Appendix 3: Selected Episodes

Episode: BE Carpenter Corner	**Setting:** PreSch	
Subject: Mathematics	**Age Group:** 4-6 years old	**Teacher**: Maaike
Key factors:		
Learning activities: Planning investigations / Making connections		
Pedagogy: Teacher scaffolding / Role of problem solving and agency		
Contextual Factors: Self assessment / Rich physical environment for exploration / Variety of resources		

Aims

This activity took place on the first day of a new atelier (workshop) cycle. Maaike wanted to observe the children to get to know what were their interests and talents. They had to choose which materials to use, what they wanted to explore and what they would like to design and make in the 'Carpenter Corner'.

Analysis of key features

The Carpenter Corner had a **very rich physical environment** with a special work bench and with real carpentry tools; several saws, nails, pincers, hammers, and wooden materials were made available. The children could also go outside the classroom to bring in other materials. Maaike stressed the importance of using real materials to design and inquire. The children could select the materials they wanted to use by themselves, so, **ownership and agency** was very much stimulated.

Two children chose to work in the Carpenter Corner. One of the children was a four year old girl; she belonged to the (morning) class group of Maaike and Sarah (who team teaches with Maaike). The other child was a five year old boy. For him everything was new as it was his first time in this atelier and this classroom. Maaike encouraged the children to work with their peers and children who were confident with an activity were expected to teach those who were less competent.

During the episode the two children **planned to make a house**. First they had to learn how to saw the wood. Maaike showed the children how to use the saw and explained that they always had to use the saw when other people were present for safety reasons. To use the saw, the wood had to be placed in a clamp to hold it still. The girl opened the clamp on the work bench and, when asked by the teacher if their box would now fit in, **the children decided to measure** their box. The boy **initiated this use of mathematical skills** himself and found a folding ruler (meter) to measure their box. He made careful marks with a pen to make his measurements accurate.

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The initiative of the children was encouraged tremendously; the children were allowed to work with all materials in the Carpenter Corner. Instructions were only given for safety reasons. The different materials stimulated the imagination and the creative thinking of the children. By asking questions, the teacher also **stimulated the children's reasoning and problem solving skills**.

Opportunities for inquiry and creativity

The resources looked exciting and appealing as the carpenter corner looked just like the work area of an adult carpenter. The children were able to work freely in this area – probably unlike any previous experiences, if such equipment was used in their homes. The **children were fascinated by the different tools** in the corner and enjoyed playing with them before they started making anything. **Playing with the various tools helped them to make their own choices** about what materials to use and how to make their own design.

Children were able to **make connections** with other subject areas. Some children **integrated artistic skills with their design whilst others adopted a more scientific/mathematical approach** using measurement skills in the making of their product.

Children led their own activities and the teacher only intervened to show them how to use a new piece of equipment or to promote the children's reflection and evaluation of what they were doing.

The children were engaged in **self-assessment** as they all had to evaluate what they had made themselves. No child's creation was copied as the designs came from the children themselves. They evaluated what they had made and also the processes they followed.

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ILLUSTRATIVE EXTRACTS FROM DATA

Rich variety of resources/ Agency – children solving problems themselves

The children could choose from a wide variety of resources in the Carpenter Corner. Child 1, who had never worked in this corner before, had a very good idea to transport the wooden materials.

Child 1: *Can I use that big bucket?*
Teacher: *Why do you need a bucket?*
Child 1: *I would like to transport the wooden materials in it, because otherwise I can get a splinter in my finger.*

Working with peers to encourage agency

Peer tutoring was encouraged by placing older children with younger children.

Both children worked together to build a house.

The 4 year old girl, however, did not know exactly what to do; the teacher said to the 5 year boy: "*Could you explain it*?"

The boy answered and showed what had to be done.

In this activity the boy was the designer and the girl liked to be doing things. Later, the boy continued to work on this house whilst the girl made lots more smaller houses.

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Children encouraged to assess what they are doing

Although there were instructions from the teacher, children were also stimulated to reflect on what they were doing.

The boy suggested they needed to saw a window in their house. The teacher showed the boy and the girl how they must clamp wooden box in the workbench in order to cut it safely. They needed to turn the lever, so that the work bench opened. The girl started turning the lever, the teacher asked several times, "*Does the box already fit in the workbench?"* Each time it was measured by the girl and the boy.

Making connections – linking mathematics and science

Child 1 wanted to measure the wooden box. He recognized the need for accurate measurements.

Child 1: *I'm going to have a look with the meter* (ruler).
Teacher: *Yes, you can measure it.*

Child 1 finds a fold meter (folding ruler) in one of the bins and he unfolds the meter. He kneels on the ground.

Child 1: *I'm going to look how long this measures.* (He measures the wooden box.)
Child 1: *That's not going.*
Teacher: *Is it not good?*
Child 1: *I have to have a pen.* (He draws a line on the wooden box.)
Teacher: *Child 2 is it already OK?*
Child 2: *No.*
Teacher: *Maybe Child 1 has to put there a line too, such as here.*

The teacher showed the other measurement that was done by Child 1.

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Episode: BE Colouring	**Setting**: PreSch	
Subject: Science	**Age Group:** 5-6 years old	**Teacher**: Lies
Key factors:		
Learning activities: Planning investigations / Explaining evidence		
Pedagogy: Teacher scaffolding / Collaboration		
Contextual Factors: Variety of resources / Rich physical environment for exploration / Use of outdoors		

Aims

The goal of the teacher (Lies) was to engage the children in extracting dyes from a range of natural materials, to identify factors that affect the dyeing process (e.g time and temperature of the water) and for the children to engage in collaboration and autonomous learning.

Analysis of key features

The activity was part of a bigger project about American Indians that the children had chosen to do. The children found out that some American Indians use natural dyes to colour their clothes, so the children first explored how to dye cotton fabric and later on they made their own clothes.

This episode focuses on four girls who chose to work in the corner where they were dyeing pieces of cotton fabric with dyes from natural products. On the table were **a rich variety of materials, such as oranges, grass, herbs, coffee, tea (also rose hip tea), funnels, sieves (in different sizes), cutting boards, scissors, cups and knives**. The children were also allowed to go **outside to collect more natural materials** if they wanted to do so.

To **scaffold the children's technique for extracting the dye** the children were given an instruction card with pictures showing how they have to handle the natural materials and how to separate these materials from the coloured water to extract the dye**. Lies only interacted when necessary or when the girls explicitly asked for her help.** The children were given the freedom to select the materials themselves and two of the girls **decided to go outside** to collect more grass and mud for their investigation.

Although the children had an instruction card to guide them, **they were allowed to plan their own investigations**, for example, they had to **choose which sieve to use by investigating** which size was most successful at separating the materials from the water. Indeed, one child chose not to sieve her coloured water at all. They could also **choose how long to leave the cotton fabric in the water** and one girl left her cotton fabric longer in the water and **she noticed the colour deepened the longer it was in the dye**.

The children worked together giving each other instructions about how to follow technique of making the dyes and how to do so safely when handling warm water. They took turns in stirring the water and **discussed how much**

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orange peel to add and how small the pieces of peel needed to be to get a deeper colour of dye. The children were not sure what colour the dye will be with some of the materials: *"I'm curious what colour this is going to be"* one girl said to her partner. *"I'm also curious"* was the reply but they were confident to predict that the curry powder would be yellow.

In order to bring in an even wider range of natural materials, the teacher decided **to go outside to the park** with the children after playtime so they could find more natural materials in the park.

At the end of the activity the children had a class discussion where Lies asked Girl 3 questions to scaffold her explanation of why she decided to leave her fabric in the rose hip tea dye longer - *"because it hasn't enough colour"*.

Opportunities for inquiry and creativity

Although the children were given support with the instruction sheet they were still in control of planning their own investigations. By following their own ideas **they were curious about the results and were very motivated to explore further**. This curiosity was demonstrated by the girls who went outside to collect other materials, which were not present on the table, such as grass and mud.

Providing a range of materials stimulated another girl's interest and **she carried out her own investigation** in which she chose to explore what would happen if she added several different natural materials to the water rather than just one.

The teacher's role was one of facilitator and to provide support when the children needed advice. The interactions between the teacher and the children were short and focused on questions that promoted the children to reflect on their ideas. Thus, the children **were able to make their own decisions** as could be seen by one girl who left the materials in the water and did not separate them from the water before adding her cotton fabric to be dyed.

By supportive questioning the teacher also enabled the children to provide **their own explanations** of their evidence.

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ILLUSTRATIVE EXTRACTS FROM DATA

Providing a rich variety of resources

The children had lots of different materials from which to extract dye and a wide range of equipment from which to choose. They could also go outside to choose other natural materials to use to dye their fabrics.

Child 1: *We went for more grass.*
Child 2 (who stayed in the classroom): *You may pour water in your cup.*
Child 4 (who also stayed in the classroom): *If you want to bring in the new grass, you first have to put this grass in your cup. And if you want to have water in your cup, then you have to ask her* (she means Child 3).

Children collaborating

Child 2: *I cut it with a knife. It has to be little pieces.*
Child 4: *Like this* (She showed a piece to Child 2.)
Child 2: *A little more warm water.*
Child 4: *There is some in the measuring cup.*

Child 2 took it and Child 4 held the cup with her hands. However, Child 4 did not want Child 2 to add too much additional water, so she pushed the measuring cup away.

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Scaffolding the dyeing technique

Child 1: *Teacher, may we do it in little pieces?*

She showed how she did the pieces in the cup before her.

Teacher: *You may do it. Look, you can see here what the child is doing.*

And the teacher pointed to the pictures on the instruction card.

The children talk to each other about their techniques and ideas

Child 1 was still cutting up the materials with her tongue sticking out of her mouth concentrating hard. Child 3 was saying "*Little pieces*" to her.

Child 1 to Child 3: *But my fingers are almost broken.* (They, however, continue to cut up the material even further.)
Child 1: *I'm curious what colour this is going to be.*
Child 2: *I'm also curious.*
Child 1 to Child 2: *With you, it will turn yellow.* (Child 2 is working with the curry powder.)

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Episode: BE Sand Box **Setting**: PreSch
Subject: Integrated **Age Group:** 3 years old **Teacher**: Katrien
Key factors:
Learning activities: Gathering evidence (through observation) / Gathering evidence (using equipment)
Pedagogy: Role of play and exploration / Role of problem solving and agency
Contextual Factors: Rich physical environment for exploration / Formative assessment

Aims
During this activity the children had to build something using the materials provided by the teacher. The children decided what they wanted to build after playing with the resources provided and they could choose whether to work individually or with others.

Analysis of key features
This episode was situated in a theme about stones. In the sand corner the teacher had placed **materials to build with, including real bricks**. They also had unfamiliar **specialist tools to help with the building process** such as plaster trowels and spirit levels, as well as the familiar bucket and spades.

First, the two children worked separately in order to make their own wall. However, after some time they started working together to build one wall and they shared the tasks required to prepare their materials. The teacher guided the process by asking the children what they had done or what had happened. When, at the end of the activity, the wall fell down, the teacher (Katrien) interacted with the children to discuss the reasons why the wall fell down.

In this activity the learning process of the children was characterised by the ownership of the children, who were learning by doing and **by observing the effects of their actions.** For example, when Child 2 was pouring out the water to mix with the sand she noticed that the sand was not mixing enough with such a great amount of water and so she poured some of the water out of her bucket. Child 1 **observed this effect** and only put a little bit of water on the sand in his bucket, indicating that he had **used the evidence** from his partner's mixture to make decisions about his own mixture.

The **self regulated learning and construction of their play** was also enhanced by the space they got from the teacher, for example, the teacher was present in the classroom observing the children, but she gave them more than 10 minutes before she came to interact with them. When she did interact, the main focus was on appreciating what the children were doing and on supporting them to go on to a next step. **The teacher offered learning opportunities** just by making the suggestion to place the bricks next to each other, to offer new possibilities in the play of the children. Katrien scaffolded her questions to

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help the children reflect critically on their work in order to promote their conceptual understanding.

At the end of the activity Katrien took time to assess what the children had done and to ask the class a new question. She asked them to look at the walls of the school building when they are playing outside to see if the bricks are laid in the same pattern as they had used when making their wall (i.e. one on top of the other). All children in the class were involved in the discussion, thus, what was learned by a few children could be shared with all the others. During the sand box activity the children learned a lot about the effects of combining sand and water, and how to use this combination to **solve the problem** of how to fix bricks together in order to build a wall successfully.

During their **play they also came across different strategies** to balance their bricks, and the importance of placing them in a balanced way. They also got the opportunity of using different materials in order to construct their wall.

To find evidence that their walls were level the children used spirit levels to measure whether the bricks they had placed in their wall were level.

Opportunities for inquiry and creativity
In this episode the children were working very independently and had **to make their own decisions** about what materials to use and how to prepare them; they **made their own plans** about what to build and whether to work on their own or with other children. Building a wall **presented the children with problems** of how to stick the bricks together and the best way to place the bricks.

The materials the children could use provided a rich set of resources as they included real bricks rather than toy bricks and special technical tools that they did not know how to use at first. **Playing with these tools helped the children work out how** to use them in the building process.

The activity presented them with several problems and they were given the **opportunity to solve these problems themselves**. This episode also contained opportunities for **collaboration between children** as they played, they watched what each other did and they made decisions based on **their observations and evidence** of the impact of what other children were doing.

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ILLUSTRATIVE EXTRACTS FROM DATA

Interaction with the resources – at the beginning separately and then together

The children have different starting points concerning the content of the activity.

Child 1 is filling the bucket with a shovel until it's completely full.

Child 2 is filling the bucket until it's semi-full.

Later they worked together:

Child 2: *I have to make some more mortar.*
Teacher: *Why?*
Child 2: *To help Child 1 with the building.*
Child 2: *I need more water then.*
Child 1: *I also want some more water.*

The teacher let them go and fill their beakers with water.
Child 2 is adding some more water to her bucket.
Child 1 is adding water to his bucket filled with sand.

Child 2: *We need 2 more bricks!*
Child 1: *I will make them.*
Child 2: *I will place some sand.*

Children's self assessment and learning from each other

The children, who were learning by doing, observed the effects of each other's actions and changed their actions accordingly. Child 1 watched Child 2 pouring the water into her bucket and she noticed that the sand was not mixing enough with that amount of water:

Child 2 puts some more water in her bucket and starts stirring again. After a while she notices there is too much water and she pours out some water.

Child 1 assesses that only a small amount of water is required and so puts a little bit of water on the sand in the bucket.

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Children's play – observing effects of their actions

The wall the children had been building fell down.

Child 1 continued to prepare his brick ready to keep on building.

Child 2 tried to rebuild the fallen wall by replacing the bricks up on each other, but she failed to lift them up to be able to place them up on each other. After a few tries, she placed one brick on top of the two bricks next to her side of bricks. Then she grabbed the stone below and placed that one on top of that side of the wall.

Child 1 is finished with preparing his brick and looks at the actions of Child 2. Child 2 is trying to place her two resting bricks on top of the tower, but she doesn't succeed. She seeks help from Child 1.

Child 2: *Child 1, can you make this?*

Child 1 grabs the bricks and places them one by one on top of the wall.

Child 1: *Please!*
Child 2: *I will place some more wet sand on top, so the next one will be fixed in a proper way.*

Teacher scaffolding – questions for the children

Teacher*: Oh, look what happens?* (She lets the stone loose and they fall).
Teacher: *How is this possible?*
Child 2*: Because it wobbles.* (…) *I will take some wet sand.*
Teacher: *Can you place the sand on the brick?*
Child 2 places the sand on top of the brick.
Teacher: *Can you make it completely flat?*
Child 1 hands over the plaster trowel. Child 2 makes it flat with the plaster trowel.
Teacher: *Can you place the next brick on it now?*
Child 2 is placing the brick on top of it.
Teacher*: Can you use your spirit level to see if the bricks are in balance?*
Child 2 places the spirit level on the bricks and sees they are balanced.

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Episode: FI Melting Snow	**Setting**: PreSch	
Subject: Science	**Age Group:** 5-6 years old	**Teacher**: Mary
Key factors:		
Learning activities: Gathering evidence (using equipment) / Gathering evidence (through observation)		
Pedagogy: Teacher scaffolding		
Contextual factors: Small grouping / Formative assessment / Outdoor resources		

Aims

The aim of the activity was for children to observe states of water and know what happens to snow when heated. This experimental activity was typical of the sort used in which the children learn to plan an experiment. They also learned how to estimate and conduct the experiment, observe the changes during the experiment (follow the process of boiling) as well as becoming familiar with scientific concepts such as melting, boiling, heating, evaporation, liquid and solid.

Analysis of key features

In this learning activity the children studied snow and the states of water. They were set a problem-based activity; what happens when snow is heated? The children collected snow using various measures, through these they also learned measurements e.g. 1 litre, ½ litre, 3 decilitres. Because the camping cooker was used for heating the snow, for safety reasons the activity was partly in the form of a demonstration; the teacher was strongly involved in the activity and asked questions about the phenomena observed.

The teacher asked for volunteers to participate in the activity and provided materials. The children worked independently but followed the teacher's guidelines. The children worked in small groups of 5 or 6 and each had individual responsibilities to a) collect snow b) follow the experiment, including observation and discussion with the teacher and c) mark down the results of the experiment. The teacher conducted the experiment twice with two different groups of children.

The teacher lit a fire in the camping cooker outside the classroom and asked the children to use **containers of different shapes**, but all with a volume of one litre, to collect snow. Once the children had collected the snow, the teacher poured the snow from one of the children's containers into a bowl on the cooker.

The teacher used **questioning to scaffold** children's **predictions** about what would happen to the snow and to focus their **observations** e.g. *"What do you think, how much water will we have when the snow has melted*?", "*What you can see here*?" (pointing at the steam). Later, the teacher poured the water from the melted snow back into the original container, and asked the children to observe if there was more or less water than there had been snow.

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When working with the second group, the teacher asked the children to compress the snow when they were filling up their containers. When the snow they had collected had melted, she asked the children whether they would have more or less water than the first group.

Once the experiment had been conducted, the children were asked to **record individually what they learned by making a drawing** on a blue piece of paper, which featured images of two containers. Children were to colour with white chalk one container full of snow and to indicate the amount of water that was observed as a result of the experiment in the other container.

Several **formative assessment** strategies were used during the session and there were signs of learning assessment. The teacher provided feedback during the whole-group discussion and asked questions, observed the children's activities and shared reflections with them. She also collected the children's drawings to evaluate their understanding. Reflection together with the children, and the teacher's questions e.g." *How do you know that we have 1 litre of water here*?" also provided an arena for self-evaluation.

Opportunities for inquiry and creativity

Children's **inquiry skills** were fostered as they were tasked to find out about what happens when snow is heated by **making predictions and gathering evidence using observation and measuring equipment.** Children were supported in trying to solve the problem, follow the change of state of water and discover the reasons for it. **Teacher scaffolding** and involvement varied across the episode as she was guiding the approach to the activity, encouraged children to articulate and reflect on their observations and drew attention to concepts and processes associated with changes in state.

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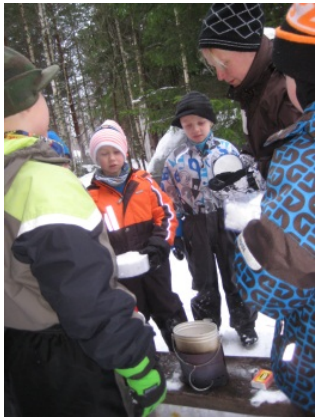
ILLUSTRATIVE EXTRACTS FROM DATA

Teacher questioning to scaffold discussion with the children about their observations and measurements



Snow is melting in the camping cooker.

Teacher: *What do you think, how much water will we have when the snow has melted?*
Children: *More / Less.*
Teacher: *What you can see here?* (pointing to the steam)
Children: *Steam.*

Snow has melted into water. The teacher pours water back onto the dish.

Teacher: *What do you think now: Is there more or less water than when there was snow?*
Children: *Less*
Teacher: *Could you tell me how much there is approximately?*
Children: *There are 3 litres, there is ½ litre, there is 1 litre.*

After discussion they agree that there's about half a litre of water.

Teacher: *How much snow did we have?*
Children: *One litre.*
Teacher: *So when water is in the form of snow it needs more space.*

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Making a drawing to record learning

Children were asked to **record individually what they learned by making a drawing** on a blue piece of paper, which featured images of two containers. Children were to colour with white chalk one container full of snow and to indicate the amount of water that was observed when it had melted in the other container.

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Episode: FI Multiplication Story **Setting**: Sch
Subject: Mathematics **Age Group** 7-8 years old **Teacher** Helen
Key factors:
Learning activities: Communicating explanation / Making connections
Pedagogy: Affect / Collaboration / Children's agency
Contextual factors: Peer/self assessment / Materials that foster creativity

Aims

The aim of the activity was for children to learn about multiplication through story making. The teacher (Helen) told the observer that in an earlier lesson they had made up this kind of story using the same paper form, so the approach was already familiar to the children. She said that it is important to use different kinds of examples so that children understand that they can use any sorts of objects or things in the stories.

Analysis of key features

Helen, the teacher, started the lesson by drawing a tree with three branches on the blackboard. With the whole class, Helen discussed how to make multiplication questions from the drawing she had made. She then went on to draw two apples on each branch, and subsequently two leaves on each apple. Again, the children were encouraged to create multiplication questions from the additional details she had drawn.

Right after the whole group discussion the children **worked in pairs** to collaborate in creating their own multiplication stories and questions as well as in recording them on a worksheet. The worksheet provided space for children to record their multiplication stories in diverse ways, ranging from graphically and numerically to using words, highlighting how Helen valued **diverse forms of expression**. The teacher observed and scaffolded, using questioning to prompt children to articulate their questions and ideas.

At the end of the lesson the children told their stories to the whole class. This encouraged children to **communicate and explain** their ideas, and to share and discuss different possibilities for mathematical stories linked to the apple tree. The stories created in the activity supported the children's understanding of multiplication. The mathematical operations were discussed and the children learned how to create and solve mathematical word problems.

The children were also encouraged to engage in **self-assessment** by writing their feedback at the bottom of the worksheet.

Opportunities for inquiry and creativity

The activity of writing their own stories encouraged the children's **imagination** and **creative thinking** skills, and working in pairs motivated them and provided an opportunity for **engagement and agency**. Questioning was a crucial part of collaboration with the teacher, and dialogue was fostered in peer interaction.

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In generating multiplication problems and stories relating to children's everyday experiences children **made connections** between mathematical concepts and learning in the classroom and mathematical patterns and relationships in the living world outside. The task aroused children's **curiosity** as they were **motivated** to explore more **connections** between school mathematics and mathematics beyond their classroom.

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ILLUSTRATIVE EXTRACTS FROM DATA

Teacher questioning to scaffold children's ideas, questions and story making

The teacher asked questions about the tree, and several children answered:

Teacher: *I have drawn a tree on the chalkboard. How many branches are there? / Think what kind of multiplication you could make from this tree?*
Teacher: *What kind of tree is this? / What kind of multiplication could you make from apples and branches?*
Teacher: *What do you see on the apple? / How many leaves are there on one apple? / What kind of multiplication can you now make?*

The teacher then drew two leaves on each apple, and the children and Helen counted the leaves together.

Teacher: *Come up with a short story which includes the branches and the apples.*
Child 1: *There was one tree with three branches. There were two apples on every branch.*
Teacher: *So what is your question?*
Child 1: *How many apples are there in the tree?*
Teacher: *Once before, we have made a multiplication story together. Now you can make new ones in pairs and in small groups.*

Teacher modelling an example, connecting the mathematical concept of multiplication to children's everyday experiences

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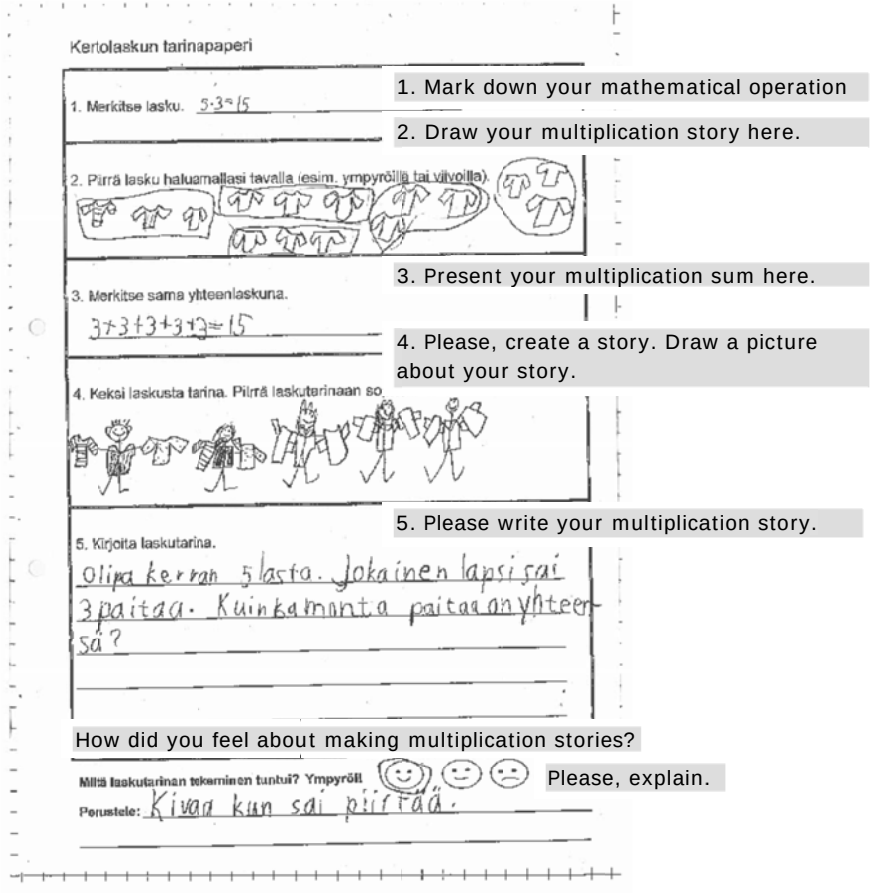
Valuing diverse forms of expression and encouraging self-assessment.

The worksheet provided space for children to record their multiplication stories in diverse ways.

At the bottom of the worksheet, children were also asked to provide their feedback of the task, providing an opportunity for them to engage in self-assessment

Work sheet for multiplication stories



1. Mark down your mathematical operation
2. Draw your multiplication story here.
3. Present your multiplication sum here.
4. Please, create a story. Draw a picture about your story.
5. Please write your multiplication story.

How did you feel about making multiplication stories?

Please, explain.

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Episode: FI Ways to count	**Setting**: Sch	
Subject: Mathematics	**Age Group** 7-8 year old	**Teacher** Rachel
Key factors:		
Learning activities: Gathering evidence (using equipment) / Questioning / Communicating explanations		
Pedagogy: Dialogue / Teacher scaffolding / Role of problem solving and agency / Diverse forms of expression valued		
Contextual factors: Formative assessment / Summative assessment		

Aims

The aim of the activity was for children to use a range of physical objects to solve subtraction problems.

Analysis of key features

Rachel, the teacher, had noted that several of her children found a particular subtraction problem in a recent test difficult. The problem in question was "*What number is 4 numbers smaller than 18*?". Rachel used the recent **summative assessment** information about her children to help inform the lesson from which this episode is drawn.

Rachel provided her children with **a range of physical materials and equipment**, such as beads ("pearls") and rulers, as well as reminding them that they could also use their fingers to help solve the problem too. Whilst specific materials and equipment, and the problem were provided by the teacher, the children themselves had an opportunity to **select resources** and **plan** how the equipment and materials would be used. **Diverse forms of expression** were fostered in encouraging children to present their methods in their own ways.

Children were **encouraged to work in pairs** and each pair had their own set of materials and equipment. The children had to try to solve the problem and then teach their approach to others.

During the plenary, children were expected to take turns to **present their solutions** to the rest of the class. This provided Rachel with opportunities for **formative assessment.** Once the children presented their methods, Rachel set additional problems for the children.

Throughout the classroom activity and plenary discussion, Rachel asked children a range of **questions to scaffold** children's use of resources to solve the problem. Examples of her questions and children's responses are included in the illustrative extracts from the data that follow.

Opportunities for inquiry and creativity

A range of creative dispositions was fostered in this lesson. For example, by turning a closed mathematical question (i.e. "*What number is 4 numbers smaller than 18*?") into a relatively open-ended investigation of different strategies to

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answer the question provided opportunities for children to select materials and approaches, and children's **problem solving skills** were reinforced.

Some of the suggested 'tools' (e.g. children's own fingers) aroused children's **curiosity** and **motivation** to **solve the problem**, as can be seen from one of the children's questions: "*How can you count up to 18 with fingers? I don't have so many fingers.*"

As previously mentioned, whilst specific materials and equipment were provided by the teacher, the children themselves had the opportunity to plan how the equipment and materials would be used, promoting their **sense of initiative** and **creative thinking skills**. This was particularly the case when Rachel's scaffolding questioning was used to extend the children's creative thinking. For example, as can be seen in the following extracts from the data, two children who had proposed to solve the problem of 18-4 using their twenty fingers, were challenged by the teacher to think of a way to solve the problem if there was only one child, and hence only ten fingers to work with. Their solution of keeping ten in their head and only using their ten fingers to work out the difference between the remaining 8 and 4 was relatively innovative in their context.

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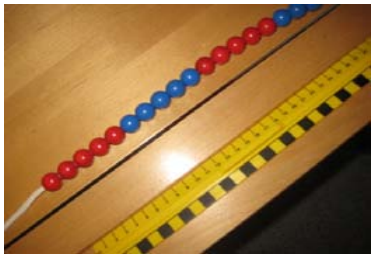
ILLUSTRATIVE EXTRACTS FROM DATA

Materials and learning tools, such as rulers, fingers and beads (“pearls”) offer different approaches to solving problems



Children’s questioning valued by the teacher

Child 1: *How can you count up to 18 with fingers? I don’t have so many fingers.*
Teacher: *That’s a good question. Let’s see if we can soon find a solution to your problem.*

Children take turns to share and explain their methods with the rest of the class.

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Teacher scaffolding encouraged children’s creative solutions.

The girl and the boy showed their solution with their fingers.

Teacher: *What problem do you have if you don’t have a friend with you? / How can you count with fingers if you’re alone?*

Teacher tells them that they have a correct solution and the class applauds.

Child 2: *I will reduce 4 from 8.*
Teacher: *Ok, so what number you keep in your head?*
Child 2: *Number 10.*
Teacher: *After you have counted with fingers the units, you add that 10 from your head. Great! You all found a correct way!*

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Episode: FR Ice Cream Sticks	**Setting**: Sch	
Subject: Mathematics	**Age Group** 7-8 years old	**Teacher** Nani
Key factors:		
Learning activities: Planning investigations / Explaining evidence		
Pedagogy: Dialogue / Reflection and reasoning encouraged		
Contextual factors: Small group/ Use of physical resources		

Aims

The aim of the activity was to encourage children to devise strategies to count systematically a large number of objects, and promote understanding of place value - the transition between units to tens, then the transition between tens to hundreds, and the transition between hundreds to thousands. According to the teacher Nani, it is an interesting activity for children who have difficulties because they can focus their attention on units and tens and for gifted children because they can focus their attention on bigger numbers such as hundreds and thousands. To construct collectively a new tool (the sticks organised in groups of 10, 100, 1000), for children to understand numbers' composition.

Analysis of key features

The lesson started with Nani, the class teacher, showing a large number of ice cream sticks to the children. One of them asked excitedly if she had eaten all of the ice cream herself. Building on the children's excitement and interest in the ice cream sticks, she asked the children to estimate how many sticks there were altogether, and later to devise their own counting strategy. Strategies of various levels of efficiency were proposed to her e.g. by counting in twos, tens and twenties, and discussed as a whole class. Then, in pairs at tables, the children manipulated and ordered the sticks in various ways to find out how many there were.

The strategy of the teacher was to build up the activity step by step through collective discussions. The teacher scaffolded and helped to organize democratic discussion and decision making. She explained during the interview with the researcher the importance of the *'democratic'* dimension of this activity. It was quite clear to children that democratic decision making is the way to do their daily activities (**Child Sh**: *"The children on the tables, if they agree…"*). According to Nani, this kind of lesson can be proposed to the class only when this approach to classroom functioning is accepted and acquired by the children.

Moreover, one of the important aspects of Nani's pedagogy is to encourage children to **explain their own views**, or understanding. Indeed, she argues that if teachers cut down children's explanations, they may stop children's learning. For example in this episode, a child initially suggests counting the ice cream sticks in twos. It is an interesting idea, but it was not the one that Nani was expecting (every ten is more appropriate for her goal). Nevertheless, because in her approach the best solution is decided collectively, she does not make any comment on this specific solution.

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Furthermore, she encourages collaborative work between gifted children and children with difficulties by placing them together for specific purposes (for example: **Teacher***: "Child Au could you come to work with Child Ma?"*).

It was noticed that children developed greater understanding of number through the activity. They recognised that the grouping strategies adopted were not just useful for representing the number of ice cream sticks. These forms of representation were useful generally for counting faster (e.g. *'hundred is easier'*). Through this activity they managed to decompose big numbers.

In another part of the lesson, the children devised interesting approaches for future activities. They replaced a big pile of ice cream sticks by a clear and simple organization of the ice cream sticks. More precisely, they organized them into different kind of groups: 10 units were held together through elastic string, 10 groups of 10 units were placed into plastic bags, and 10 plastic bags were placed into an aquarium. This material follows children for their entire school years. In the future, the teacher will send them to the ice cream sticks corner to solve any difficulty with number problems.

Opportunities for inquiry and creativity

Creativity was fostered here at each step in the progression of the workshop. The children had to find by themselves the best strategy to count the large number of ice cream sticks. The teacher's role was mainly to choreograph the discussion, to stress important ideas, and to ask children to make choices between different strategies. Children had to reason, to find solutions, but also to listen other suggestions and to decide democratically which solution was the most appropriated and why.

According to Nani "*this approach suits entirely with the idea of the curriculum to help children to become citizens"*. Furthermore, the presence of a challenge, counting such a large number of ice cream sticks, enhanced children's curiosity and motivation. Finally, collaboration and dialogue constituted key aspects of the process, and regular discussion of progress with the entire class allowed them to succeed.

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ILLUSTRATIVE EXTRACTS FROM DATA

Teacher's engaging introduction to the problem

Child A: *You have eaten all of them?* (He is talking about the ice cream sticks)
Teacher: *Yes, I've eaten all of them, can you imagine it? According to you, how many are they?*
Children: *100, 2.000 … More than 100 …*
Teacher: *That is what I want to know, how many ice cream have I eaten?*

Children were encouraged to explore the materials and to plan their own counting strategy

Opportunities for children's reasoning

Teacher: *Does everybody count every 10? Does someone count every two? Child D, why do you count every ten at all?*
Children: *Because it goes faster!*
(…)
Teacher: *Wait, wait, and listen, there is another idea which is arriving, listen, then we will choose the best idea, the easiest way to count. Child D you say that we have to make …?*
Child D: *Hundreds.*
(…)
Teacher: *So do we make packets of 100? Or* (…) *the other idea is that we take all the units on the tables to make tens. So what do we do?*
Child E: *If you count all the tens on the table you can forget some … when hundred is easier.*

Learning environment where children were encouraged to listen to others' ideas and make a collective decision

Teacher: *Hey children, 10 seconds of attention. Child C has said that after we will count and see how many ice cream sticks there are.*
Child A: *Yes, but we have to agree on something.*
Teacher: *We have to agree on something. And, we have to be able to check. If you say to me "there are 48", I have to be able to check that there are 48!*
Child B: *We will count them again!*
Teacher: *Again?!*
Child C: *The children on the tables, if they agree, will count every 10, when they will have the correct number and we can do 10, 20, 30 and it doesn't take a lot of time, and we will be able to know the number.*

Episode: FR Magnet attraction or not **Setting**: PreSch
Subject: Science **Age Group** mixed age 3-4 and 5-6 years old **Teacher** Ivette
Key factors:
Learning activities: Communicating communication
Pedagogy: Reflection and reasoning encouraged
Contextual factors: Variety of materials

Aims
The teacher's goal was to enable children to categorize objects depending on their attraction or not by magnets.

Analysis of key features
This episode involved the children exploring whether some given objects are attracted to a magnet or not. **Included in the objects were pairs of scissors which were made out of iron and plastic,** so part of the scissors were magnetic and part of them were not magnetic.

The activity was initiated by the teacher and involved children working in small groups (n=5-6) testing the objects and then as a whole group (n=13) for the discussion of their findings and the **formation of a collective statement** about the magnetic properties of materials.

In the small group activities the teacher discussed the children's discoveries with them and helped them sort out their categories - 'Magnetic' and 'Non-magnetic'. The teacher emphasised the importance of children testing their objects during the first phase **in order to have evidence to be able to justify their own decisions** about the magnetic properties of the objects.

In the next phase of this episode the children **worked together as a whole group to share their findings and to come to a common conceptualisation about magnets and magnetic materials.** During this sharing and conceptualisation phase, the teacher asked the children to test objects again if necessary so they were sure of their categorisation of the magnetic properties of the objects. The discussion **fostered the children's ability to express themselves and to listen to the others**. Some children placed the scissors in the 'Magnetic' category and some placed them in the 'Non-magnetic' category.

The teacher used a large sheet of paper and drew two columns to record the children's results; one column for the magnetic objects and one for the non-magnetic objects. The children tested the magnetic properties of the objects again, **one at a time *together* and a common categorisation was created.**

During the collective discussion, **the teacher supported the children to explain their own ideas**. In pre-school, language difficulties are frequent and children can find explaining their ideas a barrier to communication. For example, one child tried to say that iron objects are attracted by magnet. In French *'iron'*

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(fer) is similar in sound to *'green'* (vert) which is similar in sound and spelling to *'glass'* (verre). At first the teacher did not understand the child's explanation due to his enunciation difficulties. **However, although it would have been possible to guess what the child meant, the teacher showed him a glass and asked**: *'Do you mean glass ('verre')?*'. The child thought about the question and says *'No, I mean iron ('fer')'* and showed the iron part of the scissors to the class.

The category in which to place the scissors confused the children as anomalous results for the scissors had been recorded depending on which part of the scissors had been tested with the magnet. None of the children said that the scissors could go in both categories but at the end of the workshop a girl proposed a solution to the problem of the scissors' categorisation, she suggested that they could be placed 'on the line' between both categories.

Opportunities for inquiry and creativity
By letting the **children make their own categorisation** in small groups and then to **foster a collective categorization as a whole group** allows children to construct their own understanding to contribute to a collective discussion. They were able to make adjustments following a discussion to their original decisions. This way of processing ideas supports children forming their own concepts of magnet's properties rather than just being told the properties by their teacher. In suggesting a way to categorise the scissors the girl showed **creativity in offering a solution,** fostering **new understanding** that an object might belong in more than one category linked to the different materials from which it is made.

Providing **resources which create cognitive challenge** e.g. the scissors helps promote collaborative discussions as the children have to resolve the dilemma of the anomalous results.

By allowing children to use different forms of expression and **supporting them to make their own explanations** rather than making assumptions about what they are intending to say, values children's contributions to the collaborative construction of ideas.

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ILLUSTRATIVE EXTRACTS FROM DATA

Testing familiar objects to see if they are magnetic or not
The teacher discusses children's discoveries

Teacher: *So, I have a look on what you have done… the red container. The red containers are all at the same place, the green are also together. Nobody has said to me "I don't know…". You did know, it sticks or it don't. Child Ax told me the scissors sticks* (Teacher takes the scissors). *Ah! They are in the box where it doesn't stick!*
Child B: *I've tried and it didn't stick!*
Teacher: *Ah… Ah… Ah…. Come Child Ax, we will try, if we don't know* (Teacher is sitting, near her is Child Ax). *I've heard many children who said the name of the object… No? Don't you know the object's name?*
Children: *No.*
Teacher: *Child Fé you told it! Child Ma?*
Child Ma: *A magnet.*
Teacher: *Yes! Magnet! I've heard many children who have said it!*

Children share their findings: The problem of the scissors

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Teacher: *We can place it in both containers … So why in a side, it sticks and not on the other side? Yes, the red, what do you want to say Child Ca?*
Child Ca: *The red, because it is scissors.*
Teacher: *Yes, it is scissors you are right, Child Ma*?
Child Ma: *Because it is big*.
Teacher*: Because it's big. Child Ax?*
Child Ax: *It doesn't stick because it only sticks on the green.*
Teacher: *On the…?* (in French, glass, green, and iron have close spelling)
Child Ax: *Only on green, as green… you know, green.*
Teacher: *Wait, are you talking to me about glass. (*Teacher shows to the child a pot in glass).
Child Ax*: Yes*, (Child Ax scrubs his head) *no, in iron.* (Child Ax shows the iron part of the scissors).

The teacher proposes collective categorisation of the objects
Solving the problem of the scissors

Finally the question of the scissors is still confusing children.

A creative solution is proposed by one of the children. The solution might be to place scissors on the line of the paper sheet.

Teacher: *Yes, it doesn't stick on the orange side! Child Ax, do you remember that? Looks, on this side it sticks and on this side it doesn't.* (Teacher tries with the magnet on both sides of the scissors). *Where will we place the scissors?* (Child Ax shows the column where it doesn't stick).
Child Ca: *We will stick it on the line!*
Teacher: *Come and show me, that is a good idea. How do you place it? Show me.*

Child Ca places the scissors on the line, the iron part on the stick column and the plastic part in the column where objects do not stick on the magnet.

Teacher: *That is a great idea, Child Ca!*

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Episode: FR Share	**Setting**: PreSch	
Subject: Mathematics	**Age Group** 4-5 years old	**Teacher** Sandy
Key factors:		
Learning activities: Explaining evidence / Communicating explanations		
Pedagogy: Role of motivation and affect / Teacher scaffolding		
Contextual factors: *Human resources*		

Aims

For the children to explore and discuss their own strategies to share a handful of sweets into three equal portions.

Analysis of key features

The activity from which this episode is drawn formed part of a classical topic in division, and was based around the familiar story of the Three Pigs. This activity therefore embraced the different domains of literacy and mathematics. The activity had been initiated by the teaching assistant (TA) a week ago in small-group activities at a table to investigate children's capabilities and strategies in sharing money equally among the three pigs, using cardboard counters.

This time, sweets had to be shared among the three pigs: Henry, Raphael and Christopher. The TA had enhanced the complexity of the task, as she said "*I wanted to see if they have really understood fair sharing*". To do that, she provided children with a handful of sweets (using salt dough) and not a number that was a multiple of three as she did the last time (as when children are provided with a number, which is multiple of three, it is easier because there are no remainders.) With handfuls of varied numbers of sweets, the children encounter problems. For example, they can have 2 sweets left and cannot share them among the three pigs. While children are expected to encounter difficulties, the TA emphasised no failures because *"we do it again and again, with the help of the other children. It seems important that children can go until the end of their strategy"*.

At the start of the lesson, the TA and the small group of children discussed what 'equally' means. It was noted that each child knew clearly what share meant, but the notion of 'equality' was more difficult for them. Indeed, acquisition of the notion of sharing equally constituted the central goal of the TA's activity.

Additionally, the TA also made the strategic decision to use sweets made of salt dough of different colours instead of cardboard counters **to make the activity more attractive for children**. This also prompted new ideas from the children. One child proposed that the sweets should be shared equally according to the colour.

During the activity, the children worked together. One of them tried to share equally a handful of the sweets. The others had to look at what was happening and at the end discuss the child's strategy. Each child, in turn, **explored**

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his/her own strategy then discussed it. As indicated earlier, the aim of this activity was for the children to explore their own strategies to share a handful of sweets into three equal portions. The children knew how to share, but they encountered difficulties in doing this equally. When children encountered difficulties, the TA did not provide solutions but fostered children's collaboration and own exploration of their strategies.

This mathematical activity provided children with a rich context to develop general skills and dispositions for learning. Through this activity, children acquired knowledge/understanding about mathematical content, they developed mathematical process skills, and capacities to carry out inquiry and problem based approaches. Moreover, creative dispositions were fostered, associated with **exploration of the possibilities and reflection and reasoning**. Finally, the TA was gifted in listening, and in **scaffolding** children and to **foster dialogue and collaboration** between children.

Opportunities for inquiry and creativity

Creativity in teaching might be recognized through the **motivating material used in the activity**, such as the sweets, and pigs' names. Moreover, this activity was linked to a story that was being read at the time in the classroom, but also at school level. These elements encouraged children to engage with the mathematical activity. The TA said she had modified the workshop by using sweets instead of cardboard counters "*because it is more attractive for them"*. Moreover, during the session, she modified the activity where necessary to see if it would help children (e.g. "*try sharing them with your brother"*). This flexibility underlines her close involvement in scaffolding children's progression.

The TA was also creative in her attitude towards **scaffolding children's progress** as she did not guide them toward a particular *sharing* strategy. She let them try, and organized sharing of ideas, explanation and collective checking. At the end of the workshop, most of the children managed to do an equal sharing among the pigs by using different strategies. For example, Child Fl tried to share ten sweets by placing two sweets in each of the three plates initially, then adding one more sweet in each of the plates, leaving out the remainder of one. Child Vi and Child Ro attempted to share 14 sweets equally among the three pigs by placing four sweets in each of the three plates initially before adding one more in two of the three plates, resulting in two plates having five sweets each, and one plate having only four sweets. Through the teacher scaffolding, they then decided to remove the fifth sweet in two of the three plates, so that all plates would have four sweets each.

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ILLUSTRATIVE EXTRACTS FROM DATA

Examples of the TA's scaffolding questions and children's explanations

Example 1: The children have a handful of 10 sweets. Child Fl shares the sweets firstly two by two. Then, one by one and keeps in his hand the last one.

TA: *So what happens?*
Child Fl: *It is not the same!*
TA: *You did place…*
Child Fl: *3, 3 and 3*
TA: *And you still have one in your hand… We cannot share this one, so?*
TA: *If I place it here* (Henry's plate), *does it work?*
Children: *No.*
TA: *If I place it here* (Christopher's plate), *does it work?*
Children: *No.*
TA: *If I place it here* (Raphael's plate), *does it work?*
Children: *No.*
TA: *No, no, why? Because, it is not the same number. I put it away. And there, is it just?*
Children: *Yes*
(…)

Example 2 : Another child (Child Vi) tries to share. TA gives him a handful of sweets of 14 sweets. The child places 4 sweets each time in each plate. Two sweets remain at the end. Child Vi shares them between two of the three plates.

TA: *Does every pig have the same number of sweets?*
Children: *No.*
TA: *How many sweets are there? Shall we count them together?* (She points out at each sweet at a time).
Children: (First plate) *1, 2, 3, 4*. (Second plate) *1, 2, 3, 4, 5.*
TA: *Is it the same?*
Children: *No.*
Child Ro (Counts the sweets in the last plate): *1, 2, 3, 4, 5*.
TA: *Which plates have the same number of sweets?*
Children: *Those ones* (They point at the plates where there are 5 sweets each).
TA: *Those plates have 5 sweets each, and there* (she points out the remaining plate) *there are …?*
Children: *4* (for the 4 sweets)
TA: *So what can we do?*
(Child Ro picks up a sweet in one of the plates where there are 5 sweets.)
TA: *What have you done, Child Ro?*
Child Ro: *I've removed one.*
TA: *How many sweets there are now?*

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Children: *4.*
TA: *Really good!* (TA takes the sweet removed from the plate by Child Ro). *You have removed one, and there are now …*
Children: *4* (for the 4 sweets).
TA: *Are there 4 sweets everywhere?*
Children: *Yes.*
TA: *Yes, we will manage I think!*

Example of a child's additional idea for investigation

TA: *So, we will try to share them fairly. That means … Who can remind me, what does it mean? What will we have to do?*
Child Fl: *To provide the same.*
TA: *We will try to provide the same number of sweets in each plate. All right?*
Child Ro: *And the same colour!*
TA: *No, the colour is not important here. We will not take the colour into account! Ok?*
(The child's idea was not taken up by the TA at this point.)

Children working collaboratively

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Episode: GE Building Blocks	**Setting**: PreSch	
Subject: Integrated Maths/Science	**Age group:** 5 years old	**Teacher:** Bea
Key Factors:		
Learning activities: Planning investigations / Communicating explanations		
Pedagogy: Role of play and exploration / Role of motivation and affect / Teacher scaffolding		
Contextual Factors: Rich physical environment for exploration		

Aims

The aim of this activity was to foster communication and reasoning as well as number and spatial sense. Thinking mathematics (problem solving, communication, reasoning) was important as well. The children used science process skills (observing, predicting and describing), and social factors of science learning played an important role too (collaboration and communication).

Analysis of key features

The teachers had observed that the children enjoyed very much **playing with wooden building blocks** (KAPLA). The children often built roads and tracks, but only rarely higher buildings like towers.

Bea (the teacher) initiated an activity for a small group of older children. Using a photograph of a wooden block building as model, the children were supposed to copy it. Inspired by other pictures on the wall, the children decided to build the "Leaning Tower of Pisa" as well.

Bea took two children to the construction corner and presented them with a book with photographs of buildings (these buildings were all made from wooden building blocks). She told the children about her plan of copying one of these buildings together with them. By **letting the children decide** which building to copy, it became a joint project.

To be able to copy the building, the children had **to observe carefully, describe and count**. In the beginning, the children needed more support, and Bea assisted them. The children worked together as a team, and Bea stood back and observed. **Bea got involved only when her help was needed**.

Bea **fostered communication and collaboration**. Child 2 placed a brick in accordance with the model. However, since the brick was difficult to see, Child 1 removed the brick. Bea asked Child 2 "*You wanted to place this one, right? You have to discuss that with Child 1, so that she knows what's your plan*."

When trying to build the top of the building, the bricks repeatedly fell in. The children tried to find a solution, and **Bea helped them verbalise their ideas** with questions. When the children failed to build the roof of their tower Bea had a go but did not succeed either. The children were laughing and realised that it was a difficult task – even for their teacher.

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However, the children continued with their task and finally managed to do it The children were very happy and proud, and one of them went to get a camera to document their result.

Inspired by photographs of real buildings on the wall, the children decided to build the "Leaning Tower of Pisa". One child took the lead, and Bea helped and **followed the Child 2's instructions, making him feel he was the expert**. Although, it seemed obvious to the teacher that by following the boy's instructions, the tower would not get very high, Bea **did not interrupt** the construction and followed Child 2's plan. When the tower tumbled down, she used the incident **to help the child reflect**.

They started building again, and another child joined them. Bea stood back then, observing the children's work. To be able to solve the problem together, the **children had to observe and predict and to communicate their ideas**. Bea encouraged the children to express themselves clearly and she valued their ideas. The **children seemed proud that they found a solution on their own**.

Opportunities for inquiry and creativity

The children's reasoning skills as well as their connection-making played an important role in this activity. In the second part, where **the children took the lead** and were allowed to build the "Leaning Tower of Pisa", their creative dispositions were fostered. The children were motivated and inspired by using the wooden bricks, which the children like a lot.

The teacher **supported their learning, valued their ideas** and **helped to overcome difficulties**. As a result, the **children were self-confident and showed initiative**.

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ILLUSTRATIVE EXTRACTS FROM DATA

The teacher encourages the children to collaborate and to communicate their ideas (express themselves clearly)

Using a photograph of a wooden block building as model, the children were supposed to copy it. Inspired by pictures on the wall, they then decided to build the "Leaning Tower of Pisa" as well.

Child 2 places a brick in accordance with the model. However, since the brick is difficult to see, Child 1 removes the brick.

Teacher: (to Child 2) *You wanted to place this one, right? You have to discuss that with Child 1, so that she knows what your plan is.*
Child 2 replaces the brick.
Child 1: (indignant) *But first there has to be the wall.*
Teacher: *You have to come to an agreement about what you want to do.*

Children take the lead.

Although it seems obvious that the tower will not get very high this way, the teacher follows the children's plan.

Teacher: *Well, Child 2, now you really have to explain to me how such a Leaning Tower has to be built. I actually have never built one.*
Child 2: *You always have to put one like this and another one like that.* (Child 2 places four bricks in front of her and explains).
Teacher: *You mean always to one side?*
Child 2 nods
Teacher: *And then it won't tumble down?*
Child 2 shakes his head.

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(Child 2 and the teacher quickly build the tower which does lean extremely wide to the left. Teacher follows Child 2's instructions. After some while the tower tumbles down and a new plan is made.)

The children's reasoning skills as well as their connection making is supported, and the teacher helps to overcome difficulties.

Teacher: *Even if it sometimes doesn't work, stay patient, wait, and the 10th time it finally works out. But to withdraw as an adult and to really let it happen and if it then works, there is this "aha-experience" which you can often already tell from the posture, the children then sit up "Ha, yes, made it".*
Teacher: *Why does it fall in again and again? What do you think?*
Child 3: *Because there is no space … for this* (points to the tricky spot).
Teacher: *Yes, it doesn't have enough support there, right? We have to think about something else there.*

Child 3 starts to pile up bricks as a sort of supporting pillar.
Child 3: *We build a tower from below to fix it.*

Child 2 starts to carefully slide bricks in the tower from the side.

Teacher: *Ah, you're adding a supporting step!*
Child 3: *Child 2! Good idea!*
Child 2: *And now it has to be unbuilt a little bit over here!*
Teacher: *What do you mean?*
Child 2: (explains to Child 3) *And here it has to support.*
Child 3: *Yes, I know.*
Teacher: *Now you added a supporting construction. Now it is stable.*
Child 3: *Luckily. At last.*

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Episode: GE Fermi Questions	**Setting:** Sch
Subject: Integrated Maths/Science	**Age group:** 7 years old **Teacher:** Andrea
Key Factors	
Learning activities: Planning investigations	
Pedagogy: Role of motivation and affect / Role of problem solving and agency	
Contextual Factors: Outdoor learning / Formative assessment	

Aims

The main objective was to foster the children's problem solving skills (e.g. defining the problem, generating ideas, considering various ways of approaching, selecting and evaluating alternatives) and to encourage the use of different approaches to answer mathematical questions. Dimension analysis and approximation are practised as well.

Analysis of key features

In circle time, the teacher, Andrea, presented a new kind of mathematics activities to her children. In small groups, the children were to solve Fermi problems that were connected to different objects or phenomena (e.g. "*How many stones are in this glass?"* or "*Cut a 1-m string from this ball of wool*."). The children were not allowed to count or to use any standard equipment for measurement.

To increase **interaction between children and to foster cooperation**, the children worked in small mixed ability groups of four children. Depending on the activity/question, the children worked in different areas of the school building (e.g. one question was to estimate the height of the school building, and the children went outside on the schoolyard to solve this problem).

The different groups of children started to work on their Fermi tasks. All the tasks referred to either concrete items (e.g. ball of wool, stones in a glass) or to phenomena linked to the children's everyday world (e.g. height of the school building, length of a pitch). The **children were very motivated**, discussed the right method to solve the task and drew on their everyday knowledge to be able to make estimates, e.g. about the length of 1 metre: "*I jumped down from a 1m board in the swimming pool on Saturday*" (the child shows the distance between board and water surface with his hands); or "*I'd say a metre is more or less as long as a leg*" (using Child 5's body to demonstrate it). As a team, the children made a guess and then discussed their estimations: **they asked for the other's opinion and found innovative methods** in order to check their estimates.

Andrea walked around in class, observed the children during group work, using **formative ways of assessment** (e.g. *"How does a child behave in the group?, What does it contribute to the group work?, How does it interact with others?, How does it approach such a task?",* as highlighted in the teacher interview). She occasionally gave advice or answered questions. However, her advice

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exclusively referred to the working approach, methods, and relevant question, but never to the solution itself.

Reasoning and reflection as well as metacognition were fostered - at the end, the groups documented their working process by writing down how they had proceeded. Then they presented their work to the other groups of children in circle time.

Opportunities for inquiry and creativity

All the Fermi questions were related to real-world phenomena, taken from the children's (school) environment. This was very engaging, and the children were **curious and motivated to solve** this new - and for them unusual - kind of maths activity. They came up with **many different ideas how to solve** the problem, drawing back on individual experiences as well as on previous knowledge. One group of children even "invented" a new scale: They found out that one of their teachers is exactly 2 metres tall and called this size "*1 Mr. X*". 1 metre was respectively "*1/2 Mr. X*"! This scale was then used for example to estimate the height of the classroom or the school building.

The children's **reasoning skills were fostered** as well. The teacher used **scaffolding and encouraged collaboration and dialogue** between the children. The children worked as teams and shared and discussed their ideas to come to a common solution.

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ILLUSTRATIVE EXTRACTS FROM DATA

The children communicate and discuss their estimations (based on everyday knowledge) within their group until they reach consensus

The Fermi problem for this group of four children consisted of drawing three lines of different lengths (1 m, 10 cm and 1 cm) on the blackboard without using a tape measure or ruler.

Child 5: *I jumped down from a 1-m-board in the swimming pool on Saturday.* (Shows the distance between board and water surface with his hands).
Child 6: *I'd say a metre is more or less as long as a leg.*
Child 7: *Until here, right? Or till here?* (using Child 5's body to demonstrate it).

Child 5 tries to maintain the distance between his hands while moving them to the blackboard. Holds them close to the board, Child 7 draws a line between Child5's hands.

Child 7: *T-h-a-t long?*
Child 6: *No. This long*
Child 7: *I don't think that this is one metre.* (laughing)
Child 6: *I don't think that either.*
Child 5: *Right. Much too short.*

Child 6 draws a longer line.

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Reasoning and reflection: The children document their working process and do a short presentation to the other groups

Children write down how they had proceeded. Then they present the working process as well as the result to their class members.

Teacher: *And these Fermi question are ideal for that because the children get into interaction and they have to think on their own about questions like: "How can I approach this?", "What am I doing here right now?", "How can we solve such a task?" And they just have to talk to each other a lot and to think about "How does this actually work?" and not only to solve a ready-made maths problem.*

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Episode: GE Water Inquiry **Setting:** Sch
Subject: Science **Age group:** 6 years old **Teacher:** Nadja
Key Factors:
***Learning activities*:** Planning investigations / Communicating explanations
Pedagogy: Role of motivation and affect / Role of problem solving and agency / Teacher scaffolds
Contextual Factors: Rich physical environment for exploration / Indoor and outdoor resources

Aims
The children had to plan their own experiments to prove that ice and steam both come from water. They were allowed to use any of the equipment in the room to carry out their experiments. IBSE and creativity were specifically planned for this lesson.

Analysis of key features
This activity took place in the "Science Lab". In circle time at the beginning of the lesson, the teacher Nadja talked with the children about the findings of their previous lesson. The teacher acted as if she did not believe that there was a connection between water, ice and steam. She asked the children to prove there was a relationship between water, ice and steam.

The children had to form hypotheses and **plan and conduct experiments** all by themselves, working with a partner or in small groups. They were allowed to work inside the "Science lab" or to **go outside (in the school yard / garden**) if they wanted to, as the children were free to choose.

Before the children could start their experiments, they had to document their plan by writing down or drawing their ideas and procedures on a prepared "Scientist's sheet". Nadja went around from group to group **asking the children to explain their ideas and plans.** The worksheet seemed to help the children to structure and elaborate their ideas. The children were very excited, **discussed a lot and came up with many different ideas** how to prove that ice and steam come from water.

Ice cubes were then handed out to the children and a water boiler could be used as well, when assisted by an adult.

The children conducted their experiments, using ice cubes and different ways of warming them (e.g. putting them close to the radiator or melting them in their hands). When they realised that the sun was shining, some children asked if they were allowed **to continue their experiments outside in the garden**. Nadja encouraged them to do so and went along with them while the other two adults stayed in the room with the rest of the children.

The children's knowledge and understanding of the connection between the three states of water deepened during this lesson. (e.g. **Interviewer**: "*And*

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what do you need in order to transform ice into water?" **Child:** "*You need, for example, a radiator, so you can hold the ice to the radiator. Then it also becomes water*." **Interviewer**: "*Exactly. Because what comes from the sun and what comes from the radiator*?" Children [in unison]: "*The heat!").* At the end of the lesson, the children came together and compared their experiments and findings in circle time.

Science process skills and social factors of learning were fostered (open inquiry: predicting, planning and conducting experiments, observing, explaining evidence and communicating explanations) as the children had to devise the experiment themselves. They had to **solve the problem of proving** that both ice and steam come from water.

Opportunities for inquiry and creativity
Children were very engaged in this activity and enjoy it a lot to be able to **work independently and even outside the classroom**. They really enjoyed **planning their own investigations** and having the **freedom to make choices**.

The **rich environment** and freedom to try out whatever they wanted (variety of resources, sufficient human resources) motivated them and gave them room for creative approaches. Working together with a partner or in small groups, the children **communicated a lot and brought together many different ideas**. The teacher's real interest in their experiments encouraged them to try out new things.

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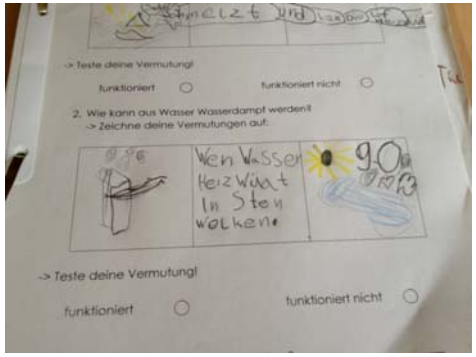
ILLUSTRATIVE EXTRACTS FROM DATA

The children make connections and plan their own experiments



The children planned their own experiments to prove that ice and steam both come from water. They were allowed to use any of the equipment in the room to carry out their experiments. However, before the children could start their experiments, they had to document their plan by writing down or drawing their ideas and procedures on a prepared "Scientist's sheet". They were allowed to work inside the "Science lab" or to go outside (in the school yard/garden).

Teacher: *And what's this? I don't really understand that.*
Child 1: *There, the BBQ is set up.*
Teacher: *You put the ice on the grill?*
Child 1: *Noooo…*
Teacher: *I see, sorry. You put water on the grill?*
Child 1: *Yes. And here, on the top, some water is heated up.*

Child 2 (talking to his partner): *Or I draw 100° and then water steams. It could get that hot, though* (…). *Or 90°* (Child 2 remembers the number of degrees from the last lesson and writes a "90°" next to his sentence "When water gets hot clouds arise").

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Experimenting inside and outside the classroom

When they realised that the sun was shining, some children asked if they were allowed to continue their experiments outside in the garden.

The children enjoy investigating on their own. They find different solutions to make ice cubes melt (inside and outside the classroom).

Interview with children:
Child: *I had fun today!*
Researcher: *So today was the best day in the science lab? Why?*
Child: *Because we were allowed to experiment. Whatever we wanted. We were allowed to try things out outside.*
Child: *Yes today we had to draw and to think about it with our brains and the other time we just had to look and write.*

Interview with the teacher:
Teacher: *The children first had to think about it and to then draw or write their thoughts and then also to try out what they came up with. And I said "You can use everything what we've got here in the science lab"* (…) *And they really came up with amazing ideas.*

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Episode: GR Measuring tables **Setting**: PreSch
Subject: Mathematics **Age Group:** 5-6 years old **Teacher:** Mina
Key factors:
Learning activities: Planning investigations / Gathering evidence (using equipment) / Making connections / Explaining evidence / Communicating explanations
Pedagogy: Role of motivation and affect / Children's agency / Collaboration / Fostering reflection and reasoning / Teacher scaffolding
Contextual factors: Valuing potential of physical materials

Aims

The teacher's goals for the lesson were to encourage children to: keep "mathematical notes" as they are working in the classroom using symbols; count in their everyday activities; make estimations and predictions; be able to form and check hypotheses; be able to solve problems (process information, take decisions, come to a result, confirm results) and to foster children's interest and motivation in mathematics using everyday situations and building on their experiences.

Analysis of key features

The episode involved the children taking measurements of their work tables using measuring tools provided by the teacher (a tape measure, a wooden meter, ribbons, spoons, pencils) or any tool of their own conception. The teacher Mina introduced the activity by asking the children to help her in giving the carpenter measurements to create new worktables for the classroom, identical to the current ones. By **setting the activity within a meaningful context,** she wanted children to **make connections between mathematics and their everyday life**. The children **worked in small groups** choosing the measuring tool to use and taking and recording measurements in their group notebooks. They then had **to present and explain their findings to the whole class**. Finally the children **discussed and reflected on the activity**: what problems they faced and how they felt about it.

Once the teams were set up, no further instructions were given. Mina however stressed several times the need to **work collaboratively** to achieve the task. In most teams, one child ended up being in charge of taking the measurements, another two assisting him/her in the task, and one being in charge of recording the measurements in the notebook. Some teams kept these roles throughout the activity, while others rotated them so that all children could get the chance to contribute to all tasks. Mina **emphasised the importance of recording measurements** for the purpose of presenting their findings. She gave them specific instructions about how they should present their findings: to mention the measurement tool used and give the findings for the shape, length, width and height of the table.

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In the next phase of this episode the teams **presented and shared their findings**. The teacher **prompted the children to reflect on their findings and collection processes**, continuously reassuring them that it was OK to make mistakes. Two unsuccessful measurements (one team used a ribbon shorter than the table, and one recorded the number of the measurement the wrong way around) were turned into learning opportunities related to **the nature of science inquiry**, such as the need to 'repeat' and 'verify' measurements. During the collective discussion, **she invited children's reflections on what they enjoyed and issues related to collaborative work**, which complemented their more formal accounts on the acquired understandings.

Opportunities for inquiry and creativity

Features of creative teaching were observed during this lesson in the efforts made **to enhance children's attitudes** to mathematics by **connecting mathematical knowledge with everyday life**. Creating a safe environment, where mistakes are accepted and treated as learning opportunities is an integral part of this teacher's practice. Her interest in the affective dimensions of mathematics learning was also evident in her choice of focus for the collective discussion at the end of the lesson, in which she asked the children to evaluate the lesson and suggest way to improve it in this respect. Opportunities for development and demonstration of children's creative dispositions were present in this episode in **fostering collaborative work and inquiry skills**. Issues of collaboration featured highly in children's reflections on the lesson although it is unclear if the children felt that collaborative work assisted them in developing understandings. The teacher encouraged **children's agency** in carrying out the task, by offering minimal directions. She chose a more guided approach when children reported their findings to foster **explanation and reflection and reasoning**. Finally, an important contribution to creative learning in mathematics was the conscious efforts of the teacher to promote understandings **about the nature of inquiry** through **processes of reflection** on their measurements. The skills of reflection *and* reasoning are very important to IBSE, and conceptions of creativity which focus upon the generation and evaluation of ideas. In helping children to develop these skills the teacher skillfully shifted the children's attention from the process to the product and back, exemplifying the importance of both.

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ILLUSTRATIVE EXTRACTS FROM DATA

The teacher embeds the task in an everyday life context.
She encourages collaboration and fosters children's agency.

Teacher: *A few days ago we said we would like to order a new table from a carpenter. The carpenter rang me and said: Mrs Mina, I will make the table you want. However, you have not given me any instructions.* (..) *I want you to help me to give instructions to the carpenter. OK? So this is what we are going to do: Every team will go to their table and take its measurements. I will give you notebooks so you can write down your notes.* (…) *Each team will decide how they are going to take their measurements. We need to provide three measurements to the carpenter: shape, height and width. Last time we said that we can use different tools for measurement.*(..) *To make it easier for you, you need to collaborate. If every one of you wants to keep the tool for himself/herself, the team will not succeed in the task.*

Children share their findings:
Teacher turns children's mistakes into a learning opportunity.

Teacher: *Team 5 used the ribbons to measure the table. What did you measure? The width?*
Child A: *Yes. And the legs.*
Teacher: (..) *Let's see how they managed to measure the table with something different (..) I have never measured anything before in my life.*
Child A: *We start here* (end of the ribbon on the ground) *and go…*
Teacher: *Wait, you start from here and go where? Here? But, where does our table end* (children looking) *Mmmm… Isn't it a bit shorter, or longer?*
Child A: *Longer.*
Teacher: *Is it longer? The table or the ribbon? Which is longer?*
Child A: *The table.*
Teacher: *So the ribbon then is …*

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Child A: *shorter*
Teacher: *You needed a little bit more, didn't you?*
All: *Yes we did.*
Teacher: *So, is this the correct measurement for our table then for its width?*
All: *No.*
Teacher: *We have to try again.* (Children seem disappointed). *It does not matter. (..) When we make an attempt and then we go to check it and it is not right, we try again.* Another team had written their measurements the wrong way around - 85 cm instead of 58 cm. She helps them to verify their measurements and then explains their mistake. *(..) From what I see, if we give these measurements to the carpenter as they are, he won't know exactly what to do. (..) We thus need to reach a conclusion about the measurements. (..) I will tell you a new word. It's called 've-ri-fi-cation' (..) we will check if the measurements we took are accurate.*

Children reflect about their feelings, collaboration and new understandings

Teacher: *I would like you to say, so that I know what to do next time, so that you like it even more: What from all the things we did today you liked best, impressed you most and helped you? Think about all the steps of the games we used and about the way we worked. Think.*
Child D: *When we measured the tables.*
Teacher: *You liked the measurement of the tables (…) How did you work?*
Child D: *With my team.*
Teacher: *Did you like this process?*
Child D: *Yes.*
Teacher: *Did you agree, disagree? How did you see this?*
Child D: *At the beginning we disagreed a little, but then we agreed.*
Teacher: *At the beginning you disagreed a little, (..) this happens frequently in teams. What did you disagree about? Do you remember?*
Child D: *What we should use to measure.*
Teacher: *Which tool to use for measurement. What did you use?*
Child D: *The ribbon. (..)*
Teacher: *What new thing did you learn, that you did not know before?*
Child A: *I do not know how to describe it.*
Teacher: *(..) Did it have to do with measuring the tables?*
Child A: *That if I do not have a ruler, I can use a ribbon or a meter.*

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Episode: GR Ice balloons **Setting**: PreSch
Subject: Science **Age Group** 5-6 years old **Teacher** Sonia
Key factors:
Learning activities: Questioning / Planning an investigation / Gathering evidence (using equipment) / Communicating explanations
Pedagogy: Fostering questioning and curiosity / Children's agency / reflection and reasoning encouraged
Contextual factors: Thoughtful use of physical resources / Variety of resources

Aims
The teacher's objective was for children to study the properties of ice.

Analysis of key features
The episode was part of a series of lessons entitled "Winter". It involved children in teams exploring the properties of ice using ice balloons and a **variety of materials** provided by the teacher (including syringes, paintbrushes, watercolours, dyes, bottle of vinegar and magnifying lenses) as well as other classroom materials selected by the children.

The activity had been **chosen by children** on a previous day, following free play with ice and brainstorming sessions in which they suggested questions and possible investigations. These suggestions had been recorded on flip chart paper and posted on the classroom walls. For the two most popular suggested investigations the children had **drawn their predictions.** This gave the teacher **access to children's previous knowledge and conceptions uninhibited by their language skills**. These predictions were then contrasted with children's drawings of their conclusions at the end of the sequence of lessons on ice.

One of the suggested investigations involved filling balloons with water and placing them in the school's freezer to see what happens. The teacher **had enriched the potential for creative thinking** by adding one balloon that had red dye dissolved in the water, without children knowing. The activity began with the teacher asking the children to think about the materials she had placed on the table and what experiments they could be used for. **She allowed the children time to think about the potential of the materials** before reminding them about their previous suggestions for investigations. They then voted which investigation to carry out. "Playing" with ice balloons was the most popular choice. The teacher brought an ice balloon to each team and **allowed them space and time to follow their questions and interests**. The teacher discussed the children's discoveries, **encouraging them to use different tools and materials in their explorations**. She only addressed the whole class to alert children to thought-provoking observations or suggestions from other teams.

The children then **gathered as a whole group to present their observations and explanations** to Frosty - a snowman doll often used in the classroom as

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part of the winter-themed lessons. **Using a doll** motivated the children and fostered a supportive environment, where they felt able to express themselves. Frosty was also a powerful teaching aid for the teacher, who used it **to ask questions and prompt children's discussion of alternative explanations**. One such discussion was about where the liquid in the children's tubs (where the ice balloon had been placed) had come from. The teacher had noted confusion amongst the children about this issue. A number of them maintained that the liquid in their tubs was because they had added watercolours in them, whereas others attributed it to the melting ice. The defenders presented their two **alternative explanations** to Frosty. The whole class then voted on their preferred explanation. The majority view, identifying the watercolours as the cause for the liquid in the tubs, was **questioned by Frosty**. A child who had not spoken before mentioned the cause of 'heat' in support of the 'ice melting' explanation. This resonated with children's previous experiences with ice and led to suggestions for a further exploration - testing whether ice would melt outside the classroom in the cold air - to be done on a subsequent day.

Opportunities for inquiry and creativity
A number of factors important in nurturing creativity can be found in the lesson observed. The teacher fostered children's **questioning and curiosity** through drawing on their interests or questions, as well as making links to the class theme of winter. **Curiosity** was evident in children's observations, questions, and active engagement with the activity. Children worked collaboratively in handling resources and in sharing roles during more complex tasks. The teacher **stood back** and provided limited guidance, allowing children to **work at their own pace**, intervening only rarely to support either their choice of resources or efforts to explain observations. **Explaining and communicating observations** were also points of focus in the teacher's pedagogy. Use of the doll as an audience and voting in case of disagreement, were consistently and efficiently used by her to promote **reflection and reasoning**, discussion of **alternative explanations** and common conceptualisations of the phenomena observed. **Alternative means of expression**, such as children's drawings, were valued and used in an informal way both as part of **diagnostic and summative assessment** of children's ideas.

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ILLUSTRATIVE EXTRACTS FROM DATA

Encouraging children's thoughtful use of physical resources
Fostering children's agency in planning the practical activity

T: (…) *Will we work with these materials as they are, or should we bring something else that we have been working with all these days?*
Child N: *We should bring the ice cubes.*
Teacher: *We should bring the ice cubes and then?*
Child N: *To see if they have gone bad.*
Teacher: *Ah, you want to bring the fruits we have put in the ice. (..)*
Child E: *We should bring the ice and these. To work with the ice and these, to see what would happen if we put these on the ice.*
Teacher: *So, I hear two ideas. One is of Child N who says that we should bring the fruits and one of Child E who says that we should bring the ice cubes to see what will happen with these materials*. (…) (Addressing all the children) *Do you remember the ideas expressed by Child N and Child E? Child N please repeat your idea.*
Child N: *To bring the fruits to see whether they have gone bad.*
T: *And what is Child E's idea?*
Child E: *To bring the ice and try out these materials on the ice. That is to go to our tables and put the colours on the paint brushes and try them on the ice.*
Teacher: *We can do this – a very good idea. What shall we do first?*
(Children defend the two options and disagree).
Child G: *Let's vote.* (The children choose the one with the ice balloons.)

Fostering children's questioning and curiosity

Child K: *Miss, I see something here. It's like the prickles of a hedgehog.*
Teacher: *What is the tool that can assist Child K in seeing the inside of the ice?*
Child: *The magnifying lens.*
Teacher: *Do you want to go and get the tool that you think will assist you in seeing inside the ice?* (….)
Child D: *It pricks.*
Teacher: *Does the ice prick?*
Child K: *When it breaks it pricks. (…)*
Teacher: *Does your hand fit inside? Leave your hand for some time inside to see what will happen.*

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Fostering children's reflection and reasoning using a puppet (Frosty)
Valuing children's ideas

Frosty: *It was about time that you gave me voice to speak – I have been sitting over there for so many days.*
Frosty: *Child D what are you showing me over there?*
Child D: *We made balloons which turned into ice cubes.***Teacher**: *We will now tell Frosty what we did and I, because I am getting old and start forgetting, what should I be doing?* (..)
Children: *You should write them down.* (..)
Teacher: *Each team will now tell everybody what they did, how they worked, what they saw, what impressed them, what made them go wow!!!* […]
Child D: *We had some balloons and put inside water, which turned into ice cube.* (Teacher writes down "We made ice…")
Teacher: *Child D. How did you make the ice?*
Child: *We put some water and turned into ice.*
Teacher: *We put some water. Where did we put the water?*
Child: *Inside the bubble.*
Teacher: *And then?*
Child: *It turned into water.*
Teacher: *By itself?*
Child 1: *Yes.* **Child 2:** *From water.* **Child 3:** *From the freezer.*
Teacher: *We filled the bubble with water, left it lying around and it became ice?*
Child 3: *From the freezer.* (The teacher writes this down.)
Teacher: *Anybody else from the same team? Something that you found, that you SAW, that impressed you? (..)*
Child M: *It impressed me that the water turned green - dark green.*
Teacher: *Let me now ask you. Where did we get the water from?*
Child: *We had not added any water.*
Teacher: *Had we put any water in the tub?*
Children: *NO.*
Teacher: *Child G, where did we find the water?*
Child G.: *From the colour paints. We added some paints.*
Other Child: *We put the ice, the ice melted a bit, we added the paints, we stirred them up and it happened.*
Teacher: *So what do you believe that happened? The water came only from the paints, as suggested by one of you, or the ice melted into water and then we added the paints as well? Which do you believe is the most correct idea? Let's vote.*

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Episode: GR Bee-Bot	**Setting**: Sch	
Subject: Mathematics	**Age Group:** 6-7 years old	**Teacher:** Stavros
Key factors:		
Learning activities: Planning investigations / Gathering evidence (observing) / Making connections		
Pedagogy: Role of motivation and affect / Children's agency encouraged / Role of dialogue and collaboration / Fostering reflection and reasoning / Teacher scaffolding		
Contextual factors: Confident use of digital technologies		

Aims

The teacher's goals for the lesson were for children to:

- be able to solve simple problems using a step by step approach and acquire basic knowledge about orientation (4 cardinal points);
- understand how the bee-bot rotates and the change in perspective necessary to direct it when it rotates;
- develop mathematical knowledge and skills associated with operations of addition and multiplication.

Analysis of key features

The episode involved the children playing a treasure hunt game devised by the teacher using "Voula" the Bee-Bot. The teacher Stavros introduced the activity, that had been carried out previously in the classroom, by announcing that children would go treasure hunting to help their friend the bee find the treasure in the forest. Stavros **used this context** to introduce the activity and **motivate** the children. An important focus of the lesson was the rules of the game (e.g. "You have to start from the direction of the sun rising. You will put Voula at the first square facing North. In order to reach the treasure you have to make *more* than 4 steps.") and simple instructions that the children had to follow in order to succeed. The instructions **emphasised the importance of children recording their decisions** for the purpose of presenting their findings at the final part of the lesson.

The activity involved children **working in small groups** devising their own strategy to find the hidden treasure. Children in both teams **discussed and reflected on the activity** trying to find the correct path to the treasure. As the children were discussing in their groups, the teacher repeated his instructions and reminded everybody about the **importance of collaboration** in order to complete the task. Even though the teacher emphasised his instructions at the beginning of the lesson, he allowed both teams to discuss and debate their ideas within the group without interfering **allowing children to express themselves - explain their ideas and communicate their explanations to their teammates - as well as to listen to the others.** The teacher's only interference was focused on fostering collaboration and making sure all children understood the value of teamwork.

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Both teams faced coordination issues as all children wanted to programme the bee-bot. In order to resolve any disagreements between the children, the teacher advised both teams to assign specific roles to each member. After the roles were assigned, both teams still struggled to find the treasure, mixing up right and left as the Bee-Bot moved on the map. The teacher **identified the issue** and **began a conversation with the children to resolve any misunderstandings**. At the end of the discussion the teacher suggested that it might be easier for the children to move the Bee-Bot while saying right or left depending on where it goes and not where they stand.

The team that carried out the next attempt immediately after the discussion, and following the teacher's advice, managed to find the treasure and win. After one more unsuccessful attempt, which the teacher took the time to explain what went wrong to the losing team, the game was over and the winner was announced.

Opportunities for inquiry and creativity

Arguably, this lesson fostered children's creative dispositions in a number of ways. Given the hands-on nature of the activity children were **excited and motivated** to carry out their tasks. An important aspect of the activity that contributed to children's enthusiasm was the competition element and the reward offered to the first team that reached the treasure chest. As Stavros commented in his interview "*Children especially enjoy similar activities. Whenever we have competition their excitement and interest is sustained throughout the lesson.*" Stavros used questioning during his brief discussions after a failed attempt to encourage children to **explain** what they were doing and to foster **dialogue and collaboration**. The treasure hunt activity was focused on developing **problem solving and reasoning skills**, aiming to **establish connections** between the Bee-Bot buttons and the actual movement of the robot, design the route to the target and understand the change in perspective and direction as the robot moved on the board.

Creative approaches to teaching were reflected in particular in setting a motivating and meaningful context for the activities described that allow opportunities for **physical exploration**, and **problem solving**. Stavros was actively interested in children's explorations and shared their own excitement during the entire lesson, **using questioning** as the main method of **eliciting ideas and encouraging reasoning**.

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ILLUSTRATIVE EXTRACTS FROM DATA

The teacher presents the task as a competition and sets the rules.
He emphasises the importance of collaboration.

Teacher: *Today we will use Voula to find the hidden treasure. Voula has been lost in the woods again and she has to find her way to the hidden treasure. Let's make the two groups we always play in and begin. Let's have the two teams present themselves.*

(Children seem excited to try and find the treasure.)

Teacher: *I have to remind you that only if you collaborate and work together will you be able to succeed. You don't only have to find the solution, you have to record your every attempt.*

Children review problem solving processes followed and collaboration after an unsuccessful attempt to find the treasure.

Child A: *If you did not press the right button then…*
Child Z: *But I was the captain of the team, I had to handle the bee.*
Child A: *Yes, but you need to listen to all of us.*
Child E: *We need to decide what to do together, we made a mistake and now if they are correct they will win.*
Child A: *He is doing everything in a hurry.*
Child E: *No he just wants to press the buttons on the bee.*
Child K: *It doesn't matter who presses the buttons, it only matters if we win.*
Child Z: *Let's start again then.*
[The children began to plan the path of the bee-bot, but the teacher arrives.]
Teacher: *Where do you think you got it mixed up?*
Child A: *Child K pushed the button to go right, and then Child E said that we should press forward but Child K pushed right again.*
Teacher: *Did this [the bee cut-out] help you?*
All 4 children: *Yes it did a little.*
Child Z: *But we need to fold it so it won't get wrinkles (…)*
Teacher: *Oh right, now I see. Now what do you have to do to reach the goal?*
Child K: *We need to work together.*

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Appendices of D4.4 Report on Practices and their implications

Teacher: *You need to listen to what the others are saying. For example Child A and Child K might have two different ideas. You need to discuss both ideas first before making up our minds.*
Child A: *But Child Z does not hear us and he pushes the buttons himself.*
Teacher: *Child Z is the captain of team but he needs to listen to everybody. Best way is for all of you to take turns pushing the buttons. Discuss what you should do now.*

Teacher identifies the problem and initiates a discussion.

Teacher: *I see that you keep having problems with left and right. Let's see now, which is your writing hand?*
(Children lift their arms - all children are right-handed.)
Teacher: *Which is your right hand then? Remember, I am the only one who is left-handed here.*
All: *This is right* (right hands are still up).
Teacher: *I have observed that instead of saying left and right when moving the Bee-Bot, you just keep saying "Go this way or that way". This might confuse you. Why don't you try to move the Bee-Bot while saying right or left depending on where it goes and see if that helps you. Right and left do not change for Voula. You have to check where she is looking to figure out if she needs to go right or left. If she is turned backward then what happens? Be careful when that happens. Child D, come here in and stand opposite to me. Which is my right hand?*
Child D: *This one* (points to the left hand).
Teacher: *Be careful Child D, when two people are facing each other their right hands are on the opposite side. I will turn around for you to see which one is my right hand. My right hand is on the same side only when we are facing in the same direction.*

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Episode: MA Counting Caterpillar	**Setting**: Sch
Subject: Mathematics	**Age Group** 7-8 years olds **Teacher** Fleur
Key factors:	
Learning activities: Planning investigations; Communicating explanations	
Pedagogy: Reflection and reasoning encouraged	
Contextual factors: Use of ICT	

Aims

This activity focused on a problem solving activity where the children needed to find different combinations of number pairs that all add up to the same total number. The focus for learning can be said to be on the development of cognitive skills and understanding as the teacher aimed at fostering the children's skills and understanding in the manipulation of objects to solve mathematical problems, associated with number bonds.

Analysis of key features

This episode involved the children initially working in the wider class group and then practicing approaches introduced in smaller groups. **The teacher made use of resources such as the interactive whiteboard where the children could practice strategies for solving number problems, and share their reasoning with the class.** She also provided a laminated caterpillar and segments in the shapes of circles that could be stuck on the caterpillar with Velcro to make up various number combinations.

The teacher initiated this activity by asking the children if they could remember the story concerning the number 10. Two children were called out to demonstrate how different pairs of numbers such as 5 and 5 or 4 and 6 add up to 10. They used straws to demonstrate their reasoning and strategy to the class. **The children were not only encouraged to give the correct answers but to communicate their explanations through demonstrating how they achieved their answers.**

The teacher invited another child to work out another example where two pairs of numbers were needed to add up to 4. This time the teacher used the interactive whiteboard and encouraged this child to use an image of a caterpillar and organize its segments in different colours to represent the different number combinations. **The use of ICT stimulated a discussion where the children proposed different strategies to acquire the answer.** The teacher made use of this opportunity through testing out these strategies on the interactive whiteboard. Therefore the interactive whiteboard provided an opportunity to introduce the use of the counting caterpillar for the children to **communicate their reasoning** regarding the task to the class and **to reflect upon their peers' reasoning. This supported their understanding of this activity.** Additional examples were used to reinforce the use of the caterpillar to solve mathematical problems **where the teacher asked questions** about the different parts of the strategy to **foster reflection** about this method**.**

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The group work was introduced after the teacher ensured that the students understood how the caterpillar might be used. Each table was given the laminated caterpillar resources that they could manipulate in their small group. The teacher provided enough **freedom to allow the groups to plan and design their work as they saw fit.** Two groups decided to take off the segment that represented the caterpillar's head. This decision was made after the children **discussed in their small groups** and reflected on the usefulness of the head and collaboratively agreed to do without it**.** The other groups concentrated on representing the total number with the circular segments and then took off individual segments to come up with the combination of number pairs to make a particular total.

The teacher then redirected the groups to join the class for a class discussion. She encouraged the children to share their strategies with the class in terms of how they came up with the different number pairs. Through **communicating about their planning and reasoning** the children were invited to **reflect on their own thinking** as they shared their strategy with the class. The children could also **reflect upon new ways of working out** this mathematics activity through **listening to their peers' explanations**. To terminate the activity the children were instructed to complete some classwork concerning employing the strategies that they had been practising.

Opportunities for inquiry and creativity

The group work organized by the teacher, **stimulated discussions** amongst the children regarding the ways they should go about this activity. This **freedom and time** afforded for the children to be autonomous provided the students with the space to be creative. This creativity is observed in the different ways they organized their resources and the **different ways they reasoned** out the activity.

Through providing the children with the opportunity to communicate their creative work, the teacher demonstrated that creativity should be embraced. Through acknowledging the **groups' different contributions** the teacher also fostered acceptance of **different methods of going about an activity**. This supported the children in making their own contributions and in making sense of different activities in their own ways.

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ILLUSTRATIVE EXTRACTS FROM DATA

The use of ICT to share children's reasoning
Teacher asking questions to promote reflection

Teacher: *What are the number pairs for 4? The caterpillar makes 4…careful…start from zero.*
Child 1: *0 and 4.*
Child 2: *No…just 4.*
Teacher: *Let's see what we have.*

Teacher: *What happens when we get 3 again?*
Children: *They are the same.*
Teacher: *Do we need to do them all over again?*
Children: *No.*

Reflecting about methods to be used in the small groups

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Child 1: *How are we going to work it out?*
Child 2: *We need to find numbers, we have number 6.*
(The children count six segments on the caterpillar and remove the other segments.)
Child 1: *We can start with 1…then count the rest…we need 5.*

Creativity observed in the child initiated adaptation to the resource

(The children are a little perplexed as they look at the caterpillar's head)
Child 3: *Do we need to count this?*
(The children decide to remove the caterpillar's head so that the segments are the only things on the caterpillars' body.)

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Episode: MA Feet	**Setting:** PreSch
Subject: Mathematics	**Age Group** 4 years olds on average **Teacher** Natasha
Key factors:	
Learning activities: Gathering evidence (using equipment) / Gathering evidence (through observation) / Communicating explanations	
Pedagogy: Role of motivation and affect / Role of dialogue and collaboration	
Contextual factors: Variety of resources	

Aims

The aims of this activity involved further developing the pre-skills needed for measuring, where children learn that length can be measured in different ways through the use of different tools such as measuring tape, paper rulers and blocks. The teacher also aimed at instilling awareness concerning how to use the different tools such as positioning the 0 at the start of the scale on the measuring tape and ruler exactly at one end of the object to be measured.

Analysis of key features

This episode involved the children measuring the length of cardboard cutouts representing the children's own feet that they have prepared on a previous day. **The different measuring tools included blocks, measuring tape, and paper rulers.** The children worked together in small groups (n= 4/5) and were encouraged to use these different tools to determine the length of their feet. All the children were already familiar with using these measuring tools as they already had previous experience of measuring the height of objects.

In the first part of the activity the teacher collected the children together in a whole class group and reminded them of a previous activity were they had drawn the outline of their own feet. She engaged the children's attention through selecting a child to draw the outline of her foot. The Learning Support Assistant (LSA) and the researcher were also invited in this initial part of the activity, as two other children were selected to outline the adults' feet whilst the rest of the children observed. This initial exercise **captured the children's attention successfully, fostered motivation and a positive affective response** as the children laughed excitedly and were eager to participate.

Afterwards the teacher distributed the cutouts of the children's feet and the measuring tools to each of the four tables **whilst instructing the children to measure their feet by using the different tools.** The children seemed to prefer using the blocks to measure as they immediately selected this tool. They were proficient in its use since they had already investigated how to use blocks to measure length or height in a previous activity. One of the children **communicated his results to his group** and to the teacher by **explaining that the length of his foot corresponded to 9 blocks.** On observing the children's preference for blocks, the teacher prompted the children to use the other tools. On one table a child took on the teacher's advice and **demonstrated to his group how to use the measuring tape** on his cutout**.**

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Appendices of D4.4 Report on Practices and their implications

The teacher **monitored the group work** and noted that some children were not using the measuring tape or paper ruler correctly. This difficulty was due to the emerging skills of fine motor and eye-hand coordination that the children were still developing and mastering. **Through questioning,** the teacher invited the children to reflect about the correct procedure of measuring that implies starting from 0cm. The students themselves came up with this explanation as one of the children expressed that you need to start from 0cm. The opportunity **to communicate this explanation** redirected this particular student's awareness towards observing the positioning of the tool he was using and adjusting his work in order to follow what he had proposed. This discussion motivated the other children on the same table to investigate the measuring tape and paper ruler and follow the guideline expressed by their peer. The children were counting aloud as they explored with all the different tools.

The group work organized by the teacher provided opportunities for peers to observe each others' work, to **communicate their own explanations and to demonstrate to each other to use the different tools.** The freedom to explore the different tools also contributed to the children's positive attitude towards this activity.

As the activity was coming to an end the teacher redirected the children's attention towards the goal of this activity. She asked the children to think about how they can measure the length of their feet. The children replied that they could use a variety of tools such as blocks, measuring tape and ruler. This indicated that the children had **successfully understood that there are different ways of measuring length.** The teacher also consolidated the children's counting skills by counting numbers all together as a class pointing out that counting is also an important aspect in measuring.

Opportunities for inquiry and creativity

By providing a variety of resources and organizing their exploration within small groups the teacher provided opportunities for children to interact with different measuring tools in different ways. The group setting also enabled children to observe, **communicate and demonstrate to each other** the different ways these tools could be utilized. By **providing questions** were the children where to reflect upon their own work, instead of the correct procedure, the children were encouraged to come up with their own solutions and guidelines.

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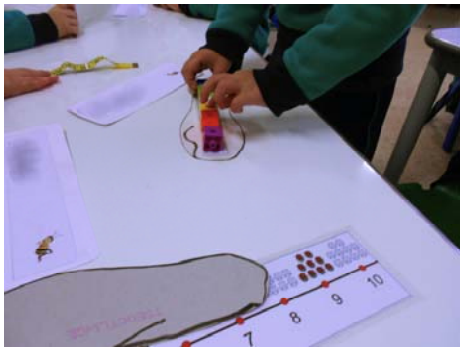
ILLUSTRATIVE EXTRACTS FROM DATA

Child communicating his results to his peers
The teacher challenges students to use other tools



Child 1: *Look it is 9 blocks.*
Teacher: *Ok now see if you can use these too.* (The teacher points to the paper ruler and the measuring tape)

Children communicating and demonstrating the use of different tools

Child 1: *You can do it like this* (holding the measuring tape against the cutout. He is still not aware that he needs to start from 0cm)

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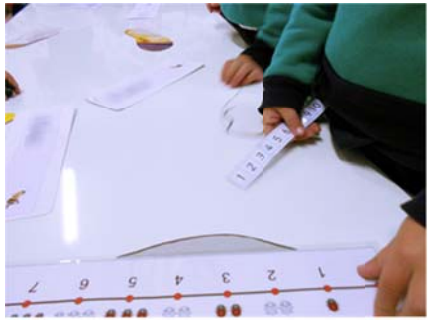
Appendices of D4.4 Report on Practices and their implications

The teacher poses questions to engage the children in reflection and observation
The child communicating and demonstrating the procedure



Teacher: *Now look at the numbers on the tape, how do you have to do it?*
Child 1: *You have to do it from 1.*

The teacher consolidating the learning

Teacher: *So how can you measure the length of your foot?*
Child 1: *You can use the blocks.*
Child 2: *Or the measuring tape or the ruler.*

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Episode: MA Minibeasts	**Setting:**Sch
Subject: Integrated Maths/Science	**Age Group** 6-7 years olds **Teacher** Lydia
Key factors:	
Learning activities: Gathering evidence (through observation) / Communicating explanations	
Pedagogy: Role of motivation and affect	
Contextual factors: Outdoor resources	

Aims

The activity focused on science inquiry. This involved developing and consolidating the children's observation skills whilst enhancing knowledge about and awareness of different types of minibeasts and their habitats. Mathematical concepts were also introduced as the children needed to record their observations through using tables provided in the distributed worksheets.

Analysis of key features

This episode involved the children **exploring the schoolyard** and **observing** the different minibeasts present in their **outdoor surroundings.** A worksheet with a table was distributed to the children so that they could record the minibeasts' characteristics, the number and the habitat. The children worked together in small groups and were left free to explore their environment as they wished.

The teacher initiated the activity by asking the children about their own experiences of nature by **posing the questions** of what they usually find in their gardens at home or in the countryside. **The children were very eager to express themselves and responded positively to the question raised by participating.** After listening to the children's prior experiences, the teacher distributed a worksheet and instructed the children to explore the school's yard and garden and record what minibeasts they encounter.

One group found a pupa stuck to a tree. They excitedly discussed this minibeast and engaged in communicating explanations about the characteristics of the pupa. This encounter **stimulated the children in sharing their previous experiences of the insect, exchanging knowledge** regarding the process of transforming from a caterpillar into a butterfly **and posing questions** regarding this process**.** The group recorded this observation and moved on to exploring other parts of the yard.

Another group spotted some ants and started counting how many they could see**. This encounter also triggered a discussion about their previous experiences of ants as one of the children described how his mother does not like it when she sees ants in her kitchen.** This group also engaged in **questioning the behaviour of the ants** as they commented about how fast the ants were running and were curious if they are carrying food.

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Both these encounters with minibeasts demonstrated how the two groups were very curious and interested about their surroundings. This activity made use of the **children's curiosity to foster positive attitudes towards science,** as the teacher recognised that **the outdoors presents a variety of resources that engage children** in observation, meaning making and sharing of scientific knowledge.

The mathematical concepts introduced in this activity, associated with recording data, were not as easy to grasp for children as the process of observation associated with the scientific inquiry. The researcher assisted the children in recording the minibeasts in their worksheet, as one group was struggling with representing their observations in the tables. The teacher terminated the exploration by directing the children to class. She encouraged the children to **discuss their observations with the whole class.**

Opportunities for inquiry and creativity

The teacher allowed the children to work freely in groups and explore their environment as they saw fit. This freedom resulted in the children engaging in discussions where they were spontaneously questioning and discussing their surroundings.

This exploratory activity organized by the teacher permitted the children to **make connections** to their everyday life making the scientific inquiry and knowledge discussed relevant and meaningful. This was evident as the children communicated about their previous experiences and exchanged knowledge about the minibeasts.

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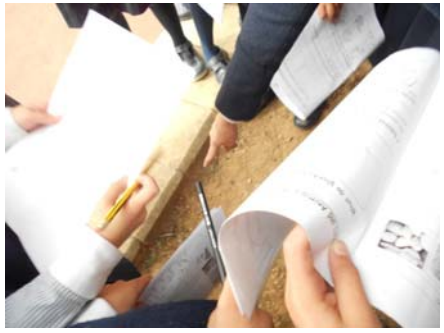
ILLUSTRATIVE EXTRACTS FROM DATA

Communicating explanations about the pupa stuck to the tree

Child 1: *See what this is …?*
Child 2: *That is a pupa…it was a caterpillar once.*
Child 1: *Yes we had one in our garden…it turns into a butterfly.*
Child 2: *Look how it is stuck to the tree. Will it fall?*
Child 1: *How long do they take to become a butterfly?*

Children observing their environment, communicating about previous experiences and questioning their observations



Child 1: *Look, we have lots of those ants at home too.*
Child 2: *How many are there?* (Children count the ants)
Child 1: *We also have them in the garden the ants.*
Child 2: *We also have them inside. My mum does not like them in the kitchen.*
Child 1: *Look how they run about, they go fast…do they have food?*

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Children are eager to explore the outdoors

The children observe different minibeasts and are very interested, engaged and motivated to record and discuss their observations.

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Episode: PT Sun Distance	**Setting:** PreSch	
Subject: Integrated Science/Maths	**Age Group** 5 years old	**Teacher** Carol
Key factors:		
Learning activities: Gathering evidence (using observation) / Questioning		
Pedagogy: Diverse forms of expression valued		
Contextual factors: Sufficient space / Variety of materials		

Aims

To understand the relative sizes of the Sun and the Earth and the distances between them, using proportions; to know basic facts about the solar system.

Analysis of key features

First, in their classroom, they had a conversation with questions and hypotheses about the Sun's size, the Earth's size and the distance between them. Through dialogue between the teacher and the children, they gathered many facts about the Sun and its importance for life.

Then using a ball and a little piece of plasticine they compared the relatives sizes of the Sun and the Earth. The teacher set the problem: *"If the Sun is represented by a ball what would the Earth's size be and what would be the distance between them?"*

The children were then challenged to think about what size people would be to be in proportion. One child's response was 'microbes', making connections to prior knowledge.

The children became interested in the notion of proportion and relative sizes and wanted to compare sizes further. They came up with **their own questions**, for example, "*If the ball was the Earth, what would be the Sun's size? And what would be the size of people?"* "What if the Earth was this room size?" and "If both were of the same size?" The teacher **encouraged children's questioning** and **allowed them time** to answer their peers' questions.

The focus of the lesson then shifted to the distance between the Sun and the Earth. The children were asked to use their hands to show the diameter of the ball (i.e. the Sun) and were asked how many diameters would represent the distance between the Sun and the Earth. When the children learned that it would take around a hundred of them, they were **fascinated** by it. The teacher then gave children one hundred pieces of paper, each was roughly the length of the diameter, to model the distance between the Sun and the Earth **out in the corridor**.

Through their own observations, the children noticed that the grain, which they had chosen to represent the Earth, could no longer be seen from the position of the ball, which represented the Sun. Subsequently, they concluded that the distance between the Sun and the Earth was too great and that the size of the Earth was too small for it to be seen from the Sun.

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The activity provided opportunities for children to develop and **apply their knowledge** about the Sun and the Earth, showing creativity in coming up with their own ideas and new understandings.

The teacher talked about the **notions of distance and proportion** between the objects. She used **several ways to represent** the ball diameter. She gave opportunity to the children to **raise questions** and **explore hypotheses**. The children were very much involved in the activity and interested about the theme. They compared the size of the Sun and the Earth using proportions and also compared the distance between them using the size of the Sun.

Opportunities for inquiry and creativity

The activity created by the teacher was creative. She made use of **a variety of materials to represent** the size of the Sun, the Earth and people (ball, plasticine, grain) and to represent the distance between the Sun and the Earth (using hands and pieces of coloured paper).

The initial use of the ball and a little piece of plasticine to compare the Sun and Earth **sparked the group's curiosity**. Children had the opportunity and time to **raise questions, make many hypotheses and interpret evidence**. The teacher **gave them enough time to explore this**. The children represented their ideas in various ways: through dialogue in a group or drawing pictures where they may use their imagination. They showed creativity in suggesting **new ideas and explanations**.

After some days, when talking with the group about the activity, they explained very well what they had learned and made in that activity. Their curiosity was stimulated, they brought books about the theme, they talked with their parents and **raised more questions**. For example they showed drawings where they answered the question: "*How did Copernicus find out that the Earth moves around the Sun?*" They suggested many interesting hypotheses: "*He went on a rocket and he saw the Earth moving*"; "*He searched in the web*"; "*He searched in his books in his big library*".

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ILLUSTRATIVE EXTRACTS FROM DATA

Children's questions and hypotheses

(The teacher shows the ball and says it represents the Sun and the little piece of plasticine represents Earth.)
Teacher: *If the Earth was this size, what would be the people's size?*
Child A: *I think people were the size of microbes.*
(...)
Child C: *If the ball was the Earth, what would be the Sun's size? And what would be the size of people?*
Child B: *The people would be the size of microbes.*

(Children ask questions about the sizes of the Sun, the Earth and people)
Children: *What if the Earth was this size* (ball size)*? / And if the Earth was this room size?*

Teacher's scaffolding questions / representation using varied materials

Teacher: *If the Sun was this size* (the ball) *and the Earth this size* (the grain), *what would be the distance between them?* (Teacher put both objects on the table).
Teacher: *This would be a good distance?*
(A child separates the two objects.)
Child D: *Maybe the Sun would be here and the Earth would be in the next room.*
(The teacher uses the hands of each child to measure the diameter of the ball)

Teacher: *Do you see this length? What is the name of it?*
Children: *Diameter of the ball.*
Teacher: *Do you know how many of this we have to use to make the distance between both?*
Teacher: *One hundred.*

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Children: *Ah!*
(...)
Teacher: *How far is the Sun from Earth?*
Children: *150 millions of km*
Teacher: *What is 1km?*
Children: *Is the distance from that wall* (the opposite) *to the window / The size of this school / From Braga to Lisbon.*

Use of corridor space /varied materials to represent the distance between the Sun and the Earth / Children gathering evidence through observation

(The teacher gives to each child a set of colored papers of the size of the ball diameter.)
Teacher: *Let's go to the corridor and see the distance between the ball and the grain.*
(They go to the corridor. They put the ball on the floor and start to put the papers through a line.)
Teacher: *What are we doing?*
Children: *We are going to see where we put the Earth.*
Teacher: *How many papers do we have to put between them?*
Children: *One hundred.*
(They put the papers – in pattern - between the two objects and they notice they can't see the plasticine from the ball)
Children: *We can't see the piece of plasticine from the ball!*

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Episode: PT Swing Game		**Setting:** PreSch
Subject: Science	**Age Group** 5 years old	**Teacher** Olivia
Key factors:		
Learning activities: Planning investigations / Gathering evidence (through observation) / Explaining evidence / Making connections		
Pedagogy: Role of problem solving and agency/ Fostering reflection and reasoning		
Contextual factors: Sufficient space / Rich physical environment for exploration		

Aims

For children to discover some principles of swings by executing experiments with the swing game, as well as for them to practise and develop the skills of systematic observation, questioning, planning and recording to obtain evidence.

Analysis of key features

The lesson began with children sitting in a circle on the carpet. They were presented with **a variety of materials**, such as ropes, adhesive tape, different weights to attach onto the rope, among others. They were then asked to design their own swinging game: "*If you want to make a swing (game), then you need a good swing. What is a good swing?"*

The teacher used questioning to foster discussion about the length of the rope and its effects on the motion of the pendulum, *"Which rope should we use? A long one or a short one?; "If you want to make a swing (game), then you need a good swing. What is a good swing?"*

The teacher started the activity with only one wire, all had the same size. Children began to predict that it was possible to have multiple movements. They concluded that the movement could be tilting to one side and the other, with a rhythm. The children also came to the conclusion that they could hang something at one end of the wire. Suggestions included putting oranges in a plastic bag and attaching the bag to the rope, or attaching a coffee bean to the wire. Some children also **made connections with their everyday experience**, by comparing the class pendulum with their grandmother's pendulum clock.

One child tried to attach the pendulum on the side of the door, but it kept banging the wall when the child was trying to swing it. Drawing from **their observation**, the children **explained** that "*We need to use a long rope, an open space (like the door opening) so the pendulum doesn't hit anything while moving*", and suggested that the pendulum needed to be attached to an open space, specifically at the top of the doorway instead.

After this short exploration phase, children are confronted with specific **scientific problems** concerning the swing game:

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For example: "If you want to make a swing game, then you need a good swing. What is a good swing? And what can be the rules for the game? How can you make such a game of your own?" This provided a valuable opportunity for **reflection and reasoning.**

Opportunities for inquiry and creativity

Creativity was present in the opportunities the teacher provided for **children's problem solving and agency**. The children were able to choose the context of their swing game. The **rich physical environment** and **the use of space** in the classroom enabled children to explore different ways of making a swing and what made a good swing game.

Children made their **own connections with experience** registered in expressions like: *"My grandmother pendulum clock as a swing like the one we are looking for,"* showing evidence of science process skills such as observing and describing the surrounding world. When the child was asked, *"How can we build a swing like your grandmother has*?" the child suggested ideas: *"Attach the swing to the wall, hanging something in the end of the rope,"* showing signs of **imagination and problem solving skills.**

Examples of creativity were also shown in children's suggestions of ways to extend activities or solve problems that emerged. For example when some children had made their swings they fixed them to the wall. When trying to make them go backwards and forwards they observed *"This isn't a swing! It hits the wall and doesn't swing."* Many children tried to make it swing, unsuccessfully so they reach a conclusion: *"The swing can't be fixed in the wall, because it's impossible to make it swing, hanged in there."* This part of the activity shows that students were able to use questioning, gathering evidence, interpreting evidence and communicating findings. And we see the process of scientific creativity at work as the children **reason critically between their strategies.**

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ILLUSTRATIVE EXTRACTS FROM DATA

An open-ended problem

Teacher: *If you want to make a swing* (game), *then you need a good swing. What is a good swing?*
(…)
Child M: *With the plastic bag we hold the oranges fasten to the rope, and there is the pendulum!*
(…)
Child R: *Attach the swing to the wall, hanging something in the end of the rope.*

A variety of materials

Opportunity for children's reflection and reasoning

Teacher: *What do we know at this moment about pendulums?*
Child S: *We need to use a long rope, an open space* (like the door opening), *so the pendulum doesn't hit anything while moving.*

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Appendices of D4.4 Report on Practices and their implications

Children's own investigations / Children gathering evidence through observation
Rich physical environment for exploration

The teacher helped a child to attach a capsule of coffee to the end of the rope and fix it to the wall. Children tested their hypotheses, trying to swing it.

Child R: *This isn't a swing! It hits the wall and doesn't swing.*
Child S: *Pull away from the side.*
Child J: *Take it more out.*
Children: *Let me try, I think I can make it swing and don't hit the wall.*

Many children tried to make it swing, unsuccessfully. Finally, they reached a conclusion:

Children: *The swing can't be fixed in the wall, because it's impossible to make it swing, hanged in there.*
Child R: *Maybe we can fix it to the top of the door opening.*

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Episode: PT Wolf, Sheep and Cabbage	**Setting:** Sch
Subject: Integrated Science/Maths	**Age Group** 8 years old **Teacher** Florence
Key factors:	
Learning activities: Planning investigations / Communicating explanations	
Pedagogy: Reasoning and reflection encouraged / Diverse forms of expression valued	
Contextual factors: Small grouping	

Aims

The aim of the problem is to move the wolf, sheep and cabbage to the opposite shore of the river. It gets more difficult though because when the man is not around, the wolf will eat the sheep, the sheep will also do the same when alone with the cabbage. This involves the use of knowledge of food chains to solve the problem – analysing possibilities and predicting if there is more than one solution.

Analysis of key features

The teacher introduced the well-known **problem** 'Wolf, Sheep and Cabbage' on the blackboard, and explained the rules of the game to the children. The children had to carry the wolf, sheep and cabbage on a boat from one side of the river to the other, one by one. The conditions were that 1) if the wolf is left alone with the sheep, it will eat the sheep; 2) if the sheep is left alone with the cabbage, it will eat the cabbage; and 3) the wolf will not eat the sheep and the sheep will not eat the cabbage if the farmer, who is sitting in the boat, is right nearby to side of the river that they are on.

Using the paper cut-out models of the wolf, sheep and cabbage that the children had made and painted previously, and an *origami* boat that they created at the start of the game, they were encouraged to **work in groups** to solve the problem.

Throughout the activity, the children **collaborated** with their peers to think of different possibilities; to try out the different potential solutions; and to **give reasons** why certain ideas would not work.

The whole class reached conclusions and solved the problem presented in the beginning, and had the opportunity to verify their solutions against the on-line version of the game, which is available freely on several websites. The **use of ICT** allowed the children to experience and **represent the same problem in different ways**.

Opportunities for inquiry and creativity

The context of the game provoked children's **imagination**, and the informal and fun nature of the task **motivated** the children to become engaged in the problem. Working in groups encouraged children to articulate their ideas and

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reasoning. Children **collaborated** in sharing and discussing different ways to solve the problem.

Children's **problem solving skills** were fostered as they suggested and modelled different potential solutions and gave **reasons** why certain ideas work or would not work. Children used and developed science skills such as predicting, observing, analysing and describing, demonstrating scientific or mathematical creativity in generating alternative ideas and strategies and **reasoning critically between them**. They also had to **make connections** between the combinatorial / mathematical aspect of the task and their knowledge of food chains.

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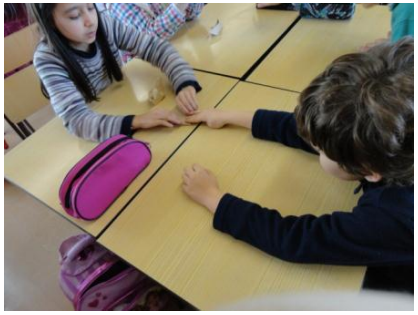
ILLUSTRATIVE EXTRACTS FROM DATA

An example of children collaborating and giving reasons

Child L: *The sheep eats the cabbage.*
Child R: *The sheep has to go first because the wolf doesn't eat the cabbage.*



Examples of children explaining why certain ideas would work and would not work

Child R: *If we took the sheep first, then the cabbage, then the sheep will eat the cabbage.*
Child R: *So we have to leave the sheep and bring the cabbage back.*
Child R: *If we took the cabbage in first place, the wolf will eat the sheep.* (…)
Child G: *First we take the sheep across, then we go back and get the cabbage, then we take the sheep back and take the wolf across, then we take the sheep across.*

The informal and fun nature of the task helped in engaging children

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The integration of ICT for children to verify their solution

Reflecting on learning

Child LA: *With this activity we learned that to solve a problem we have to make relationship between what we are 'analysing'.*

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Episode: RO Float or Sink	**Setting:** PreSch	
Subject: Science	**Age Group** 5-6 years old	**Teacher** Maria
Key factors:		
Learning activities: Planning investigations / Gathering evidence (through observing) / Communicating explanations / Explaining evidence		
Pedagogy: Role of problem solving and agency / Reflection and reasoning encouraged		
Contextual factors: Variety of materials / Small grouping		

Aims

For children to become familiar with the concepts and processes of floating and sinking, as well as for them to develop their knowledge about the forest and the objects and materials that can be found there, in addition to insects and birds that live in the forest. Additionally, the activity also aimed to foster the children's problem solving skills.

Analysis of key features

Maria, the class teacher, started the lesson by inviting her 12 children to come and pick a card from her. Each card had a picture, and there were three different pictures altogether. Children with the same picture formed a group, resulting in **three groups of four children of randomly mixed abilities**.

She asked children what a forest is, what kind of trees can be found in a forest. There was a permanent dialogue with children who responded to teacher's questions. The little ant is looking for food. What seasons are used by the ants to gather food? All the children were engaged in the dialogue were asked if they agreed with the answers. Then one day, the little ant fell into a river. A dove flying by saw what happened and wanted to help the ant. Whilst telling the story, Maria showed the children pictures of both animals and the children were asked to describe the two characters and to compare their anatomical differences, before asking the main question of how the ant could be helped by the dove.

Initially, children's proposed solutions included those that required the dove to help the ant directly, for example, the dove should use its beak to pick up the ant and the dove pick the ant up using one of its paws. Through **class dialogue** and drawing from the previous discussion on the two animals' anatomical differences, other children highlighted the weaknesses of the two aforementioned solutions, including the fact the dove's peak would be too hard for the ant and it might injured the ant, or that the dove's feet would be too large and too long to hold the ant up properly.

Maria then hinted at the fact that the dove then tried to look for something that it could help to get the ant out of the water. Additionally, she also highlighted at the location in which the story took place. Through Maria's careful **scaffolding**, the children's focus then shifted from how to get the dove to help the ant

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directly to thinking about what natural materials in the forest the dove could use to help keep the ant afloat and out of the water. Maria wrote down the names of each of these natural materials on the whiteboard next to the name of the child who suggested it.

Later, Maria suggested that the children run an investigation to **identify the best idea to solve the problem**. The children were given small containers with water in order to verify what materials existing in the forest could be used as little 'boats' for the ant. **A variety of materials** were made available including nuts, feathers, wooden sticks, leaves, little stones, acorns, pieces of bark, fir cones, etc. Maria asked every group to come to the front table and to take the materials they thought were the most suitable for the task to save the ant, items they intended to test. Children had to predict which objects would float.

Opportunities for inquiry and creativity

By providing an inquiry-based problem that had more than one solution and by giving them autonomy to come up with their own ideas, the children were able to **plan their investigations**. For example, some children proposed that *"The dove can place [a small stick] below the ant and lift it up and place it on the stone"*, whilst another child suggested that *"The dove keeps the stick in its beak and gives it to the ant and draws the ant from the water".*

Through teacher scaffolding, children were given opportunities to foster their creative thinking **drawing on evidence from their observations**, as was the case when one child was asked to describe what happened to an object (napkin) he was experimenting earlier, to which the child responded: "*It sank. (…) It went wet and went to the bottom of the container*", and to subsequently draw a valid conclusion when asked whether this object would be appropriate to help save the ant.

Through peer-to-peer dialogue, children's creativity was also noted when they made sensible **explanations** to their peers whether a proposed solution would work. While one child, for instance, recommended the dove to help the ant using its beak, another child explained that "*It does not work; dove's beak is too strong.*" Through **making connections** with their knowledge of forest, the children were able to offer solutions that were practical and useful, for example a leaf, a wooden stick, a feather, a blade of grass, and among others.

Children's creative thinking was also evident when they were given freedom to **communicate their findings** in a variety of forms, be it through writing or drawing on their worksheet, as well as a verbal presentation at the end of the lesson.

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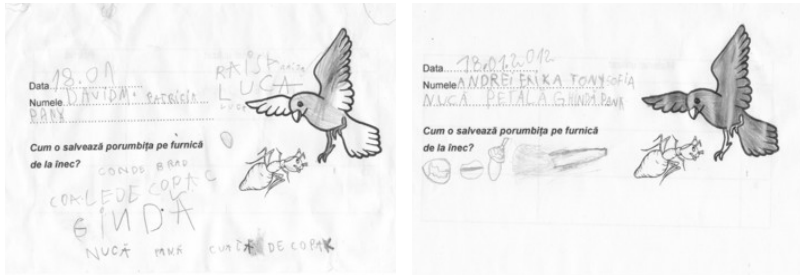
ILLUSTRATIVE EXTRACTS FROM DATA

Children working together to find the best materials to keep the ant afloat

Children communicating their findings in various ways

[Name/Date/By what means did the dove save the ant from sinking?]



Example of teacher scaffolding and children's creative solutions

Teacher: *Then the dove looked around to find something to help the ant out of the water. I wouldn't tell you what it found. I shall leave you to guess what it used. You have to discover what is the object dove used.*
(…)
Child 3: *A liana.*
Teacher: *That is a stick?*
Child 1: *It was a stick, a small stick. The dove can place it below the ant and lift it up and place it on the stone.*
(…)
Child 5: *The dove keeps the stick in its beak and gives it to the ant and draws the ant from the water.*
Child 1: *The dove takes a stick with a hole inside and places it in front of the ant, and the ant goes inside and comes out.*

Example of class dialogue

Teacher: *What do you think the dove had done to save the ant?*
Child 1: *It took her with its beak.*
Child 2: *It does not work; dove's beak is too strong.*

Children using evidence from observation

Teacher: *Besides this conclusion I notice Child D that you tested a material which was discharged away by the end of the investigation. We had an object, which, according to my opinion, can be use to rescue the ant. What was that object?*
Child D: *The red feather?*
Teacher: *No, besides the red feather. What it was? A piece of …*
Children: *Napkin.*
Teacher: *What did you notice happened to this piece of napkin?*
Child D: *It sank.* (…) *It went wet and went to the bottom of the container.*
Teacher: *Do you think this object can be used to save the ant?*
Children: *No. No.*

Episode: RO Ice	**Setting:** Sch	
Subject: Science	**Age Group** 7-8 years old	**Teacher** Stela
Key factors:		
Learning activities: Planning investigations / Making connections / Communicating explanations		
Pedagogy: Collaboration / Role of problem solving and agency		
Contextual factors: Variety of materials / Rich physical environment for exploration / Small grouping		

Aims

For children to become familiar with the concepts of liquids and their properties, and the melting process, as well as for them to conduct experiments to test their hypotheses.

Analysis of key features

The lesson started with Stela, the class teacher, showing a short animation of Scrat, a squirrel, who had been stranded on an island. In order to survive, it had to find a way to get acorns, Scrat's only food supply, out of ice cubes. Stela paused the video there, and turned her attention to the children, inviting them to help Scrat **find a solution to the problem.**

Children were asked to **work in groups** to **propose the best solution to the problem**, using **a range of materials** that had already been prepared for by Stela to test their idea. These materials included hot water in a thermo, sugar, salt, and a small hammer, in addition to ice cubes with acorns frozen inside.

For Group 1, the children chose to use hot water to try to melt the ice cube to get the acorn out, by carefully pouring hot water out from a thermos to the ice cube. Following the group's experiment, a child also suggested using sugar to melt the ice.

The children in Group 2 chose to use salt to melt the sugar, as one of the children recalled how salt is normally used to melt ice on the streets during winter, **making a connection** between the learning activity and their everyday life experience.

For Group 3, the children discussed and agreed to use the wooden hammer to break the ice to retrieve the acorn. One child attempted to hit the ice cube with the hammer several times, before the ice cube got was broken into small pieces (*"I broke the ice very quickly, it was not difficult. Scrat can eat the acorn now"*).

The teacher just supervised the children and offered some consultancy when needed. In dealing with the problem they were facing, the children followed some of the steps of the **inquiry-based learning: problem identification, proposal for a solution, set-up of an experiment, selection of materials to be used, observing a phenomenon, and recording the results**.

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The inquiry approach was evident in the lesson as the children were asked to **record their findings** on a worksheet with the following headings: 'Planning' (*"we have to free the acorn by the impact of the hammer"*, *"the ice has to be crashed"*), 'List of materials used' (*"hammer, ice"*), 'Action taken' (*"we struck the ice with the hammer"*), **'Observation'** (*"the ice is broken"*), 'Conclusions' (*"the ice is took off rapidly"*).

At the end of the lesson, each group was asked to nominate a child to **present the results and conclusions to the rest of the class**, as well as comparing if the test result matched their predictions. One of the conclusions: *"the method works"*.

During the activity, Stela assisted the children to keep them safe from working with hot water and a hammer. Additionally, she also observed children during their investigations, focusing on the manner in which children adopt and apply various strategies to obtain a sound result, as well as other broader aspects of scientific learning, such as their attitudes, collaborative skills, discipline, vocabulary, and the way children progress in their "research". Stela also evaluated their outcomes based on their completed worksheets.

Opportunities for inquiry and creativity

Children's problem solving skills were fostered as the children **conducted their investigation** and used their **observation** data to draw their conclusions. For example, when a child suggested that, in addition to hot water, sugar should also be used to melt the ice, and when he conducted the experiment with sugar, he observed that "*Nothing happens. The ice is already melting."*

An additional creative disposition was noted when a child made **a connection** between the provided resources and what was observed in their everyday life outside the classroom, more specifically when a child chose to use salt to melt the ice cube as a result of having the former being used to melt the latter on the streets during winter.

Children's creative thinking was also evident when they were given freedom to **communicate their findings** in a variety of forms, be it through writing or drawing on their worksheet, as well as a verbal presentation at the end of the lesson. An example of their communicated finding includes "*We expected ice to melt quickly, but it took some time, and still now the ice did not melt completely."*

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ILLUSTRATIVE EXTRACTS FROM DATA

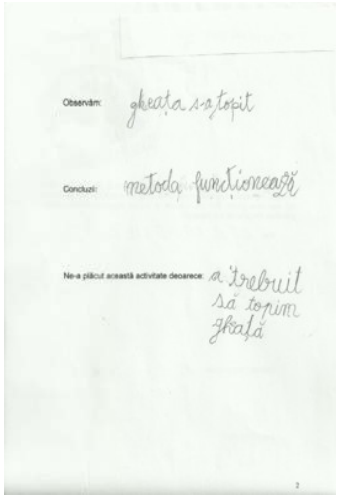
Children conducting their investigations





Examples of children communicating their findings both verbally and in writing

Teacher: *One pupil of the group please present the results in front of the class.*
Group 1: *Conclusion: hot water was a good solution and ice melted rapidly. We added some sugar, but nothing happened.*
Group 2: *We expected ice to melt quickly, but it took some time, and still now the ice did not melt completely.*
Group 3: *Conclusion: I broke the ice very quickly, it was not difficult. Now Scrat can eat the acorn.*



Name/Date/ Scrat is hungry.
The Ice Age acorns are frozen. Let's help Scrat to release its favourite fruits from the ice trap. By which methods and by what means can you take out the acorns from the ice as fast as possible?
Ideas/Hypotheses/ We use materials/ We experiment/ We observe/ Conclusions
We liked this activity because……

A child's curiosity was aroused, resulting in an additional investigation

Group 1 received a tray, one ice cube with an acorn inside and salt. Children poured hot water on the ice, the latter started to melt and finally the acorn was freed:

Child A: *What if we shall add some sugar? Let's try!*
(…)
Teacher: *What do you observe?*
Child: *Nothing happens. The ice is already melting…*

Episode: RO Measuring Volume (Non-Standardised Units) **Setting:** PreSch
Subject: Integrated Science/Maths **Age Group** 5-6 years old **Teacher** Sanda
Key factors:
Learning activities: Gathering evidence (using equipment) / Gathering evidence (through observation) / Communicating explanation
Pedagogy: Reflection and reasoning encouraged
Contextual factors: Variety of materials / Rich physical environment for exploration

Aims

For children to understand the use of and become familiar with a range of non-standardised volume-measuring units. Additionally, the following were the concepts that the teacher wanted her children to grasp:

- measuring means comparing the quantity to be measured with a small quantity considered as "unit";
- the number of units associated to a quantity to be measured depend on the ratio between the quantity to be measured and the unit value;
- in various measuring situations appropriate units have to be used.

Analysis of key features

The lesson started with Sanda, the class teacher, asking children which unit is used to measure liquids. Some children were able to identify the unit as the litre. They were told that they would not be measuring the volume using the litre, but **"various other units"**, for example, glasses, cups, tubes, bottles and cylinders. The teacher then asked what other liquids could be measured to which the children responded "oil, vinegar, milk, juice, beer, tea and wine".

The children then worked **in groups** to compare the volumes of the different containers, as previously indicated. For example, some children were asked to pour water from a glass to a cylinder, others from a bottle to a cylinder, among others.

Conclusions about the volumes were then made by the children either independently or through **teacher's scaffolding** (e.g. *"What can you say about the two vessels? Are they the same, in terms of volume?"*). As it can be seen in the 'Illustrative extracts from data' section, some children were able to give **reasons** for their conclusion based from their **observations**.

It might be worth noting that there was no worksheet in this activity as the teacher indicated that:

*"Sometimes worksheets are very useful during the work in class, but there are situations when children can get new knowledge much easily by **discussions**, both in each group and with the whole class, by repeating each new concept several times."*

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Appendices of D4.4 Report on Practices and their implications

Opportunities for inquiry and creativity

Children's creative thinking was fostered through their **observations** and in **communicating explanations** to others either independently or through teacher scaffolding. For example, when the children were asked to pour water from a bottle into a cylinder, they offered the following conclusion and explanation: "*The bottle is bigger than the cylinder because there still is some water in the bottle…".* Similarly, when the children were asked to pour water from a cup into a cylinder, their conclusion and explanation were as follows: "*The cup is bigger because there still is some water in it that does not fit in the cylinder."*

Arguably, the children's **problem solving skills** were also fostered as they had to **conduct the investigation**, and used the data from their observations to draw a conclusion on whether the volume of a container was equal, greater or less than the volume of the other container in question. By the end of the exercise, the children concluded that not all units have the same volume.

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ILLUSTRATIVE EXTRACTS FROM DATA

Children gathering evidence from observation and use of equipment






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Children drawing conclusions and reasoning from their observations

Teacher: *Now let's see the next experiment. You will pour water from the bottle in the cylinder till you will reach the last line on the scale.*
Child 1: *The bottle is bigger than the cylinder because there still is some water in the bottle…*
(…)
Teacher: *Now, you pour water from the cup into the cylinder.*
Child 2: *The cup is bigger because there still is some water in it that does not fit in the cylinder.*
Teacher: *Let's compare some other cups. You have water in the cylinder and now pour it in the cups. Does water fit in the cups?*
Children: *They are the same! The water from the cylinder fits in the cup!*
(…)
Child 3: *In my glass did not enter the whole quantity of water. There still is some water in the cylinder.*
Teacher: *And what can you say about the two vessels?*
Child 3: *The cylinder is bigger then the glass.*
(…)
Teacher: *How these two containers are, if the water from one of them can fill the other one?*
Child 4: *They are the same, they are equal.*

Learning through working with others

Teacher: *What can you say about the two vessels? Are they the same, in terms of volume?*
Child 5: *Yes.*
Child 6:*Nooo … the glass is bigger than the cylinder!*

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Episode: UK(EN) Balancing Pens	**Setting**: Sch	
Subject: Mathematics	**Age Group** 5-6 years old	**Teacher** Emily
Key factors:		
Learning activities: Gathering evidence (using equipment) / Gathering evidence (through observation) / Questioning / Explaining evidence		
Pedagogy: Collaboration		
Contextual factors: Formative assessment / Variety of materials		

Aims

To estimate, weigh and compare objects using both standard and non-standard units or measuring instruments.

Analysis of key features

The episode was drawn from the Weighing activity that took place at the weighing table. The activity was a part of a carousel of measuring activities, including the 'Filling Boxes' activity, the 'Capacity of a Jug' activity, the 'Building Towers' activity, and the 'Measuring Length with a Metre Stick' activity. These activities were made available for children over two consecutive days and were carried out in mixed ability groups in a rotation. They illustrate the **play-based approaches** emphasised by the teacher, Emily, and her concern to foster **alternative ideas and reasoning.** In planning, the tasks were set up to also allow **problem solving** in mathematics. The episode was also drawn from Emily's plenary discussion at the end of the session.

The weighing table was set up with a range of **materials and equipment**, including small pens, Berol pens (larger), small animals, paintbrushes and a balance scale to be shared between two children. The children were asked to use the balance to find out how many of each object was needed to weigh 100gms. They had a worksheet to fill in as they went along. On the worksheet they had to record the object and how many of that object weighed the same as 100gms.

As it can be seen in the *Illustrative extracts from data* section, children were given opportunities to use their **observation** skills to solve the set problem. This was highlighted in one example when two children Neil and Henry were working **collaboratively**. They were having difficulties in getting the scales to balance using Berol pens. Based on their observations, they attempted to make predictions of whether to take one pen off or add another one to balance the scales. Furthermore, through such collaboration, evidence of **children's questioning and explaining** was also noted. This was illustrated below when Henry had suggested that mini pens, instead of bigger Berol pens, should be used to balance the scales, and Neil asked why. Henry attempted to explain that as 100gms is not heavy, the mini pens would be more suitable to balance the scales than the bigger Berol pens.

During the plenary, more evidence of children's creative thinking was elicited and **formative assessment opportunities** were made possible through Emily's

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questioning. For example, when asked which tool, given the choice of unifix, a ruler and a metre stick, would be more appropriate to measure the width of their bedroom, a girl said unifix or cubes would be better. She explained that this is because there were lots of them and she could line them up along the entire width of the bedroom. As there was only one metre stick, it would not be enough to measure the bedroom's width.

In sharing her **evaluation** of the session, Emily indicated she was concerned that the children did not understand how to use a metre stick to measure longer lengths. The children seemed to think that it was impossible to measure without having many metre rulers. She decided therefore that in the next session she would provide activities going beyond a metre to give them the opportunity to think through the problem of measuring longer lengths.

Opportunities for inquiry and creativity

Creativity in teaching was shown through the rich opportunities Emily provided for **exploration.** Emily planned **meaningful contexts** and activities making links to **everyday events**. She modelled **enthusiasm** portraying the subject as being interesting. Emily **scaffolded** learning through small steps, slowly **building on children's ideas** in whole class discussion. She used **questioning** to motivate and to encourage children to express their ideas and to **foster reflection and reasoning** – making **connections** across experiences for example at the beginning of the plenary she talked about the appropriateness of the container for measuring the capacity and then moved onto the appropriate tool for measuring length.

The planned activities fostered children's **creative dispositions.** The children's attitudes to the mathematical activities were positive. They showed high levels of **engagement** and they were not daunted by challenges or by failing to get an answer. They showed a **sense of initiative** in coming up with ideas to **solve the problems** they faced and **reasoning skills** in justifying their suggestions.

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ILLUSTRATIVE EXTRACTS FROM DATA

Variety of materials

Children working collaboratively

Two children, Neil and Henry, were using Berol pens to weigh how many pens would balance 100gms. They were working **collaboratively**. They were having difficulties in getting the scales to balance.

Neil: *It's not balancing.*
Henry: *Put on another one.*
Neil: *But now it's too heavy.*
Henry: *Take one off.*
Neil: *It's still not balancing. It doesn't make sense.*

Henry offered an **alternative idea -** that they use smaller pens to balance the 100g weight. Prompted by Neil, he **explained** his suggestion and his estimation of how many would be needed.

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Henry: *Let's try the mini pens they will work better.*
Neil: *Why?*
Henry: *Because they are smaller.*
Neil: *It isn't 100.*
Henry: *Think we will need 30 to balance the 100g weight.*
Neil: *This is too little because they weigh nothing. 100gms is not heavy.*
Henry: *It's 39 that's right. 39 is 9 more than my guess.*

Opportunities for formative assessment and children's reasoning through teacher questioning

Teacher: *Which would you use – there is a choice of unifix, a ruler or a metre ruler?*
Child Grace: *Metre stick*
Child Sarah: (disagreeing) *The bedroom is bigger than a metre stick. Cubes would be better because there were lots and you could use lots of them. It would be better if you had 2 rulers. It won't stay like that if not enough sticks.*
Teacher: *What would choose if there were enough sticks?*
Child Audrey: *Using a metre stick isn't good because when you get to 10 then you have to go back to zero.*

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Episode: UK(EN) Buttons **Setting:** PreSch
Subject: Mathematics **Age Group** 3-4 years old **Teacher** Fleur
Key factors:
Learning activities: Gathering evidence (through observation) / Questioning / Explaining evidence
Pedagogy: Role of motivation and affect
Contextual factors: Formative assessment

Aims

The aim of the lesson was to reinforce learning about changes to materials. The children had previous experience of melting chocolate and had also been exploring ice.

Analysis of key features

In this lesson Fleur, the class teacher, gave each child a chocolate button to hold while she read a poem called Chocolate by Michael Rosen. After listening to the poem the children were told to open their hands and observe what had happened. The teacher asked about the shape of the chocolate, which the children found difficult, whether it was soft or hard and whether it was still chocolate. The children were then allowed to lick the chocolate from their fingers to check.

This lesson with the afternoon group was based on **formative assessment** of these children's previous experiences of melting. Fleur had led a similar lesson with the morning children but had altered it based on her observations of that lesson. Questioning at the beginning and end of the short lesson allowed her to make further assessments. These then resulted in changes to future planning.

In her interview Fleur was pleased to note that the children had moved on from the previous activity; *"The first time most said it wasn't chocolate anymore but straight away this time they remembered it was still chocolate. They understood just because it looks different it's still the same and that's hard for them to understand."*

Opportunities for inquiry and creativity

Fleur had demonstrated a creative approach to **planning the activity**, recognising that the children would be **motivated** and **engaged** in an activity that involved chocolate. This was a material that they were familiar with and presented a good contrast to the previous activity on ice – which had the same learning objectives, and demonstrated that the effect of heat on different materials presented the same results.

Holding the chocolate while listening to the poem allowed them to **act out a small part of the story in the poem**. At the conclusion of the poem they had melted chocolate in their hands, just like the boy in the poem. Throughout the children were being encouraged to **make connections** between the previous

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activity and their own explorations. Following this teacher led lesson the children were given opportunities to explore independently.

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ILLUSTRATIVE EXTRACTS FROM DATA

Questioning based on previous lesson

Teacher: *Who can remember what we did on Tuesday?*
Child: *Melted buttons.*
Teacher: *Yes, how did we do that?*
Child:*Squeezed.*
Teacher: *Yes, we squeezed in our hands. Why did we do that?*
Child: *Hot*
Child: *Warm*
Child: *Melted*
Teacher: *Did it still look like a chocolate button then?*
Child: *No.*
Teacher: *Was it still chocolate?*
Child:*Yes.*
Teacher: *How did we know?*
Child: *We licked our fingers.*

The children then held chocolate buttons in their hands while the teacher read the poem *Chocolate* by Michael Rosen. This poem is about a child who is carrying chocolate home but it melts in the child's hand, who then licks it. When the poem was finished the children opened their hands and observed what had happened to the chocolate.

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Explaining evidence

The teacher had held her own chocolate button, but interestingly this hadn't melted which led to more questioning. This demonstrated that the children understood the role of heat in the melting process.

Teacher: *Why hasn't mine melted?*
Child: *Your hands are cold.*
Child:*Our hands are hot.*

Girl: *It's chocolate still but it isn't round anymore.*

Motivation through chocolate

The children were allowed to lick their fingers to check that it was still chocolate despite having melted.

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Episode: UK(EN) Café **Setting**:PreSch
Subject: Mathematics **Age Group** 4-6 years old **Teacher** Jenny
Key factors:
Learning activities: n/a
Pedagogy: Affect / Role of play and exploration
Contextual factors: Sufficient time / Sufficient human resources / Variety of materials

Aims

For children to apply mathematics in practical situations including counting, adding and subtracting, as well as for them to identify different coins and to understand that different coins are worth different amounts. The application of the children's mathematics was a key focus in the fruit café.

Analysis of key features

This episode is based around a single observation but the Fruit Café is an on-going, daily activity. Each day the children are provided with a snack of fruit or vegetables and a drink. Jenny the teacher has turned this into a mathematics activity by getting pairs of children to run the fruit café, supported by a teaching assistant. The children who are running the café take the coins and in some cases make change. They keep track of the children who have been to the café by ticking their names on a recording sheet and they serve the snack.

There is a menu with prices that are set each day for the various items. There are pots of real coins, which the children use to pay for their snack, determining the coins they need with the support of the teaching assistant. Because the children often purchase a drink and a piece of fruit there is addition of two numbers. By changing the prices on the menu Jenny is able to influence the numbers being added. In some cases the children running the café have to make change so are practising subtraction, either as counting on or as taking away or difference. There is also some data handling involved. The children have to find the prices for the relevant items on the menu, while the children running the café keep track of which children have taken part.

While the fruit café is a primary focus of this episode, this lesson contained several activities that developed counting and understanding what different coins are worth. The lesson started with the class singing *Hickory Dickory Dock, I am a digital clock*. In this activity, the children take turns clapping out the 'hour' and the rest of the class have to count the claps to identify the time. Jenny commented that counting sounds was more challenging than counting objects that could be seen and touched.

This was followed up with another sound counting activity. Jenny would take a number of coins and drop them one at a time into a metal tin, with the children counting the sounds in their heads, checking with their talking partner and showing the appropriate number of fingers. She was able to assess their

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responses quickly and repeated the activity if there were many children with the wrong answer. When the children had successfully counted the number of 1p, 2p and 5p coins, she set these out on pieces of coloured paper. She set up a scenario where a kindly uncle was going to offer them some coins and they had to choose which ones they wanted by showing the appropriate coloured paper.

Opportunities for inquiry and creativity

An important aspect of teacher creativity in this episode **is recognising the opportunity** for developing mathematics in an everyday activity. It is common in England for children to have a morning snack but it is unusual to see this turned into a mathematical activity. By using **a variety of everyday resources** (fruit, vegetables, drinks and real coins) the teacher was able to **make the links between mathematics and real life activities** very explicit.

Time is also a positive factor in this episode. Although a single lesson was observed, this is an on-going activity that will be constantly developed throughout the year. **Sufficient space** allowed the fruit café to be in a separate area to the rest of the classroom so the different activities did not disrupt each other. **Sufficient human resources** allowed a classroom assistant to support the activity while the teacher worked with the rest of the class.

While the activity was teacher-initiated and structured in nature, the combination of **role play** and the use of everyday context promoted their imagination and kept children engaged as shown in one of the children's comments in the *Illustrative extracts from data* section below.

Jenny stated the importance of children learning to count and she had many different activities to practise this. **Using the song engaged** the children and made them count sounds. Dropping the coins in the tin gave them another chance to count sounds but this time they were able to check by counting visually. The children were encouraged to **make connections** between the different activities and the learning that was common to all.

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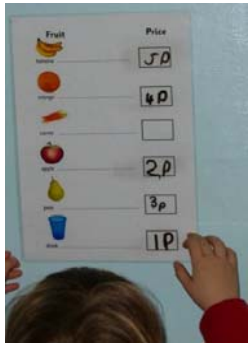
ILLUSTRATIVE EXTRACTS FROM DATA

Two children are chosen to run the café each day

The teaching assistant helps with identifying and counting the coins

Fruit café menu



Child 2 and Child 3 are in charge of serving the fruit and drinks, taking the money and keeping track of the children

Child 1: *I would like an apple.*
Child 2: *An apple. And what to drink?*
Child 1: *May I have some water please?*
Child 2: *That's 2p and 1p. 3 pence*
Child 3: *What glass would you like? Green? There's your drink. I'll tick your name off.*
(...)
Child 2: *Do you want a drink with your banana?*
Child 4: *How much is a banana?*
Child 2: *5p.*
(Child 4 hands over 5p to Child 2)
Child 2: *That's fine.*

Children's enjoyment in running the café

Interviewer: *Is it good being in charge of the fruit café?*
Child 5: *Yeah, I get to put out the money and you get to tick the list off!*

Episode: UK(EN) Counting Minibeasts	**Setting:** PreSch	
Subject: Mathematics	**Age Group** 4-5 years old	**Teacher** Lisa
Key factors:		
Learning activities: Planning investigations; Communicating explanations		
Pedagogy: Diverse forms of expression valued; Role of problem solving and agency; Teacher scaffolding; Reflection and reasoning encouraged		
Contextual factors: Sufficient space		

Aims

The lesson provided opportunities for children to practise counting objects and to encourage them to communicate results in their own ways.

Analysis of key features

The lesson started with Lisa, the teacher, asking children to help count how many chocolates there were in a bowl. Children were asked to pass the bowl around and to make a guess. A number of children were invited to write their estimations on the board.

During the main part of the lesson, the children worked in **mixed ability groups** on a variety of activities. The selected episode is drawn from a group of three children, namely Aahil, Desiree and Eleesha, who were asked to sort, count and record how many plastic minibeasts there were in a bucket:

"I've got lots of bugs here. (…) I need to know how many spiders I've got. I need to know how many flies … I need to know how many dragonflies. But I haven't got time to count, so I wondered if some of you could count them for me. And then you can use your paper to tell me how many there are."

Arguably, this provided an implicit link **between mathematics and science**, as they were also learning about minibeasts in science lessons in that week. The episode took place on the carpet area **inside the class** within **an informal setting**.

Throughout the lesson, Lisa occasionally came to observe how the children were getting on and used **her questioning to prompt** them to think about how they could record their results on a sheet of A4 paper.

During the plenary discussion, children were encouraged to **reflect** on their learning through **sharing** with the person next to them what they found difficult in their respective activity.

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Opportunities for inquiry and creativity

By **standing back** and allowing children to **design their own method** for counting the minibeasts, children's creative thinking skills were fostered. For example, while Aahil started counting the spiders by placing them carefully in rows of five spiders, Desiree and Eleesha placed all the flies in a single half-circle row. Although once Desiree and Eleesha had seen Aahil's rows of spiders, they started adopting the same formation for their caterpillars and woodlice, the fact that there were initially **different forms of representation** highlights how children were encouraged to represent and **solve the problem** in their own ways.

It might also be worth noting that Aahil's array did appear to be more strategic than merely aesthetic or accidental. For example, when the girls were arranging their minibeats into rows, their main concern appeared to be ensuring that all the rows were roughly of similar lengths, even when the number of minibeasts across the different rows might be unequal. The opposite was true for Aahil. More specifically, the spiders that Aahil was putting into rows, varied in size. Thus, even when an equal number of spiders were arranged in each row, the resulting row length would still unavoidably be different, and yet this did not appear to deter Aahil from working with rows of five minibeasts.

Through a combination of Lisa's scaffolding **questioning** and her encouragement for **diverse expression** of children's ideas, as evidenced in Ellesha's and Aahil's work shown in the extracts of data that follow, children's creative thinking skills were fostered. For example, while Aahil chose to write the names of the minibeasts, Desiree and Eleesha chose to draw the pictures of the minibeasts next to their respective total numbers.

By giving them **sufficient space** on the carpet, children were able to lay out different minibeasts in different areas of the carpet and were able to leave them as they were without having to clear their working space each time they finished counting each type of minibeasts. Consequently, this allowed children to learn from one another's work, and for Lisa to examine everyone's work at any point during the activity.

Through providing children opportunities for **reflection** at the end of the lesson, Lisa was able to draw out some aspects of the task that the children found difficult and their creative solutions to the problems. For example, Aahil was overheard saying to his talking partner that *"When you're lining them up … 'cause you know when you're lining them up, and there's only one … I don't know where to put it"*. Looking back at the photos of his work, it was found that he had four rows of five dragonflies with each of two remaining dragonflies being placed on the end of the forth and fifth rows respectively.

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ILLUSTRATIVE EXTRACTS FROM DATA

Children were given opportunities to design their own methods to count the minibeasts

The teacher fostering children's reflection and reasoning

Aahil was overheard saying to his talking partner that *"When you're lining them up … 'cause you know when you're lining them up, and there's only one … I don't know where to put it"*. Looking back at the photos of his work, it was found that he had four rows of five dragonflies and two extra dragonflies, which were placed on both ends of the fifth row, highlighting Aahil's creative thinking in dealing with remainders.

Children were able to use the carpet space as a blank canvass to show their counting methods and to learn from others

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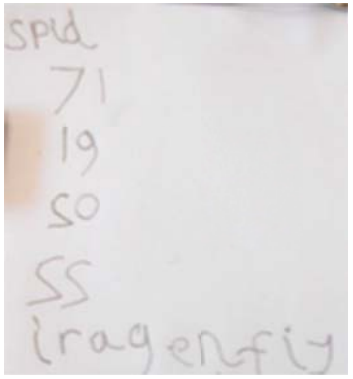
Teacher scaffolding to encourage children to communicate their findings

The dialogue below demonstrated how through **a series of guided questions** by the teacher, Aahil was allowed to arrive at the conclusion himself of how to improve the quality of his data recording:

Teacher: *Aahil, how do I know which of those numbers are spiders that you counted?*
Aahil: *'Cause* (sic) *we write the numbers.*
Teacher: *You wrote those numbers? But how do I know those numbers mean spiders, and it doesn't mean the flies.*
Aahil: *Because if we write flies and spiders then we know it means they fliers and spiders.* (see the left s right image)
Teacher: *Fantastic! Fantastic! Thank you!*



Another similar example was when the teacher came back to look at Desiree's and Eleesha's work a few minutes later:

Teacher: *How many were there?* (Pointing at the flies)
Eleesha: *21.*
Desiree: *I've got another one! 22!*
Teacher: *So what do you need to do now to remember it's 22?*
Eleesha: *Write it down.* (Drawing a picture of a flies next number 22) (see the above right image).
Teacher: *Well done. I think that's a brilliant idea. Desiree, how many of these are there?* (Also, pointing at the flies)
Desiree: *22.* (Drawing a picture of a flies)
Teacher: *So what do we need to do?*
Desiree: *Write 22.*
Teacher: *Well done! I like the way you're doing.*

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Episode: UK(EN) Habitat		**Setting:** Sch
Subject: Science	**Age Group:** 6-7 years old	**Teacher:** Ella
Key Factors:		
Learning activities: Making connections / Communicating explanations		
Pedagogy: Role of motivation and affect / Role of problem solving and agency		
Contextual factors: Peer assessment / Use of ICT		

Aims

This episode involved the children exploring how the colour of some animals enables them to be camouflaged in their habitat.

Analysis of key features

As a starter activity, Ella, the class teacher, used a programme on the interactive whiteboard (IWB) that showed five minibeasts and an environment with four habitats areas (e.g. a log pile, a flower bed). The children had to choose in which habitat each minibeast would live. Ella 'dragged and dropped' the minibeast to the area suggested by one of the children. Before she did so, the children had to **assess each other's answer** by indicating with a 'thumbs up sign' if they agreed with this suggested habitat. If it were an unsuitable habitat the minibeast would run to its most suitable habitat which the children found very engaging.

Using the IWB, Ella showed the children three paintings of the American artist Abbott Handerson Theyar (1849-1921), who painted animals almost completely disguised by their background. **Links were made with art and science** as the children had to identify how Theyar used colour in his painting of the background.

The main activity was for the children to select colours to draw the background of a camouflaged animal in its habitat. Working in ability groups, the children had to draw an animal themselves or they were given pre-prepared pictures of a variety of animals. They were able to **choose from 15 different coloured** pastel dye sticks.

Halfway through the lesson Ella selected two children's pictures to show to the rest of the class on the screen using the visualiser so they could begin **to assess each other's work**. She asked the children to identify the three colours used to colour in the background of the animal picture and asked *"Are these the colours of the animal? Do these colours help hide the animal?"* They could then go back **to their own work and assess their progress** so far as there was still time for children to improve their work if necessary.

The children were involved in further **peer assessment** at the end of the activity. They were asked to lay their pictures on their tables and go and look at each other's pictures as if they were at an art gallery. They had to find things

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they liked about the pictures and one thing they would suggest to improve the picture.

For the plenary the children sat on the carpet again. Three children were chosen **to role play being scientists**. The children had to read out the information (prepared by the teacher) about an animal's camouflage and the rest of the class had to guess which animal it was from the description.

Opportunities for inquiry and creativity

The children's imagination was captured when the teacher **linked art with science** when they looked at the Theyar's paintings of the camouflaged animals. The peacock painting was particularly of interest to the children as it was difficult to see the peacock at first. The children's initiative was encouraged as they were able to **choose the colours for the background** of their own animal painting and, in some cases, choose the animal to be the subject of the painting as well.

The children were encouraged to reflect on an artist's work in a science lesson before using art work themselves to demonstrate their scientific understanding of animals' use of camouflage in their habitats.

Being asked to **look at each other's work developed a sense of curiosity** as they were given time to go round and look at all the pictures. This also **motivates children to improve** their work if necessary.

Displaying the children's work on the visualiser showed that the children's work was valued. Furthermore, as all the children display their work for all the class to view also indicates how each child's work is appreciated.

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ILLUSTRATIVE EXTRACTS FROM DATA

Making connections between Art and Science

The teacher shows the children a painting by American artist Abbott Handerson Theyar (1849-1921).

This painting is called *Copperhead Snake on Dead Leaves*. The children look for ways to explain why they find it difficult to see the snake.

They are learning about camouflage in the science topic.

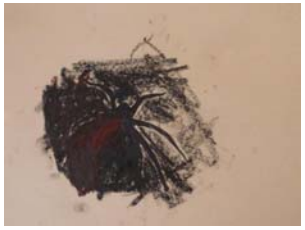
Formative assessment using the visualiser

Half way through the lesson the teacher modelled a **peer assessment** strategy by selecting the lizard picture to show to the rest of the class on the screen using the visualiser.

She asked the children to identify the three colours used to colour in the background of the animal picture. She asks *"Were these the colours of the animal? Did these colours help hide the animal?"*

Self evaluation using ICT

In the lesson Sadik was upset as some children had criticised his picture of a black spider which he had scribbled over with a black pastel. The teacher stopped the lesson and put his picture on the visualiser. She asked the children if they could see the animal on the picture; they replied *"No"*.



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She asked them why they could not see the animal and the children agreed it was because the background hid it so well.

She praised Sadik for choosing the right colour but asked him how he could have improved his work. He said that he would not scribble right over the spider next time but just shade in the background.

Peer Assessment

During the lesson the children stopped to view each other's pictures and, using the same questions to evaluate the drawing, assess the quality of the work of their peers. In the discussion at the end of the lesson, the children gave their feedback to the rest of the class.

Role play in the plenary discussion

Children read out a description of an animal's colouring and its habitat.

The rest of the class had to suggest what the animal is and justify their answer using vocabulary used in the lesson such as:

Prey Predator Camouflage Survival Habitat

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Episode: UK(EN) Shapes	**Setting:** Sch	
Subject: Mathematics	**Age Group** 6-7 years old	**Teacher** Caroline
Key factors:		
Learning activities: Planning investigations		
Pedagogy: Teacher scaffolding / Collaboration / Role of problem solving and agency / Role of motivation and affect		
Contextual factors: Rich physical environment for exploration / Summative assessment		

Aims

The teacher's (Caroline) goal was to have children work in groups with plastic interlocking polydrons to construct and explore properties of three-dimensional shapes.

Analysis of key features

This episode involved the children constructing 3-D shapes prompted by cue-cards which instructed them to make shapes under certain constraints (e.g. "make a shape with less than 8 corners", or "make a shape with more than six faces"). Initiated by the teacher as an activity in which the whole class works in groups of five at tables whilst the teacher moves between groups engaging with children as they work. The episode then focuses on the activity of two children, Tobias and Caitlin, who begin to work together to construct a shape with more than six faces. Once it has been constructed, the two children start to create a playful narrative around it. This draws in other children at the table who then participate in this narrative.

The task encouraged children to **recognise properties of three-dimensional shapes** (part of the 'Shapes and Space' section of the curriculum) by constructing a range of possible shapes using the interlocking shapes (Polydrons). The **problem-solving** nature of the task meant children were able to combine tiles to make regular or irregular shapes under the direction of different cue cards. There was minimal teacher input into the actual construction of the shapes, other than reminding the children about the cue cards, and asking further questions about the sides, vertices and/or faces.

Children could be heard counting edges of the two-dimensional Polydron tiles and counting corners, edges and faces of three-dimensional shapes, naming two-dimensional shapes (triangles, squares, rectangles, and hexagons) and using vocabulary such as 'regular' and 'irregular' shapes.

The children's behaviours reflected the Caroline's perspective that the children were confident in their knowledge, although some children, despite knowing vocabulary, such as 'irregular' and 'regular', were not able to determine which 3D shapes were 'regular'. Caroline emphasised having a strategy: "*some people on this table have picked up a sentence and thought about a shape that they already know might actually match … Rory and Rick had a sentence which was*

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"Make a shape that has less than six faces", … And they knew straight away a shape on the board that would match that … [but] Nick picked "Make a shape that has more than six faces", and had to do a bit of thinking … you said, "Well, I know that a cube or a cuboid has six faces, but it needs to have more than six faces." So he .. stopped and had a think and we … he's come up with quite a good plan of he can now make a shape that is not just going to have six faces, it's going to have more than six faces…." … So think about what you already know."

Opportunities for inquiry and creativity

The children's mathematical exploration was framed by the teacher having posed the task for the whole class, providing resources and written provocations to action that would **stimulate mathematical thinking** and **generate original and valuable ideas**.

At the start of the lesson, Caroline devoted a short period to discussion of the task in hand. Then, working at tables in groups of five, the children worked with the cue cards and the plastic polydrons, whilst the teacher moved between the groups engaging with children as they worked and occasionally interrupting the class.

Caroline's focus was on **encouraging the children to have a strategy**. However, during this particular episode **the children prompted one another's learning**. Children were, then, **generating and reasoning between alternative strategies and ideas**, core elements of mathematical and scientific creativity.

Whilst the task is set up to enable the generating of alternatives, as shown in the illustrated extracts of data the two children in this episode made a shape with six sides (therefore not a cylinder) and created a new name for it *"a cylinca"*. They became engaged in an imaginative narrative, making links between the 'new' shape they had made and the characteristics of a house, adding a roof and a door. The children had **space and time** to develop their own 3-D shapes and to consider their response to these, making first a pair-categorisation and then a group categorisation. The activity allowed **playful fluidity** in the children processing their shape construction and its mathematical meaning. Their **co-constructed spontaneous non-mathematical narrative** then led them back in to a mathematical place.

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ILLUSTRATIVE EXTRACTS FROM DATA

Children construct shapes given teacher-defined parameters generating creative language use

In this guided task where some parameters are defined by the teacher, **scaffolding** is offered in whole-class discussion at the start, and through written activity prompts set up at each table (Image 1). Using this scaffolded framework, children's creative problem-solving is nurtured. Tobias and Caitlin consider how to describe the shape that they have made (Image 2). Caitlin points out, that the shape they have made is not a cylinder, having six sides, and so they name it a "*cylinca*" (Image 3). They inform the teacher, giving their justification for it, demonstrating by touching the sides. Here we can see **creative dispositions**, e.g. **sense of initiative**, **innovative thinking**, **imagination** and **reasoning skills**.

1 Start of lesson

2 'cylinca'

3 'house' of Polydrons

Within this episode, a further creative dimension was these two children's **development of a narrative** beyond the task. Their transformation of the activity towards developing an imaginative story around the transformation of the 'cylinca' into a 'house' took them into other forms of creativity beyond mathematics. So we see them becoming **immersed** in the space of their narrative (drawing in others including the researcher) and sustaining engagement with the materials and with their construction.

Across the episode the children mathematically explore together and manifest:

- Asking questions – '**What if…'** and **'what can I do with this**'
- **Play** –operating in an exploratory, playful fashion

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- **Problem-solving** – the problem is 'found' for them by the teacher's instructions however the children together chose one of these – make a shape with more than six sides - and then worked to solve it
- These children develop a **collaborative and communal outcome**.

In relation to synergies between mathematics and creativity, the children demonstrate:

- **Play and exploration** –using Polydron shapes and within the narrative
- **High value of motivation and affect** – particularly in the 'house'
- **Dialogue and collaboration** – Caitlin's explanation to Tobias of his cylinder misconception, and when discussing the 'house' narrative
- **Problem solving and agency** – how the task is constructed
- **Questioning and curiosity** – throughout the task
- (to an extent) **reflection** – in feedback to the teacher at end of lesson

And **teacher's scaffolding** is apparent in task structure, throughout the lesson.

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Episode: UK(EN) Sound	**Setting:** Sch	
Subject: Science	**Age Group** 7-9 years old	**Teacher** Louise
Key factors:		
Learning activities: Communicating explanations; Gathering evidence (through observation)		
Pedagogy: Dialogue; Diverse forms of expression valued; Collaboration		
Contextual Factors: Formative Assessment; Self-assessment; Rich physical environment for exploration		

Aims

The aim of the activity was for children to understand how sound is made and to find ways of communicating this visually.

Analysis of key features

The tables were set up with a **variety of resources for exploration**: bass drum, snare drum or steel pan, each with a cup of rice; bottles and coloured water in a jug; trays, jugs, water and tuning forks; wind instruments; hollow tubes of different lengths; frog guiro; all tables have large paper and felt tip marker pens. The children had about 30 minutes to explore the resources on two tables and then had to **find a way to represent on paper** how sound is made. Louise, the teacher, said she was being experimental and did not know what would happen *"…but that's exciting, isn't it?"* Although she had set out the equipment with ideas about how it would be used, Louise was quite pleased when the children *"…took the resources in their own direction"* and noted how engaged the children were in the lesson.

The class was fortunate to have five adults to support the children but the teacher stressed **child agency**. "The adults are there to help but only if asked. You have to decide how the things on the table will show you how [sound is made]." She emphasised that the children had to take the lead even when seeking help. "No, not please can you help. You have to ask them direct questions. They can supply words, vocabulary."

The children worked in **small groups or pairs, which encouraged dialogue**. They discussed their **observations**, trying to find the vocabulary to **explain** what they had found. The children exploring the bottles of water focused on pitch and the fact that you could create different notes depending on how much water was used. Several children used the terms darker and lighter when referring to pitch, rather than lower and higher, but some did know the technical vocabulary and this was further modelled by the adults. In the plenary children demonstrated making higher and lower notes with bottles, with tubes of different lengths and with wind instruments. One child was able to offer an **explanation** of why this happened.

The children with the drums and the tuning forks focused more on the vibrations that occurred when the instrument was struck. They could see this through the

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rice jumping on the drum and the waves created in the water by the tuning fork. The children were able to use the term vibrations. Some **represented** this just through drawings, while some children used a combination of drawings and words.

Part way through the lesson the teacher asked the children to **self-assess** whether they had learned about how sound works. The children were then given time to explore a different set of equipment before being asked to self-assess again. Then, those children who were confident about how sound was made explained to another group, demonstrating on the equipment and using their posters.

At the end of the lesson some children explained orally what they had found. Then the teacher used ICT to present the percussionist Evelyn Glennie in concert. They discuss why she might be bare foot and come to the conclusion that she feels the vibrations through her feet because she is deaf.

Opportunities for inquiry and creativity

The children had **freedom to explore** the equipment provided. Some did this in unexpected ways, such as making maracas out of the rice cups and clanging the bottles together. Because they used at least two sets of equipment themselves and then observe others, the children were encouraged to **make connections** between different ways of making sounds. Having to represent sound visually challenged the children to make connections between the senses. Some children **developed new understandings** of how sound is made and were able to explain this.

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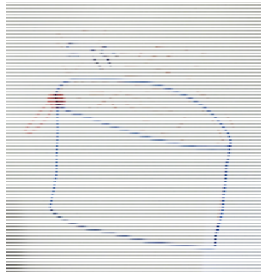
ILLUSTRATIVE EXTRACTS FROM DATA

Resources for exploring sound.



Some of the children used the resources as the teacher expected, such as putting rice on the drums, but others used them in unexpected ways, such as using the rice cups as maracas.

Small groups explore making sounds and then represent this visually.

Rice in steel pan drum

Child 1: *It's jumping!*
Child 2: *The noise is so loud it makes it jump.*
Child 3: *It's vibrations.*


Joseph and Maisie added different amounts of water to the bottles and discussed the impact when they clinked them together.

Maisie: *When the bottles have water and you bang them together they bounce off each other but when they don't, they just clang.*
Joseph: *It makes it darker. Thought it would be lighter.*
Maisie: *That one's gone really high pitched.*

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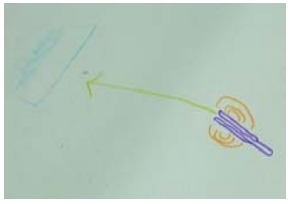
Two children demonstrated blowing with bottles and different amounts of water. George explained the difference in the pitch.

George: *Because there was more air for the sound to go in and get back out and less for Marek because the water was taking up the space.*
He then related this to a flute.
George: *If you cover the holes the air has to travel farther to get out*
Child:*I just noticed when you whistle you make a column of air.*

Child 1: *I can make it jump really high.*
Child 2: *It's the vibrations.*

Self-assessment

Teacher: *Thumbs up if you found a way for showing sound. Wiggle if you're not quite sure. Have you learned something more about sound? How does sound work? What is making it travel? Yes, you can see sound or I'm not really sure. Show me.*

In addition to the self-assessment, the teacher formatively assessed the children by observing and questioning them during the explorations, listening to their explanations and analysing their visual representations.

Teacher: *Lovely explanation. You can really see it.*

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Episode: UK(EN) Starting Point	**Setting:** Sch	
Subject: Science	**Age Group** 5-6 years old	**Teacher** Wendy
Key factors:		
Learning activities: Questioning		
Pedagogy: Fostering questioning and curiosity		
Contextual factors: Formative assessment		

Aims

The purpose of this session was to elicit the children's current conceptual knowledge of animals and their needs for formative assessment purposes. The intention was to raise questions and potential gaps in understanding, which would form the basis for planning future topic work sessions.

Analysis of key features

Wendy, the class teacher, had prepared for the 'Carnival of Animals' topic by setting up a role play area with a fish tank and other animal toys. On the carpet, she asked if the children knew what the new topic would be, hinting at the new items in the role play area. Children correctly indicated that the new topic would be about animals. The children were particularly excited by this topic as this is an area in which they had some prior knowledge.

Wendy then asked the children to tell her what they already knew about animals and **what they wanted to learn about them**, beginning by asking, "*So what do we mean carnival of animals?*" The children came up with terms such as 'carnivore' and 'herbivore', which Wendy praised them for remembering from a previous activity; in her interview Wendy identified that this built on knowledge from their topic on dinosaurs.

The children were eager to participate and Wendy used a good range of open questions to engage the children in discussion; alongside this she helped them with their vocabulary – introducing correct vocabulary alongside their own word choices. Examples of the questions included how heavy different animals are, where they live and what they eat.

On a flipchart, Wendy wrote the children's prior knowledge and questions. Wendy also used this opportunity to **formatively assess** her children, particularly by looking at what they already knew. This is an activity which was familiar to the children as each time they start a new topic they begin with a brainstorm of what they already know about a topic and what they would like to find out.

Wendy's questioning directed the children towards different categories / classification of animals, which were recorded on the flip chart and then she began to focus on how the children could research information on different animals; "*I didn't know that, perhaps this is something we could find out children, remember I don't know everything, sometimes we have to write questions to find out later – let's write the questions down*". These questions were written down on post-it notes and added to the brainstorm. The children identified different ways to research from asking parents to the internet. Finally, Wendy reviewed what had been put on the flip chart and reminded the children of what questions they were going to find out as a result of this.

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Opportunities for inquiry and creativity

This episode demonstrated the commitment Wendy showed to working from children's current knowledge and understanding, and there was evidence of rich **dialogue and communication**.

Questioning was used throughout as a means of generating discussion and gauging the children's current levels of knowledge and understanding, and the children were actively encouraged to formulate their own questions, which would be answered as part of planned activities later in the topic. This reflects Wendy's comments in her interview about motivating the children to learn.

Some child **agency** was evident in this approach to the start of topics. The brainstorming activity also illustrated the approach to **assessment**, eliciting conceptual knowledge at the start of the topic and "*at the end of each term… well half term now it's changed… we look at what the children have done… we go back to the brainstorm and children tell us what they have learned … and any answers to questions we have found out… I like the children to find things for themselves, not that I know everything sometimes I don't know so I set them a challenge*".

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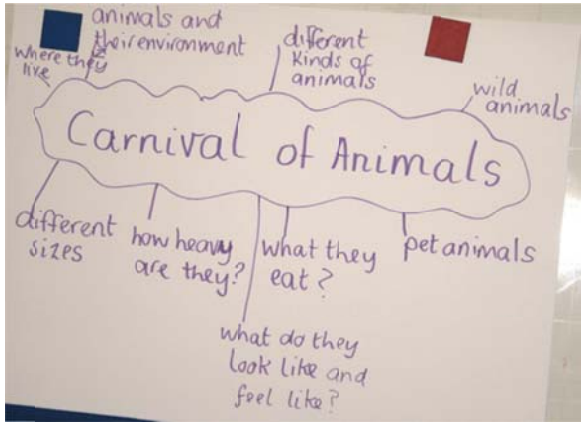
ILLUSTRATIVE EXTRACTS FROM DATA

Examples of what children already knew and what they wanted to know about animals.

Teacher: *Yes, what do we know about animals?*
Child: *Carnivore.*
Child:*Herbivore.*
Teacher: *Well done, you remembered that from last time, anything else?*
Child: *If they're big or small.*
(Teacher writes different sizes on the flip chart)
Child:*How much they weigh.*
Teacher: *Yes, how heavy they are.* (Teacher writes on flip chart)
Teacher: *What could we find out about animals?*
Children: *Where they live / What they eat.*

The teacher creates a topic web based on the children's questions



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Fostering children's problem solving skills

Teacher: *Where do we find this information?*
Child: *From home / Ask mum.*
Teacher: *Yes … good idea, anywhere else children?*
Children: *Books / Internet.*

Child K's drawing from her everyday experience

TA: *Ooh fish now – Child K knows all about fish – she has a big tank at home.*
Child K: *Two tanks.*
Researcher: *Two tanks – goodness, who looks after them?*
Child K: *My daddy – he has to clean them out a lot.*
Researcher: *What else does he do?*
Child K: *He has to feed them – with flakes.*
Researcher: *Not bacon and eggs?*
Child K: (laughs) *No silly, they have to have special food – not people food or they would die.*
Researcher: *Well we wouldn't want that. Do they have special water?*
Child K: *I don't know… but we have a light in the tank, and they have to have plants because they like to hide, and lots of room so they can swim around.*

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Episode: UK(NI) Gloop	**Setting:** PreSch	
Subject: Science	**Age Group**: age 4-5 years	**Teacher**: Siobhan
Key factors:		
Learning activities: Questioning / Gathering evidence (using observation) / Gathering evidence (using equipment)		
Pedagogy: Role of play and exploration / Role of motivation and affect / Fostering questioning and curiosity / Role of problem solving and agency / Teacher scaffolding		
Contextual factors: Rich physical environment for exploration / Informal learning resources		

Aims

This activity presented a wide range of aims and objectives. The activity provides opportunities for children to develop "an awareness of texture, motor skills necessary for writing, pattern making… the ability to work with small tools… (and) to communication with one another in a group setting" as indicated in the school documentation.

Analysis of key features

This episode comes from the activity of making 'gloop' – mixing water and corn flour in a large plastic tray that had been placed on a desk. The activity was largely child-directed and ran for the whole morning session. Children were free to attend and leave the activity as they pleased. Over the course of the morning, nine different children had visited the activity, with a maximum of six at any one time. After approximately 15 minutes, the teaching assistant placed a number of different tools – spatulas of varying sizes, rubber paint brushes, a funnel – into the tray to further provoke interest and exploration. Aside from this, practitioner intervention was limited to brief, sometimes less than 15 second visits by the practitioners (teacher plus two nursery assistants) in the classroom. During these visits, the practitioners observed the children's activity, engaged in short discussion with the children and asked open-ended questions. This meant that the children were **exploring largely by themselves** or with one another (pairs or threes).

A wide range of curricular objectives was addressed during this activity. Sensory development was identified by the practitioner as the most important specific feature of this activity and this could be seen. Indeed, activity such as this that was initiated by one child was quickly imitated by their partner and then by the whole group.

In addition to this sensory development, there appeared to be links to areas of the science and mathematics curriculum, such as the development of exploration skills and (science), observation skills (science and mathematics) and making patterns (mathematics). The child-led nature of the activity ensured that children were able to discuss with one another, share what they were doing and

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indeed **observe** what other children were doing and imitate and develop on these ideas.

Opportunities for inquiry and creativity

An overarching framing of this activity appeared to be to provide an engaging and **stimulating** activity that would capture the **interest** of all the children involved. The emphasis on developing the sensory aspect was clearly enjoyable to the children as they laughed and excitedly provided answers to the teaching assistant's initial questions about what the powder felt like in the bag, what it felt like when poured out onto the tray and finally when adding the water.

The task was very open-ended, with few restrictive parameters, allowing Ryan in particular the **freedom to explore** it as he wished. The practitioners all stood back and provided only occasional, judicious intervention from the practitioners, often prompting more open-ended questioning from the children, scaffolding their learning.

Immersion in the task was particularly important. Ryan was clearly **immersed** in the **playful** task. He can be seen focused on his activity, closely observing cornflour and water mix, stirring it, straining it through his fingers, pushing it and scooping it up with the spatulas, or drawing in it with the rubber-tipped paintbrushes. He could be seen to be asking creative questions – *"What can I do with this?"* This was particularly apparent when analysing Ryan's observable contemplation and subsequent use of tools in the tray. At one point, he was moving gloop across the tray with a wide spatula in his right hand, then trying to stop its return flow using a rubber paintbrush in his left hand. At another point he was scooping up the cornflour mix with the spatula and slowly dribbling it on to his forearm and hand. This generation of **alternative strategies** and ways to use the tools provided often novel and unexpected outcomes that relate closely to the aims of the task outlined on the poster ("Developing the motor skills necessary for writing" and "The ability to work with small tools – rubber pens, combs etc"). This would suggest then that the outcomes of the activity were of **value**. This immersion, development of motor skills through tool use and of exploration would all suggest that this was an extremely valuable and worthwhile activity for Ryan.

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ILLUSTRATIVE EXTRACTS FROM DATA

Using everyday objects in the gloop tray

Here, Ryan was working with the spatula, 'picking up' and 'dropping' the gloop. This allowed Ryan to experiment with equipment and observe the effect that the equipment had on the cornflour mix.

Three children playing with the gloop

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Ryan, Erin and Zoe all playing with the gloop – the mixture formed long strings as it dripped off the children's hands. This provided an added sensory element to the activity, where children could both observe and touch the changes to the cornflour as the water was added.

Children making patterns in the gloop with their hands/fingers

The cornflour and water mix was thick enough such that it held its shape long enough for patterns to be made in it, either using the tools provided or using their fingers. There was no requirement for children to work in a prescribed method with the tools, allowing the children to develop their motor skills, with a view to developing mark making and writing.

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Episode: UK(NI) Gingerbread Man Raft **Setting:** PreSch
Subject: Science **Age Group:** 4-5 year olds **Teacher** Siobhan
Key factors:
Learning activities: Questioning / Gathering evidence (through observing) / Gathering evidence (using equipment)
Pedagogy: Role of play and exploration, Role of motivation and affect, Role of problem solving and agency, Reasoning and reflection encouraged
Contextual factors: Variety of materials

Aims

This activity formed one of five structured activities in the classroom. The teacher selected which activity particular groups of children would do that particular day, and each child would do each activity over the course of the week.

The aim of this activity was for children to explore the properties of various objects and sorting them into those that either sank or floated using the large water tray and a variety of everyday objects - numerous food trays, such as those that hold fruit/meat from the supermarket, lollipop sticks, along with rolls of masking tape, items from the home role play corner (including rolling pin, sieve, plastic foods, tin foil) plastic piping and foam dominoes. Children were also free to go around the room and find other items that they might like to try.

Analysis of key features

The premise for testing items was based around the theme for the class learning – the story of the gingerbread man, who hitched a ride on a fox to cross a river. The children therefore need to find appropriate materials or objects that might act as a raft for the small plastic Gingerbread Man to cross the 'river'.

The activity, involving six children, took place in a shared space between the two early years classrooms, thus it was not possible for the practitioners to be present for the duration of the activity. During the course of the activity, Siobhan (teacher) and Sinead (teaching assistant) each occasionally visited the group to discuss with the children their findings and to prompt further exploration and investigation. This allowed the children the freedom to explore the various concepts of floating and sinking, through an **inquiry-based** approach, gathering evidence through observation through independent problem solving and exploration and investigative activity. The practitioners identified this activity as an opportunity to build on the key explorative areas of the Northern Ireland curriculum. The children were therefore free to approach the task in whatever way they felt was most appropriate and plan their investigations accordingly.

Opportunities for inquiry and creativity

The way in which the practitioners stood back, **provided the time and space** for children to follow their **own avenues of exploration**. This could be seen in

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children applying their everyday knowledge to the situation, such as Peter attaching lollipop sticks to a sieve in order to make a raft, connecting his knowledge of floating materials in the problem solving approach.

Leila, aged 5, could be observed extending the task, applying the gingerbread man story context to the activity in a way over and above what might have initially been expected or planned for. Following her experiments with a number of different objects, she focused on the clear plastic tray. Leila then returned to the table that had the items and began to look over what remained. Here she found green paper towels – none of which had been used by any of the other children. Leila then used the paper to cover the 'Gingerbread Man' on his raft

The creative activity in this episode can be seen in Leila's extension of the task and application of 'real life' concepts to the abstract task. Leila then appears to be working in both the 'real', science based world, identifying materials that will float, but also within the make-believe world, where other, additional objectives are also of concern.

Finally, the activity provided by the practitioner was situated within a **motivating** and **engaging context** – the fairytale story – that captured and sustained the children's imagination.

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ILLUSTRATIVE EXTRACTS FROM DATA

Using materials to make a raft

Peter making a raft from sieve and lollypop sticks. The lack of teacher intervention enabled much interaction and discussion between the children, with individuals offering suggestions to one another (such as "*Why don't you try this bit?*") and a variety of expressions of interest and surprise (such as "*Oh, that didn't work!*" and "*Look at this, it's floating!*"). Children therefore were able to exert a strong sense of **agency** in this activity which offered them space to extend the task, and to develop their own investigations and inquiries, as well as developing their **communicative** skills between one another.

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Leila looking through the different materials available to her

Leila (far right) was observed holding the paper for several moments, before laying it over the tray containing the gingerbread man and returning to the water tray. She could then be heard telling the other children "*Look, I've got a protector blanket!*". When queried by the teacher as to what the protector blanket was for, she replied "*To stop the gingerbread man getting wet*." Following this, a number of the other children copied her activity, some using paper, and another using tin foil. It is notable that the narrative creativity prompted by Leila moved off at a tangent from the scientific enquiry which had been their focus.

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Episode: UK(Sco) Day and Night	**Setting**: Sch	
Subject: Science	**Age Group** 5-6 years old	**Teacher** Petra
Key factors:		
Learning activities: Questioning		
Pedagogy: Role of motivation and affect / Diverse forms of expression valued		
Contextual factors: Variety of resources / Use of ICT		

Aims

This episode took place as part of a planned topic on Day and Night, with the following overarching learning intention: "children will learn about the earth, moon, sun and stars. They will observe the sun and moon at different times and relate their findings to the concept of time" as shown in the school planning document.

Analysis of key features

This session was taught by Petra, who teaches all the science sessions in this class in consultation with Mary, the class teacher. In a previous lesson, Petra, the class teacher, had already asked children **what they would like to learn** about light and dark. Children's responses, such as "About the stars", "Some planets", "Learn about space" and "To draw the moon and sun" were recorded on a mind map.

Petra started the lesson by reading children **a story**, called 'The Park in the Dark', which featured three different animals that got chased by 'a THING' and they ran into a dark park to hide. After reading the story, Petra posed questions including "*What is it like in the dark*?" and "*Why do you think it gets dark*?" to elicit discussion about children's experiences and feelings about the dark. Petra used a container of lollipop sticks each marked with a name of the child in the class to encourage responses to her **questioning** and **dialogue**.

Petra then explained that they would be learning about what is happening to make day and night time. To help demonstrate the concept, she showed a globe to the children and a little picture of a person on where the school is located. Petra also incorporated **role playing** into her teaching by inviting Gideon to be the sun, and he was given a sun hat and a torch to hold and shine at the globe. Children were also given **opportunities to give reasons** as to why Gideon was given the torch. Some of the responses included *"because the Sun is bright"*.

Children were then asked to indicate whether the little person was experiencing daytime or night time as the globe was turned, and *"how much time do you think has passed between daytime once and getting dark and daytime?"*. This latter question attracted responses, ranging from *"quite short"*, *"about two weeks"* to *"I think it's a day"*. To address these ideas, Petra **linked the turning of the globe to the children's daily experiences**: *"So it is daytime just now and when you go home to have your dinner it's going to be night-time. Then, you're going to sleep all night and get up in the morning and it's going to be …?"*

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In the next phase of the lesson, Petra integrated **ICT** in her teaching by initially introducing her new Space app on her iPad. First, she shared some high quality pictures of the Sun. These prompted much excitement, comment and sharing of new ideas and enthusiasm between the teacher and the children as they read the captions from the different images together. Petra then showed an animation of the solar system. This also provoked interest and enabled the class to revisit ideas about the Earth turning on its axis.

Children were subsequently asked to work in mixed-ability groups in one of the following four activities: 1) drawing pictures of how we get day and night using colouring pencils; 2) sorting photographs of animals into those that come out in the day and those that come out in the night; 3) sorting activities according to whether they take place at daytime or night time; and 4) making models of the Moon and Sun using plasticine. Not only did these activities demonstrate **a wide variety of materials** that Petra adopted, it also highlighted how she valued **diverse forms of expression** to help support children's learning.

The illustrative extracts from this episode include examples from the the drawing and modelling activities both of which offered opportunities for children to **express** and **reflect on** their ideas in different ways. Petra showed interest in children's progress and encouraged them to talk about what they were doing, but did not direct children's responses. Children's representations reflected the inspiration from their experiences in the earlier part of the lesson.

Opportunities for inquiry and creativity

Creative teaching was shown in particular in the **rich resources** and experiences organised for the session. Ideas about day and night were presented in a **variety of ways**. Petra encouraged engagement through sharing her own enthusiasm for sharing the wonders of the solar system. The opportunities for children to **represent their ideas in their own ways** promoted **reflection** on experiences.

The range of learning and teaching approaches adopted fostered children's **interest** and **curiosity** in the solar system. They showed imagination in the development of their models and drawings. In dialogue with peers and with adults they **raised questions** and began to **make connections** between the pattern of their experiences of day and night and the rotation of the Earth on its axis.

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ILLUSTRATIVE EXTRACTS FROM DATA

The use of role play to engage children

Children's reasoning skills fostered, making connections between features of the model and everyday observations

Teacher: *Gideon, you are going to be the sun so I want you to wear the sun hat – do you think you could wear that on your head? You are going to be the sun.* (…) *I'm going to give Gideon the torch. Why do you think we would give Gideon the torch if he is the sun?*
Lewis: *Because the Moon – because the Sun is bright.*

Teacher's scaffolding, making connections with children's daily experience

Teacher: *How often do you think the world turns all the way around?* (…)
Children: *Quite short / About two weeks? / I think it's a day*
Teacher: *So it is daytime just now and when you go home have your dinner it is going to be night-time. Then, you are going to sleep all night and get up in the morning again it's going to be …?*
Children: *Daytime!*
Teacher: *So the world or the Earth rotates once a day can you see that?*

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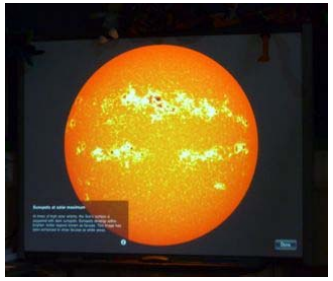
Appendices of D4.4 Report on Practices and their implications

The integration of ICT through the use of high quality images and animation of the solar system



Teacher: *I have brought in my iPad again today and* (…) *I've got a really interesting app on the iPad that shows the Earth turning.* (…) *There are also some really nice pictures of the sun taken with really powerful telescopes and it shows you that it does not really look like that – round and yellow.* (…)
Lewis: *You can see the fire and it's burning.* (Children all very captivated)

Examples of children's work – Ronald's drawing of the Sun (left) and Donald's model of the Sun (right)

Ronald: *There's lots of solar flares Earth is so far away you can never reach that… got explosions – that's the light shining at the Earth. This shows all the planets are – going round and round. That was Jupiter and one next to Jupiter – and Saturn – closest to the sun. The blue bits are the sea and the green bits are the land.*
Donald: *That's fire coming and they're the holes and that's all the lava … the sun is boiling hot fire.*

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Episode: UK(Sco) Forest School **Setting**: PreSch
Subject: Science **Age group** 3 -5 years old **Teacher**: Sarah
Key factors:
Learning activities: Gathering evidence (through observation) / Making connections
Pedagogy: Role of exploration /Fostering questioning and curiosity
Contextual factors: Recognition of outdoor learning / variety of resources

Aims

Visits to Forest School were planned to provide children with opportunities to explore the natural environment and observe change over time for example in the weather and in the life cycles of living things as highlighted in the interview with the teacher Sarah: "*seeing that place and being there in all weathers that's very important in schools – going to the same place and up the same road to get there – of course every time is different – they are affected by the weather, by the temperature, they notice that things that were here last week have been eaten or whatever that is."* Visits were also designed to encourage a range of inquiry skills in particular **observing** and **exploring**, **asking questions**, developing skills associated with reasoning and **making connections**.

Analysis of key features

The setting for the episode was a protected wildlife area in the city walking distance away from the preschool centre. It has open areas of vegetation, woodland and a pond. Children visit the site weekly, on an eight-week cycle. Activities and routines at the site have been developed over time, influenced by children's responses as well as incorporating common Forest School activities. These include making a shelter, litter picking, making a fire for cooking, climbing and balancing using ropes, as well as **observing changes** in the natural environment. Sarah indicated that the children often bring ideas and materials back to the centre, for example ideas for moving water or a hammock in the outdoor area and physical materials such as water samples from the pond or plant material, fostering on-going links between contexts.

On the day of the visit it was snowing. Centre staff, in partnership with parents, organise clothing and resources carefully to enable visits in all weathers. Mats, blankets, thermal clothing, warm drinks and snacks were taken to help children keep warm and comfortable. The outdoor trip, in harsh weather, offered the chance to encourage reflection on needs for survival, including warmth and shelter. A **variety of equipment** was packed to support activities at the site, including tarpaulin and ropes for making a shelter, magnifiers, binoculars and a camera to support observations, litter pickers and spades. Sarah was joined by two other adults on the visit, Marta and Gareth.

Conversations between adults and children on the way to the site focused on **observations** of the feeling of the wind and ice particles on their faces. Adults **asked questions** to encourage children to articulate their **observations** and to

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speculate on possible **explanations** for grit and salt on the paths. When they arrived at the site Sarah suggested various activities children might undertake including making a shelter, litter picking, climbing with ropes and observing ice on the pond. Children were encouraged to make their own decisions about what they would like to do.

This episode follows the **explorations** of Ian to illustrate the opportunities provided for children to **follow their own interests** and **make connections** to their previous experiences at the site. His immediate focus was the pond. He poked the ice with a spade. He **observed** holes in the ice and collected some water in his spade to look at it more closely. Sarah **built on his interest** drawing attention to the differences in the pond compared to the previous week and suggesting that he might look at the water more closely with a magnifier.

After some considerable time Ian was still at the pond. This time he was poking at the ice with a litter picker. Marta the Nursery Nurse asked him about what he was noticing, encouraging him to explain what he was doing. Ian explained that he had noticed bubbles. He thought that these might come from frogs and he was breaking up the ice "*so they* (the frogs) *can breathe"*.

Later Ian took the researcher round the site to photograph the different fungi he had noticed, another developing area of interest over time. In a conversation with the researcher about this visit to Forest School later in the afternoon, Ian highlighted these two activities (breaking ice and photographing fungi), **making connections** with previous experiences at Forest School. The photographs taken by Ian in collaboration with Sarah were included with Ian's reflections (**self assessment**) in his profile.

Opportunities for inquiry and creativity

The visit to Forest School offered rich opportunities for fostering creative dispositions including **motivation, curiosity and sense of initiative** reflected in Ian's active pursuit of his interests and observations. He showed **imagination and made connections** to his prior knowledge and experience in seeking to explain the bubbles he noticed in the pond and his actions in breaking the ice.

Features of creative teaching were reflected in the opportunities for learning in the **outdoor environment** made possible by careful organisation and preparation of **materials** to support **explorations** and ongoing assessment with children of the potential risks involved (for example in climbing or breaking the ice). Adult interactions fostered children's **own interests actively encouraging explorations**, **questioning** was used to encourage children to extend observations and **articulate explanations**.

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ILLUSTRATIVE EXTRACTS FROM DATA

The Forest School Setting: Variety of resources to support activities

Noticing ice on the pond: Fostering questioning and curiosity

Teacher: *It wasn't frozen last week was it?*
Ian: *It's got a little hole there.*
Teacher: *I wonder why that is? Can we find a reason why?*

Ian poked the ice with a spade and picked up some water in the spade to look at closely:
Teacher: *Very muddy water isn't it? Full of all sorts of things. Possibly if we had a really good look with a microscope we might see something?*
Ian: *I know we can put some water in and put the top back on.*
Teacher: *You mean in one of these ones* (a magnifier) *– if you put something in you can look through the top – try that one.*

Ian put some water and ice in the magnifier – and held it up to show – *"sample of water – it's a little piece of wood"*. He took another scoop of ice and water with his spade to look at.

Encouraging communication of observations and explanations

Nursery Nurse: *What can you see?*
Ian: *Bubbles.*
Nursery Nurse: *Where do you think they are coming from?*
Ian: *Animals – may be frogs? Maybe air coming up?*
Nursery Nurse: *You're doing a good job – the animals will be really pleased. Can you see the bubbles moving around?*
Ian: *Putting more air for the animals.(…)*

Ian splashed round the edge of the pond, breaking up the ice.

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Ian: *Can see big bubbles – when you hit the bubbles it makes much more.*
Nursery Nurse: *Why are you rescuing the animals?*
Ian: *So they can breathe – whole pond nearly dug up now – saw breathing.*

Self assessment: observing variety of life, noticing change over time, making connections with prior experience

Ian: *When I went to Forest School it was brilliant. I liked the most taking pictures (of fungi) and that was the best thing I did there.*
Researcher: *So the best thing was taking pictures?*
Ian: *And lots of smashing ice on the pond. (…)*
Researcher: *What were you doing in smashing the ice (..)?*

Ian: *So the animals could breathe under the ice?*
Researcher: *Have you been there another time? Have you seen any animals?*
Ian: *I think I been there a long time ago.*
Researcher: *What did you see?*
Ian: *I think I saw frogs in the summer – and before I saw frogspawn.*
Researcher: *That sounds exciting what was it like?*
Ian: *It was sort of jelly – and tadpoles inside the ball of jelly.*
Researcher: *Wow!*
Ian: *Not the kind of jelly from what you eat and got tadpoles inside it.*

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