning activity. The other preschool teacher used comments such as: 'What if you try this one?' or 'What if you use the CDs?' In some of the videos it was also difficult to compare if there were any developments in how the children built, or talked about the constructions, between the pre-test and post-test

situations. The only change noticed was that in some of the post-test videos the children built cities. This was also what they had done during the learning activity. One of the preschool teachers also mentioned how the children enjoyed building so much that she did not want to interfere by trying to teach the children. In order to deepen the possibility for the children to learn the object of learning, our result indicates that more cycles are needed. Furthermore, discussions between preschool teachers and researchers are necessary about how the learning object is possible to learn in the enacted learning situation. These discussions were not possible to conduct enough due to practical reasons, like the working situation for the preschool teachers as mentioned above.

Dovenborg, Pramling, and Pramling Samuelsson (2013) discuss that teachers need to become aware of and reflect on 'what' before they challenge children's learning. For example, they emphasise the importance of planning and being aware of how and where to direct children's attention. If a teacher does not have any training in technology, it is difficult to contribute to children developing knowledge in this area (ibid). Preschool staff should encourage children's curiosity and creativity and create positive attitudes to technology and design (the Swedish National Agency for Education, 2011), but in order to be able to support children's development, knowledge about the subject is required. Studies show that there is a lot of uncertainty among preschool teachers about the subject's content and how it can be taught (e.g. Lillvist et al. 2014).

The preschool teachers in this study were not trained in technology and design and perhaps we as researchers did not provide them with enough support during the study. Another complication was that one of the preschool teachers left for another job before the study was finished. These aspects probably influenced how the Learning study design perhaps was not conducted as intended in all aspects. More support during the learning activity could have improved the study.

Another aspect that could have affected the results was that the children at this preschool had never before used different kinds of materials for construction. Maybe this influenced the children to find the building activities so joyful because of the novelty?

Despite the limitations in our study, we argue that the results are of interest as they contribute to knowledge about what happens in preschool activities when focusing on an object of learning (stability) in relation to building and constructing using a story as inspiration. Furthermore, this study makes a contribution to the knowledge of how stories can be connected to activities at preschool level relating to technology and design and discussions about how this could be developed.

Disclosure statement

No potential conflict of interest was reported by the authors.

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