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ViduKids Case Studies

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Froebel's Peas and Sticks – Visualisation of geometrical shapes

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In this case study (Thiel, 2022), we explored how animation video production supports young children's understanding of geometrical shapes.

Introduction

Children need spatial imagination to understand geometrical shapes' structure and properties. Already Fröbel (1826, p. 92) described experiences with geometrical shapes as an essential part of early childhood education – even before counting. Producing their own animated films can make an important contribution to the transition from constructive action with tangable material to abstract inner concepts.

[1] This case study has previously been published in German: Thiel, O. (2022). Videoproduktion im Geometrieunterricht – Ergebnisse des EU-Projektes ViduKids. *Mathematik differenziert, 14*(4), 14-21.

This case study presents and analyses a selected activity developed by the kindergarten Mavrica in Slovenia and later tried out in Norway, too. The activity is inspired by Froebel's 'Peas and Sticks'. The addition is that the children document their work with a stop-motion animation film.

Context, approach & Implementation

Froebel's Peas and Sticks

Play as the child's purest intellectual product is central to Froebel's pedagogy (Fröbel, 1826, p. 69). Play helps children to express themselves in the best way and contributes to their development in all aspects. Traditionally, play in the pre-school period has meant children's actions and their own creation of meaning (Corsaro, 2017; Vygotskij, 1995).

Today the perspective is changing and play and learning are seen as two interrelated phenomena (Pramling Samuelsson & Johansson, 2006). Play is emphasised as an important part of the learning process. The kindergarten curriculum emphasises the importance of play in children's development and learning. It is also stressed that play and joyful learning foster multiple skills such as imagination, empathy, communication, symbolic thinking, cooperation and problem solving. In play, children experience and create a world of meaning on their own terms and with their own specific values. They share their life worlds with other children (Corsaro, 2017; Damon, 1977). In play, children learn about the perspectives of others and gradually learn to understand them and develop communicative competence, that is fundamental to children's learning and creativity (Pramling Samuelsson & Johansson, 2006)

Children express themselves in play. Froebel, therefore, developed 'Spielgaben' (play gifts) and 'Beschäftigungsmittel' (occupations), i.e. toys through which the children can explore the world and its connections. This sums up what mathematics is all about: exploring patterns and structures in the world to discover relationships. That is why most of the gifts involve mathematics. Gifts 1 to 6 are three-dimensional geometrical shapes the children should receive in the given order. The occupations – often called play gifts, too – are not presented in a fixed order but when the child can handle them motorically. Playing with them, the child explores more abstract mathematical objects, namely areas, straight lines, curves and points (von Marenholtz-Bülow, 1887, p. 4).

When working with Froebel's occupation 'Peas and Sticks', the children produce edge models of two- and three-dimensional geometrical shapes. For the edges, Froebel used small wooden sticks, which had to be sharpened by hand. Today, we can use toothpicks.

For the vertices (corners), Froebel used white, unpeeled peas, which had been softened in water overnight.

Froebel distinguished between *forms of knowledge*, *forms of beauty* and *forms of life* (von Marenholtz-Bülow, 1887, p. 20). Forms of knowledge are two-dimensional geometrical shapes, e.g. triangle, square, rectangle and pentagon, or three-dimensional geometrical shapes, e.g. pyramid, prism, cube, and cuboid. Regarding forms of beauty, the focus is on aesthetics that may arise from symmetry. Forms of life replicate objects from everyday life, e.g. a chair, table, staircase and house.

When working with forms of beauty and life, the children discover that these consist primarily of forms of knowledge (von Marenholtz-Bülow, 1887, p. 78).

Implementation

The children work in pairs or in small groups. One child builds the shape; the other takes pictures. The roles can be swapped. Several couples or small groups work in parallel or one after the other. When all the films are finished, the children watch them together.

A smartphone or tablet with a stop motion app is needed for the recordings. One device is sufficient if the small groups work one after the other. We used a tripod to hold the device. A hands-free recording does not work with stop motion.

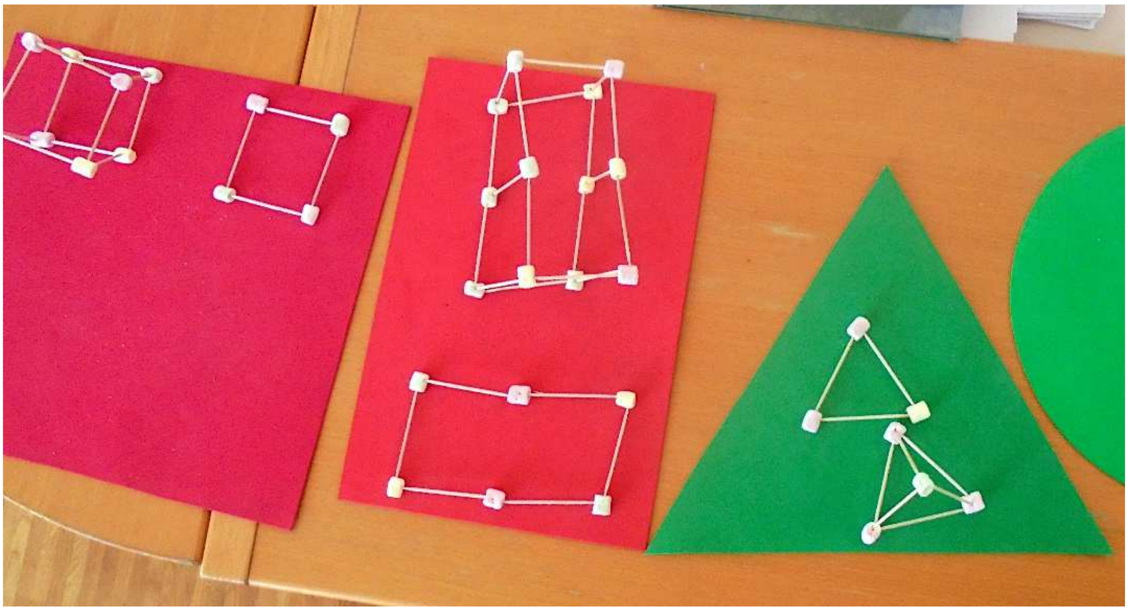

Figure 1. Two- and three-dimensional shapes

First, the children are inspired to make two-dimensional shapes. They were given a triangular, a square, a rectangular and a circular piece of paper as a template, which served as a base for the corresponding shape. After finishing the flat shapes, they wanted to extend them into the third dimension. Thus, the square becomes a cube, the triangle becomes a pyramid, and the rectangle becomes a cuboid (see Figure 1).

After the geometrical shapes, the children were given the opportunity to design their own structures – forms of life.

Materials

Choosing suitable material is crucial for the success of the activity. Toothpicks that are sharp on both sides work well. Peas, like those used by Froebel, are best suited for vertices. However, these must lie in water for 12 to 18 hours to become soft and then dry for an hour to avoid being too weak (von Marenholtz-Bülow, 1887, p. 75). That is a lot to deal with. Instead, we used mini marshmallows and sometimes PlayMais. These materials work, but has disadvantages. Some children would rather eat the marshmallows than build with them. In addition, the marshmallows will become too soft if it is too warm or if the children hold them in their hands for too long. That does not happen with PlayMais.

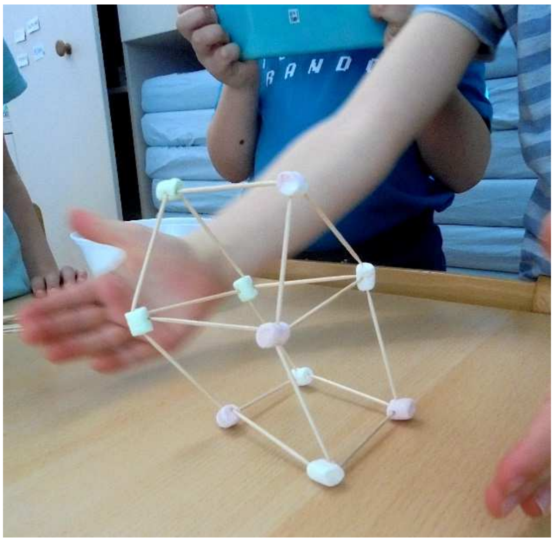

**Figure 2. Left: The children have built a house, but it is not stable.
Right: Crossbeams make the house stable because triangles are more sturdy than squares.**

You can also make small balls out of plasticine or play dough, but that requires preparation, and you have to ensure that the plasticine is neither too soft nor too hard. There is also commercial material suitable for this activity, for example, from Zometool. However, this places greater demands on the children's fine motor skills when they insert the sticks into the balls. We have also tried skewers and large marshmallows, but that was not sturdy enough.. Three dimentional shapes could easily collapse when made of mini marshmallows (see Figure 2, left) or plasticine balls. However, this also has an advantage: The children experience triangular structures being more stable than square ones (see Figure 2, right).

Results

Two-dimensional shapes

In this example Ela and Pia worked together. Pia took the pictures (see Figure 3), and Ela made the shapes. The triangle, square and rectangle were no problem for Ela, but she discovered a challenge with the rectangle as all the toothpicks were the same length. She solved this by connecting two toothpicks with a marshmallow to form a longer edge. As a result, each marshmallow no longer represented a corner.

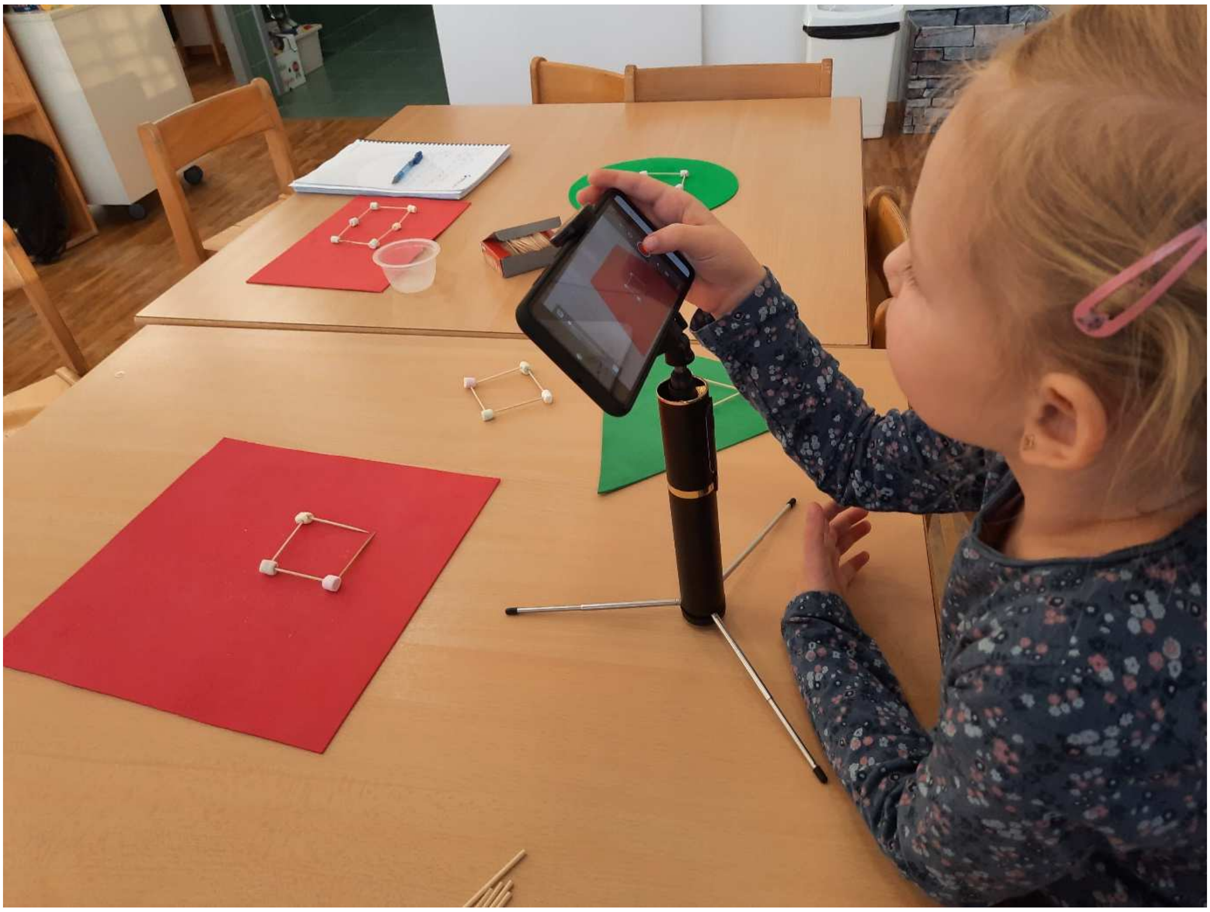

Figure 3. Pia documents the construction of a square.

Ela decided she wanted to build a circle, and began constructing as with the other forms. When she realised it did not work, she said, 'I'd rather make a pentagon.' The teacher asked why and Ela replied, 'I need something more round.' Pia commented, 'I think it will be a square pentagon' (see Figure 4). Even though 'square pentagon' is not a correct mathematical term, it is a pretty good verbal description in Pia's own words of what the shape looks like (Steinbring, 2006, p. 145) .

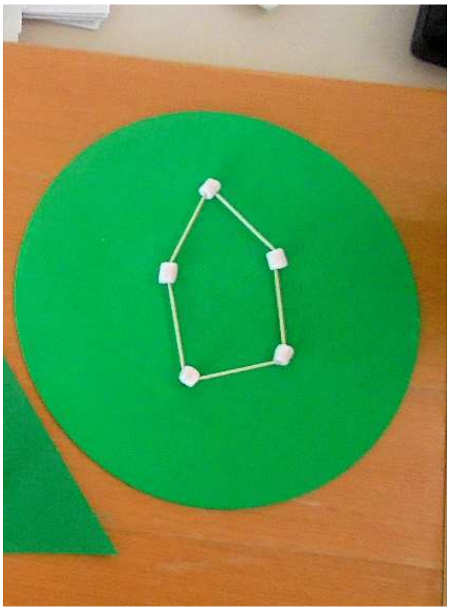

Figure 4. Ela made a 'square pentagon' instead of a circle.

Later, while watching the videos, the teacher challenged Ela to think about the round shape once again and asked, 'Ela, why didn't you make a circle?' This time she answered, 'Because I didn't have any better edges.' She probably understood that you could not form an arc from straight sticks.

Three-dimensional shapes

When Lara and Gaja worked together they decided that Lara built the shapes, and Gaja took pictures (see figure on page 2). Gaja was not that experienced with the stop motion app. Lara helped her and reminded her several times to take pictures. Lara sometimes forgot to step out of sight, which was no problem as failed images can easily be deleted.

When Edi built a pyramid, Anej took the pictures. They both worked concentrated and independently. For the cuboid, they swapped roles. In this activity they noticed that the work was not so easy. The upper edges of the long sides had to be supported with additional toothpicks. Nevertheless, the whole construction began to tilt to one side. They were also dissatisfied with the lighting conditions. Sunlight came in from the window so that nothing could be seen on the video. Finally, the children decided to redo the whole recording.

After the three-dimensional shapes were finished, the children decided to rotate them step by step while taking pictures. Thus, the videos not only show the construction, but also what the shapes look like from different perspectives. A summary of the videos can be found here: https://youtu.be/f10-10bDNl4

Forms of life

When four children worked together they faced challenges in their collaboration.. The children built their own shapes until they decided that the whole group should design a building together. Building together and wanting to use the app at the same time, made it necessary to switch roles several times. A lot of negotiation was needed.

Another challenge was that the mini marshmallows were too small and soft (see Figure 2). The teachers, therefore, decided to give the children PlayMais instead of marshmallows (see Figure 5). The children were very creative in their thinking and together created a water tower, a rescue station, a church and a lookout tower.

Figure 5. Children build a water tower model and document the construction as a stop-motion video.

Conclusion

Videos help children to illustrate abstract structures by connecting them to tangable structures in the real world. While working with geometrical shapes and taking videos, the children have many social, communicative and mathematical experiences. They have to coordinate and agree with their partners and consider how the construction can best be presented in the video.

Video production slows down the construction process, giving children more time to think about their actions. The physical construction work is one part of the children's mathematical discourse (Gejard & Melander, 2018, p. 508; Sfard, 2008, p. 148), expressing their thoughts through video production is another one. Furthermore, the reflections during the production are reactivated and deepened when the videos are watched and discussed with the other children. Video production contributes in many ways to the internalisation of geometrical ideas and knowledge.

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