The impact of knowledge of the knower: Children exploring physical phenomena and technology in construction play

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Abstract

This article contributes knowledge about technology education in pre-school, a research field that is still undeveloped. The aim is to study pre-school children's ways of discerning a physical phenomenon (equilibrium) during collaborative construction play. Two different activities have been studied: playing on a homemade seesaw made of a log and a plank, and building towers with blocks. In the first activity, 3 children aged 4-5 years from one pre-school participated. In the second, 4 children aged 3-5 years from another pre-school participated. Data consist of video-recordings of the two activities and field notes. The video-recordings are analysed based on variation theory. In both activities, children discerned and explored the phenomena of equilibrium, centre of gravity and balance. Three children tried different ways to spread their mass over the seesaw. They distributed the weight both by crawling to the middle and by standing on the ends of the plank. In the building activity, a group of four children tried to build high block towers and discerned the importance of the weight distribution for stability and for the construction not to collapse. The results showed that the children who had discerned more aspects of the phenomenon of equilibrium were able to use and develop their knowledge during the activities to a greater extent than children with less knowledge. They also shared knowledge with other children by making them notice aspects needed to understand the activity, thereby participating in a more active way. The results can be used by pre-school teachers to design collaborative play activities for learning science in pre-school.

Keywords: Pre-school, technology education, science learning, variation theory

Introduction

Though research about technology education in pre-school is limited, it is developing (Mawson, 2013; Turja, Endepolis & Chatoney, 2009). Primarily, the research conducted involves children aged 8 years and older. The Swedish Schools Inspectorate (2017) carried out an assessment on the state of science education in Swedish pre-schools and concluded that, although construction play is the most common technological activity in pre-school, it is seldom seen as a learning opportunity where the staff intentionally interact to promote learning. Construction play often concerns spontaneous games where the children play by themselves out in the school grounds or in the 'building space' (Swedish Schools Inspectorate, 2017). Play is related to children's cognitive development, especially in the early years (Bagiati & Evangelou, 2016). During play, children develop many different skills, such as social, creative and cognitive skills. Including tangible objects in play seems to benefit children´s cognitive development. Children explore and structure their environment.

In addition, playing with a variety of materials can help children to observe and explore how artefacts are constructed. When building, children can discuss design and explore concepts such as size, weight and balance; they also develop their motor skills. An important part of construction play is the trial-and-error behaviour (Van Meeteren & Zan, 2010). This is necessary for children to be able to develop spatial reasoning and a working understanding of physics. Van Meeteren and Zan (2010) conclude that children have for a long time been recognised as young scientists as they explore and try to make sense of their environments.

Results indicate the need for a pre-school teacher who is able to intentionally direct the children's attention to defined learning objects in science to enhance their learning (Hallström, Elvstrand & Hellberg, 2014; Mawson, 2013). Children need challenging questions and to be confronted with different materials in order to visualise science phenomena during play (Siraj-Blatchford, 2009). Furthermore, Turja *et al* (2009) and Parker-Rees (1997) argue that children also need to have rich opportunities to play with different materials, tools and techniques to develop their technological understanding during construction play. Parker-Rees (1997) maintains that free play is the foundation of the development of design and technology. Fantasy develops during play activities. It helps children to engage in playful and critical ways of thinking and to use earlier experiences.

For children to be able to do the above, pre-school teachers have an important role to play. Mawson (2013) argues that teachers have to develop the ability to provide children with everyday experiences in the field of technology and use it as a starting point for learning about technology. If the teachers have a 'scientific attitude' they create a learning environment at pre-school, where the children can learn scientific concepts as an everyday experience (Fleer, Gomes & March, 2014). Other researchers point out the importance of teachers being aware of children's knowledge. Eshach and Fried (2005), who have studied how children's previous experiences affect their involvement in play, claim that even small children can learn new concepts in science, as windows of opportunity to learn new concepts are created in the early years. To take care of these learning opportunities, pre-school teachers need to have both deep knowledge about the learning object/material, and how the child discerns the same learning object (Eshach & Fried, 2005; Thulin & Redfors, 2016; Kesner, Baruch & Mevarech, 2013). Setting the scene for developing a scientifically curious child requires teachers to possess knowledge of materials and how to design activities that challenge the child's interest. In their discussion of what constitutes a curious child, Spektor-Levy, Kesner Baruch and Mevarech (2011) claim that this is a child who explores different phenomena and who is open to discovering things it wants to know more about. If the child is given the possibility to investigate and understand how things work, not only is there more learning, but also more complex learning occurs. They found that almost all children who investigate an observed phenomenon asked more questions. In this study, the focus is on how different children interact and investigate scientific phenomena during construction play.

The aim is to study pre-school children's ways of discerning and sharing knowledge of a physical phenomenon (equilibrium) during collaborative construction play in pre-school. The results contribute new knowledge regarding how teachers can design and act to enhance children's collaborative learning during play. The research questions asked to fulfill the aim are as follows:

1. What characterises children's knowledge development during construction activities in collaboration with other children?
2. In what way do children with knowledge notice when and how to share this knowledge with children who have yet to obtain the knowledge?
3. What characterises children's sharing of embodied and expressed knowledge during construction play?

Knowledge and knower

In this study, knowledge is understood as the human relation to the environment and how the environment is experienced. Marton and Booth (1999) state that a 'knower' is able to distinguish different aspects and relations of a phenomenon. The more you learn about something, the more aspects of the phenomenon can be discerned. The context is crucial for what knowledge can possibly be developed, through offering the learner the opportunity to discern new aspects of what is supposed to be learned. In the Swedish curriculum for pre-school, where this study takes place, (National Agency for Education, 2016), four aspects of knowledge are defined (Carlgren, 1994; Carlgren, Forsberg & Lindberg, 2009). These aspects include: facts; understanding; familiarity; and skills: all interact with each other and are considered as nonhierarchical. Knowledge refers both to theoretical and practical knowledge. Facts refer to the purely informative aspect of knowledge and are with the ability 'to know'. Understanding refers to the ability to interpret and explain, i.e. to 'know why'. Skill focuses on practice or acting and means 'knowing how'. Familiarity is based on experience and 'knowing what'. Learning always takes place in a context where these different forms of knowledge interact with each other. To learn, both cognitive knowledge and sensory experiences are needed. Different individuals use different forms of knowledge to varying degrees. Thus, it is important not to consider the forms of knowledge as a step-by-step development (Carlgren, Forsberg & Lindberg, 2009).

The statements in the curriculum are based on research definitions about knowledge. Familiarity, according to Molander (1996) and Schön (1983), is described as knowledge-in-action where both practical and theoretical skills develop. Knowledge is developed by doing things on a regular basis and by gaining many experiences. Familiarity is defined as 'silent knowledge'. According to Polanyi (1962), knowledge has a foreground and a background. The foreground is the focus on which attention is being directed. In the background, there is experience, which is not pronounced, but which becomes a quiet part of the knowledge. It is in the interplay between foreground and background that learning takes place and which also influences how the outside world is perceived and understood. Polanyi (1966) uses the term 'tacit knowledge'. Gustavsson (2002) considers that in the notion of the knowledge of skills there is implicitly some form of reflection. In order to reflect, one needs to be able to put words on the knowledge, thus it is no longer silent. Practical action develops through reflection in an interplay between seeing and doing, and between theory and practice (reflection-in action). Consequently, theory is not overarching practice, but they are developed together through interaction (Schön, 1983).

Ryle (1949) talks about 'knowing that' and 'knowing how'. He makes a distinction between knowledge and knowing, where knowing is connected to the activity and practice. 'Knowing that' is the theoretical knowledge and 'knowing how' is the practical, embodied knowledge. Ryle (1949) relates that knowing how is not only about the practical skill, but also about understanding what you are doing and about acting with a purpose; the acting person is still learning. Merleau-Ponty (1945/2002) considers knowledge and intellectual ability as linked to the brain, as well as to the entire body. Increased body perception and body movement not only lead to better health, but also provide increased learning ability (Gustavsson, 2002). It is evident when researching young children that they show in action before communicating with words, having conquered the bodily and sensory knowledge (Gibbs, 2006; Pramling Samuelsson & Sheridan, 2016). They learn by observing and gaining real experience to learn how to act; and they learn in and through action. In many ways, the knowledge is embodied and shared with other children by moving and acting during play without verbal communication.

Scientific and technological knowledge

In this study, science is defined as subjects, or as sciences used to describe and understand nature and the surrounding world (Sjøberg, 2010). Humans have always been curious and have wanted to describe and understand the phenomena in the physical world. Science is based on empirical measurements, and new research contributes to new knowledge. To be considered scientific, the research has to be systematic and free from contradictions. The theoretical models are universal and can be used in many contexts (Harlen, 2010).

In this study, an aspect of science is studied – technology – and, even more precisely, construction play. There are differences between scientific and technological knowledge. According to Sjøberg (2010), the fundamental difference between science and technology should be that scientific knowledge is meant to understand the world, while knowledge is more theoretical and abstract. For technology, the goal is to solve practical problems. While science produces thoughts, rules and theories, technology produces products. Science is to 'know why', while technology is to 'know how', as it is applied and interdisciplinary. The word 'technology' comes from the Greek word *Têchne* and is used for arts, crafts and skill. Technology in this context is an activity that aims to accomplish something more than the activity itself, and it has a certain result or product (Gustavsson, 2002). Björkholm (2015) has a slightly different understanding of technological knowledge than Sjöberg (2010). Björkholm sees technology as both practical and theoretical knowledge. The theoretical knowledge is mostly silent, and knowledge is expressed both in physical and mental terms. Technological knowledge means different ways to discern and experience aspects of what to learn. It is a process where the individual develops a differentiated view and way of doing when discerning more aspects of the object. In this study, technology is understood as both theoretical and practical knowledge, where the theoretical knowledge is expressed by practical actions.

Theoretical framework

This study is based on the framework of variation theory (Marton & Booth, 1997; Marton, 2015). Variation theory is a learning theory that describes the conditions necessary for learning. The theoretical assumptions are that variation, discernment and simultaneity are intertwined and needed to make learning possible. Variation is required for discernment and, by simultaneous variation of different aspects of a learning object, discernment is possible. This study rests on an analysis where aspects that children have discerned are captured, and aspects not yet discerned are seen as critical aspects (Marton, 2015). Variation theory has been used to study pre-school children's learning (Björklund, 2014; Björklund & Pramling, 2014; Holmqvist Olander & Ljung-Djärf, 2012; Holmqvist, Brante & Tullgren, 2012), as well as by teachers learning about pre-school children's learning (Ljung-Djärf & Holmqvist Olander, 2013). The aim is to study pre-school children's ways of discerning equilibrium during collaborative construction play.

Participants and method

This study is conducted in two Swedish pre-schools. In Sweden, pre-school is a separate school for children aged 1-5 years. It is voluntary and the municipality is required to provide pre-schooling for children from the age of one. The task of the pre-school is based on the interaction between care, education, nursing and learning. Children's development and learning should be stimulated, and pre-school is to have children's interests and needs as a starting point. The learning opportunities are to enable the children to create, learn and explore. Learning should be playful and based on the children's perspective (National Agency for Education, 2016). Play and joyful learning, along with creativity, are emphasised. Furthermore, children are to be given the opportunity to use many different abilities and ways to learn (Pramling Samuelsson & Asplund Carlsson, 2014). The role of the pre-school teacher is to create conditions for children to be active and to have the opportunity to get to know their surroundings by interacting with other children and with adults. Although there are no achievement goals in the curriculum, a number of overarching aims exist where children's abilities to develop their understanding of the close environment are treated. In the curriculum revision 2010 (National Agency for Education, 2016), the goals to strive for in science and technology were clarified and the two former goals became five. One of the overarching goals for technology is to create the opportunities to build, create and construct using different techniques and materials (National Agency for Education, 2016).

In the study, two activities were identified and analysed from a richer data collection (Table 1). From the total sample of 34 children aged 3-5 years from two pre-schools, two activities with 3 and 4 children are the unit of analysis (Table 2). The pre-schools are situated on the west coast of Sweden. They have declared an interest in working with science and technology.

Pre-school A is situated in the countryside and has 10 age-homogenous departments for children aged 1 to 5 years. The pedagogical base is Reggio Emilia, and the school building has teaching studios and squares for children's play. The school grounds are seen as an extension of the main building, and are divided into different facilities for activities and sensory experiences. There are many different materials for the children to use for construction play. Finally, the two educators who are responsible for teaching science and technology are certified 'outdoor educators'.

Pre-school B is adjacent to a residential area close to a forest. It consists of six departments and a total of 120 children. Two departments are toddler departments. The other four departments have older children (aged 3-5 years), one of which is a

Pre-school	Children (N)	Mean age (Y) children	Video-recordings and field notes	Teachers (N)	Meetings
A	1	4,7 Y	November: field notes	2	3
	9	4,7 Y	December 2016: 39:36 min		
B	4	4.9 Y	November 2016 22:45 min	2	3
	25	4,4 Y	November 2016 46:04min	4	

Table 1: Participants and data collected.

participant in the study. This department has a clear interest in working with science and technology, with a particular focus on sustainable development.

The methods used were field notes, video-recorded observations and meetings. The video observations of the children's two activities were analysed qualitatively. Firstly, the video recordings were analysed to capture the activity. Thereafter, they were analysed from each participating child´s perspective. This was done twice for each child, with the focus on each child's verbal and body language. Finally, each child's activity with other children was analysed.

In the analysis, video clips have been selected to show cases of critical moments where children showed knowledge and guided other children in the activities, as well as the sequences where children develop their own knowledge. All video recordings have been transcribed verbatim and analysed based on variation theory (Marton, 2015), which means that aspects that the children have discerned were studied in relation to the object equilibrium.

The ethical aspects and considerations of the study were handled according to current ethical principles for research (Swedish Research Council, 2016). The names in the results are fictitious in order for the children to remain anonymous.

Pre-school	Activity	Number of children (N)	Mean age	Participating teachers (N)	Activity duration (time)
A	The seesaw	3	5,1 Y	0	1m 11s
B	The tower	4	4,9Y	1	22m 14s

Table 2: Participants and data collected.

Results

Activity A: The seesaw.

Activity A takes place in the pre-school yard, where there are many different materials to use for building and constructing. A few days earlier, the children and the staff constructed seesaws made of logs and planks. Now the three boys are playing on one of the seesaws. In the video clip, they are exploring how to make the seesaw move up and down when all three are swinging simultaneously.

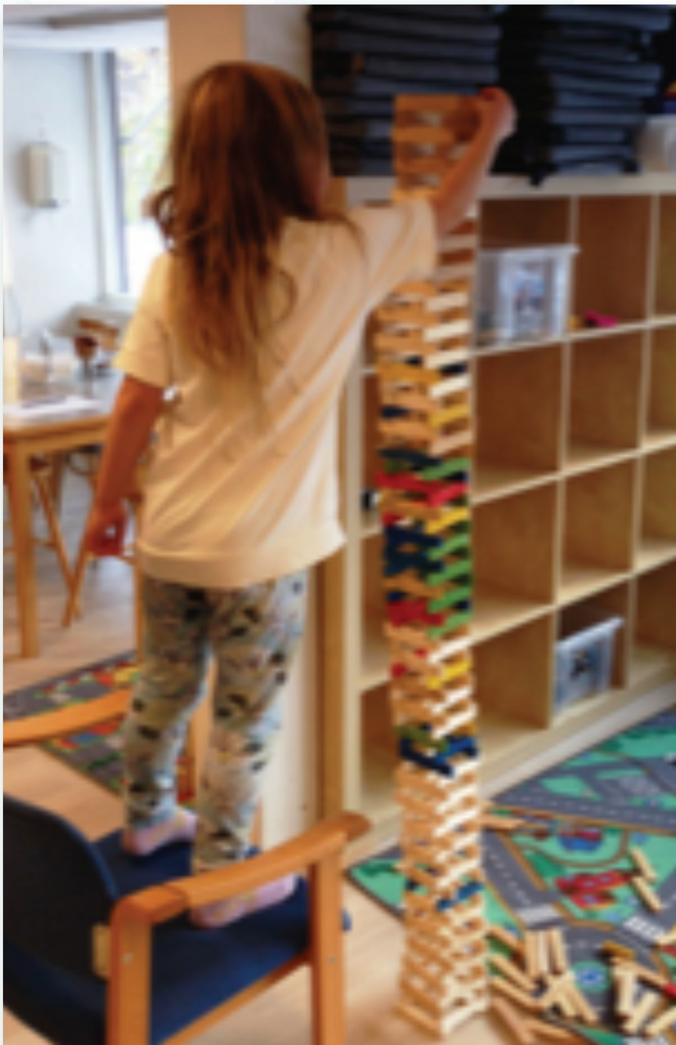
Activity B takes place in the building space. A girl starts to construct a tower, while a pre-school teacher is building one beside her. Another girl is supplying them with blocks, but she does not want to build. Two boys are playing. When one becomes inspired to join in, he also starts to build a tower. The other boy is playing beside the construction activity.

During these two analysed activities, the children have the possibility to explore the phenomena of equilibrium, centre of gravity and balance (Table 3). The results of the analysis focus on: 1) the children's knowledge development during the activity, 2) how children notice when and how to share knowledge, and 3) the character of children's shared embodied and expressed knowledge. The analysis is based on the framework of variation theory, thereby identifying what aspects the children discern and the pattern of how the aspects vary simultaneously. The excerpts chosen to illustrate the results show both verbal and embodied knowledge expressions.
The results are compiled in themed categories following the research questions.

In the first activity, the children are exploring movements of the seesaw. Aspects made possible to discern during the seesaw activity are as follows: the movement of the lever, the centre of gravity and the turning point. In the second activity – the tower – the children try to make the tower stable. Aspects possible to discern are the following: centre of gravity, gravity in relation to height, and balance (Table 3).

Children's knowledge development during construction activities

The first research question focuses on the children's knowledge development during the activity. During the seesaw activity, the focus of knowledge is strongly connected to embodied knowledge. The children move along the seesaw to adjust and explore in what way they can affect the movement as they wish. As there are three children moving at the same time, they have to collaborate



Activity B: The tower.

Activity/ Phenomenon	Pursued goal of the activity	Aspects made discernible		
A The seesaw	Movement	The movement of the lever	Centre of gravity (position of the bodies)	Turning point
B The tower	Stability	Centre of gravity	Gravity/height	Balance

Table 3: Discerned aspects of the phenomenon.

to make it work. One of the children, Arvid, has developed more knowledge of how to move to make the seesaw swing. Oskar has limited knowledge in relation to Arvid, which is expressed through him not noticing the other children's movements. Finally, Calle has not discerned how to move to affect the seesaw's swing or how to estimate the other children's movement to move in accordance with them. He has difficulties establishing balance, falls off the seesaw, and then asks the others to help him.

At the beginning of Activity A, Oskar's focus on his own body is expressed by him standing on the seesaw balancing with his arms in order not to fall off, and him not recognising the movements of Arvid, who has taken control of the swing. After a while, he discovers how his own movements on the seesaw affect the swing. When he is standing in the middle, he can have an affect by moving his foot one step aside, thereby getting that side of the seesaw down. Calle is the one who develops the most knowledge. At the end of the activity, he has discovered that, if he swings his knees and lies down at the furthest end of the board, he gets more power to lower it**.** This is expressed in a non-verbal way:

> **Excerpt 1:** *Tries to climb with the right foot, then left foot, but realises instead that he can sit on the board. Looking happy and points back with one hand as he puts the furthest out and gets down the board onto the ground. Rolls off the ground* (Calle, 5:0)

Arvid is the one with most pre-knowledge, but he does not seem to develop knowledge during the activity.

In Activity B, Agnes is the one who has developed most knowledge about constructing towers. This is expressed by her building a high tower and telling the other children how to place the blocks to establish a stable construction. She has experienced the importance of the centre of gravity and equilibrium to be able to build a straight tower, as the risk of the tower collapsing increases with its height. She constructs a new phrase to describe a tower in danger of collapsing; she says that it is 'oblique high'.

> **Excerpt 2:** *My tower can be even higher. It can get more oblique high!* (Agnes, 5:6).

After having two towers collapse, she uses her knowledge concerning the importance of building as straight as possible. When constructing her third tower, she builds at an even pace and is more careful how she places the blocks. David develops his knowledge the most during the activity. He studies Agnes carefully and is also inspired by her enthusiasm. He tries again when the first tower collapses. He manages to build higher each time. Both Agnes and David have the knowledge that a larger support area enables a more stable construction, and the first layer of blocks is placed flat on the floor. The children constantly adjust the blocks, as they know that the weight distribution is important for stability. They also have the knowledge that bricks that are thicker make the tower collapse. This knowledge is embodied. By just feeling the blocks in their hands, they can tell that they are thicker:

> *Excerpt 3: Agnes: They are too thick. Then it doesn't work, the whole construction can collapse. David: Because they are too thick... too fallish* (Agnes, 5:6, David, 4:3).

Erik does not develop his knowledge about constructing in the activity. He has no knowledge about how to create a stable construction, and he gets very frustrated when trying to build:

> *Excerpt 4: I can never build. Mine turns very easily. I cannot build more than 3cm because then it falls immediately. I think it is very boring to build this. I think it is very boring* (Erik, 5:1).

How children with knowledge notice when and how to share their knowledge

In Activity A, Arvid notices most of the other children's knowledge and their need for help. He shares his knowledge by facilitating for the others to join in. Oskar looks at Arvid to learn, and he also teaches Calle, who does not notice the others to a large extent; rather, he focuses on his own development.

Arvid has the knowledge that he controls the centre of gravity by moving his upper body and his feet forward or backwards. He sees the relationship with how the other children place themselves, and he acts with his body to compensate their weight. At the beginning of the activity, Calle has not discerned the connection between how he is placing his body and the movement of the lever. Then the other two boys help him. For example, Arvid steps off the seesaw to lower it, which enables Calle to climb on. By studying Arvid, Oskar discerns, after a while, that how he places himself affects how the seesaw is moving. He notices that by placing himself in a different position on the seesaw he can help Calle join in.

In Activity B, Agnes and David build their own towers, and they focus on their construction. There is an ongoing conversation about the construction of the towers and the importance of equilibrium and centre of gravity while building. David often stops and listens when Agnes and the teacher discuss how to build. Agnes and David notice that Erik wants to build a tower, and they try to instruct him, both verbally and by showing him how to start building. Erik tries to build according to their instructions. Because he has not yet discerned the critical aspects for the stability of a construction, he does not succeed in building a tower.

Children´s sharing of embodied and expressed knowledge

During Activity A, on the seesaw, the children's verbal communication takes place through sound, and only a few words are uttered. They communicate mainly with body language. Arvid notes and clarifies his movements to make it possible for the others to see what to do. He shows with his body where and how one must place the body to get the board moving up and down. Oskar notes not only Arvid's attempts to help Calle, but also Calle's needs, which means that he can help Calle. Consequently, Calle is a recipient. When he does not know how to negotiate the seesaw, Calle shares his frustration verbally to get help from the others.

In Activity B, the tower, the communication between the children is both verbal and through body language. Agnes shares her knowledge verbally in her conversation with the teacher. She also shares her knowledge by her enthusiasm when constructing towers. While building, she shows and tells the other children how to build for equilibrium and of the importance of the centre of gravity not shifting. She stacks a block and adjusts it before she places the next one on top. This is repeated. She shares her experiences from earlier occasions. She also notices when David needs help to read out the numbers on the ruler when measuring the height of his tower.

David has some knowledge from building on earlier occasions. Although he knows how to start building, he needs more knowledge to construct a high tower. Because he notices that Erik needs help to get a more solid construction, he gives him advice on how to start his construction. Agnes also shares her knowledge with Erik when he has problems with the tower falling down.

To summarise the findings of this study, the following conclusions are drawn:

In both activities, the repeated actions are of great importance for knowledge development. It is also obvious how the children inspire each other to try over and over again. Children with the most knowledge show more self-confidence in the activities. They can focus on themselves and share their experiences with the other children. In the activities, however, they did not develop their knowledge to a large extent. Both Oskar (Activity A) and David (Activity B) developed their knowledge by studying the children with more knowledge. They also developed their knowledge by noticing and sharing with the ones who have less knowledge. The children with less knowledge – and who had not yet discerned the critical aspects – expressed their frustration both verbally and bodily.

On the seesaw, a critical aspect to discern is where to place the body in relation to the others on the lever to make it go up and down. Arvid has discerned this aspect from the start of the activity. For Oskar and Calle, however, it takes some time to do so. For Calle, a critical aspect is also to discern how to climb the lever. At the end of the activity, Calle has developed knowledge of how to get down the seesaw by placing himself at the furthest point on the board, and he shows his understanding with his body. The seesaw is made of a board and a log, and the turning point is not fixed. This causes the board to move. Consequently, the lever arms become unequal in length and the equilibrium is unbalanced. This is a critical aspect not discerned by the boys.

To construct a stable tower, critical aspects are how to place the blocks to create a large supporting area at the bottom and how to stack the blocks to keep the equilibrium. Another critical aspect to discern is the higher the tower gets, the greater is the risk that it will collapse if the centre of gravity shifts. Agnes has most knowledge from earlier experiences, and she manages to build a high tower. David has less knowledge and less experience, but he develops his knowledge in the activity and manages to build his highest tower. As Erik has not discerned the aspects, he does not succeed in getting his tower higher than three layers of blocks before it collapses.

Seesaw	Arvid	Oskar	Calle
Knowledge development	-	+	++
Notice when and how to share knowledge	++	+	-
Sharing of knowledge	++	+	-

Table 4: Discerning and sharing knowledge – seesaw.

Tower	Agnes	David	Erik
Knowledge development	+	++	-
Notice when and how to share knowledge	++	+	-
Sharing of knowledge	++	+	-

Table 5: Discerning and sharing knowledge – tower.

Discussion

The results show that children who had discerned more aspects of the phenomenon of equilibrium were also able to use their knowledge during the activities to a higher extent than children with less pre-knowledge. The former needed some kind of input from their classmates to discern aspects important for understanding. The children with knowledge made it possible for the other children to explore the phenomenon and participate in the activity by acting as 'models' during play. By repeating their method of how to play, they visualised for the rest of the children how to discern aspects. The results implicate the great importance of rich opportunities for children to have repeated experiences of different phenomena to deepen their knowledge and understanding in science in pre-school (Thulin, 2011; Spektor-Levy *et al*, 2011). In the studied activities, children's knowledge plays a role in the volition to start an activity and to implement it. To promote learning among children with knowledge, it is important that pre-school teachers utilise activities that make it possible for the 'knowers' not only to play in the same way, but also to challenge and develop new knowledge (Mawson, 2013; Hallström, Elvstrand & Hellberg, 2014).

The pre-school teachers' role is to encourage and challenge the children to discern new aspects of the learning object that are crucial in learning opportunities that children meet. The boys in Activity A did not discern the different length of the lever arms. Therefore, they did not adjust the plank to get it balanced at the turning point. With a teacher present during the activity, leverage could have been put in the foreground as a learning aspect to explore further. According to Mawson (2013), it is important to take advantage of such experiences to develop children's learning in technology.

The tower construction resulted in more children at the department being inspired to build towers. The children continued to build towers, and they explored how high they were able to build. The results were posted on a list on the wall to compare the height of the towers. After some practice, David managed to build even higher than before, with the tower reaching almost one metre. Agnes built one over 2 metres, with her tower reaching the ceiling. The trial-and-error behaviour is an important aspect of learning in construction play (Van Meeteren & Zan, 2014). Construction play is also a way to develop spatial reasoning and motor skills, which are important factors when, for example, constructing.

In the studied activities, it has also been shown that children learn by observing. Moreover, when they get the opportunity to try to do things, they learn in and through action. Just as Gibbs (2006) and Pramling Samuelsson and Sheridan (2016) claim, it is obvious – as seen in Activity A – that the children's knowledge is in many ways embodied and shared during play without verbal communication.

The teachers at both pre-schools in this study possess a positive scientific attitude (Fleer, Gomes & March, 2014). These teachers work deliberately with science at an everyday level. They take advantage of opportunities when children show interest in different phenomena in the environment. Moreover, they design the pre-school for informal science learning to provide the children with experiences and to get them engaged in science (Fleer, Gomes & March, 2014). This attitude offers good conditions for children's learning in science and technology.

Conclusion

In view of the results in this study, I agree with Thulin (2011), who maintains that children need to repeat the same construction activity several times to get a deeper knowledge and understanding of the phenomenon. The more knowledge they get, the more interest they develop in the phenomenon. Like Thulin (2011), Mawson (2011) believes that children need to work for an extended period of time with the same area of knowledge. It is important that teachers have the knowledge and experience to support and challenge children as they play and learn.

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