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Research Article

RECOGNISING AND NAMING SOLID GEOMETRIC FIGURES USING APPLICATIONS IN CHILDREN OF PRESCHOOL AGE

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Abstract

Continuous improvement of conditions in which children grow and learn is an imperative for all of us. The youngest ones, children of preschool age, deserve special care and attention. Adequate stimulation of their learning, creative environment, motivating educators and everyone around them are crucial factors that shape the development of many young children, as well as influence their desire for further learning and exploring. In order to gather all indicators that tell us about the ways children learn, their success, the way they understand their environment, continuous research is required. However, doing the direct research with such young children is often challenging, since they often cannot understand well if they know something or not, and if they do not want something, they don't say it easily. It is why we decided to do a case study in kindergartens in Sarajevo with mixed groups. The sample was 40 children, aged 3 to 6 years. With individual approach, we researched their abilities to recognise and name solid geometric figures (ball, cube, cylinder and cuboid) using applications and colouring (red, yellow, green and blue) in order to have children's attention on given tasks. The responses that we received represent important information for further research and creating new curricula for preschool education.

Keywords: Solid geometric figures, Applications, Mixed age group, Kindergarten, Case study.

INTRODUCTION

During preschool education, children's concepts are usually built on perceptive similarities of objects in their environment and personal experience. Later, children gradually become aware of certain attributes of different shapes (Koleza, Giannisi, 2013). Concerning the mathematical knowledge during these early years, there are studies that indicate the importance of playing building quality objects (e.g., block building), puzzle, drawing and folding paper to make different shapes (Hawes *et al.,* 2015). Considering that during this age children learn what they live through, it is very important for all activities to be natural and vivid, as well as based on challenges of various unknown facts. It is why representations of space are not only perceptive realisations of children's environment, but they are created based on previous active manipulations by that environment (Clements, Batista, 1992). Grouping objects, sometimes by shape or other geometric property is a skill that is foundational for gathering data, and it makes children easily remember and talk about these shapes in the environment (Copley, 2000). In the study by Clements *et al.* (2018), it was shown that small children are able to grasp geometric concepts and processes to surprising level and depth. The main topic of Piaget's and Inhelder's (1967) theory of children's images of space is that children build their assumptions about space through progressive organisation of motoric and children's internalised action. Geometry itself encompasses two central components, one of them being reasoning about shapes (e.g., we learn that triangles must have three flat sides, three angles, but that these angles can be of different sizes, etc.), and the second one being reasoning about space (e.g., we learn how objects in space can be mutually positioned, something is next to something, something is above, etc.) Although children observe shape and space correctly in their everyday environment, preschool children should be taught to think about this.

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Our central goal should be understanding the fundamentals of geometry. Geometry is one of the branches in mathematics that develop student's visualisation, intuition, critical thinking, problem-solving, deductive concluding, logical argumentation and proving (Jones, 2002). Designers of new visualisations for science coursework often emphasise that the usefulness of visualisation lies in its ability to fulfil the student's needs for visuality (Newcombe, Stieff, 2012). The world around us is full of models of geometric shapes and figures and it is why it is important for children to recognize, differentiate and compare them. Research has shown that young children shape their ideas and concepts about shapes before they start school (Clements, 2001; Clements and Sarama, 2000). The standard content of plane and space geometry should be much more than only naming shapes (Copley, 2000). Furthermore, it is believed that children who have a strong sense for space and orientation are more successful in mathematics later in life. However, in order for children to develop a strong sense of space, they should develop their spatial skills first. The main two spatial skills are spatial orientation and spatial visualisation (Bishop, 1980; Harris, 1981; McGee, 1979). Getting to know shapes, structures, positions and transformations, as well as developing spatial abilities, helps children understand many other mathematical topics (Copley, 2000). The problem in working with small children is that it may be difficult to measure their knowledge and abilities. It is known that the developmental patterns for geometric research are still in their early phase (Hannibal, 1999). Defining shapes are often the only highlighted geometric ideas, while manipulating with them and their spatial expression are often neglected (Copley, 2000). Another limitation is that small children are on different van Hiele's levels of geometric thinking, and they understand these shapes in different ways (Yin, 2003). According to research, it was understood that children on first van Hiele's level of geometric thinking do not analyse specific components and properties of the image, and instead of naming it 'visual level' it should be named 'syncretic level' because children use declarative knowledge to explain why a certain figure does not belong to a certain class (Clements *et al.,* 1999), and the difference between a shape and a visual prototype causes description of differences (Gibson, 1985). Observing shapes from different orientations remove children's stereotypical understanding of certain shapes, supporting the understanding of important geometric principles (Seah, 2015). Educators should ensure that children experience a great number of different examples of various shapes, in order for them not to create narrow-minded ideas about any class of shapes (Clements *et al.,* 2018). Three-dimensional shapes that children are introduced to in kindergarten are: ball, cube, cylinder and cuboid. It shall be noted that during this age, children perceive cube and cuboid as different terms (not as the cube being a special case of a cuboid). During our long-term experience and cooperation with educators, we have come to a conclusion that these terms are introduced separately in kindergarten. One of the possibilities could be making a clay model of a cuboid and the cutting its sides to make a cube. By doing such demonstration, children should be practically able to learn how cube is actually a special case of a cuboid. However, we could not find any information about anyone doing such activities or anything similar. During our research, we considered that the children were taught about these two terms separately.

MATERIALS

Case study

Because of all specificities of children of preschool age, it was decided that a case study in Sarajevo kindergartens with children of mixed-age groups would work as the optimal solution. It was decided that the experiences of working with children individually shall be described and understood, respecting children's will and not influencing their responses. The study took place in natural conditions, in a kindergarten where all children stay during the day, where the child was not feeling completely separated from others, but where they had enough space and freedom to express their thoughts. Since the sample was not quite large (40 children, aged 3-6; six six-year-olds, 18 five-year-olds, 12 four-year-olds and four three-year-olds), obtained results do not allow generalisation, but they give us an in-depth analysis of certain occurrences and understanding of special cases. Therefore, the aim of our case study was to describe and explain observed occurrences as often as possible. To do this, we used a special method of data gathering. We made five questions of naming and recognising shapes of geometric figures. We used specially prepared applications which gave children questions in a specific order. All responses were noted and the children were asked simple questions without having any suggestions on how they should respond. Whenever the children wanted a pause, they had it. Children themselves decided when they would be back to answer the questions. To have their attention, vivid colours were used on the applications. Along with their responses, each child had their age noted as well. This data was given to us by the educators responsible for the children/kindergarten group because we could not be sure that every child would tell us their age correctly. We decided for this study to be qualitative, but if the number of answers is important for highlighting any occurrence, we shall allow using quantitative information as well. The examination was held using four groups of questions. Each group had a different geometric figure in its focus (ball, cube, cylinder, cuboid). The group of question was randomly chosen. Each child was approached only when and if they wanted so and each of them worked individually, with strict respect to children's needs. Simplified terminology (instead of models of geometric figures, we used precise names of geometric figures with disregard to their abstraction and adapting it to children's age) was used in conversation with the children. The results to which we'd come are going to be presented by describing each task, one by one.

RESULTS

First task

The first task was to examine whether children in kindergarten recognise the shape of a geometric figure that is shown on the application. We used applications with vivid colours in order for shapes to be clear and striking during the presentation and to keep the children's attention. Furthermore, the questions were written in a very simple language, such as: "What do you see in this picture? How is this called?" There was no suggestion to their responses. In the first application, there was an image of a blue model of a ball. All children could recognize what was in the picture. However, among correct answers the responses included circle, triangle and cube. In the second application, there was an image of a blue image of a cuboid. Only one child named it correctly, while other children responded with: rectangle, cube, square, as well as not knowing what is it called. 'Rectangle' was predominately given as the response among wrong answers. In the third application there was an image of yellow model of a cube. All children named the given figure correctly. In the fourth application there was an image of a yellow model of a cylinder. Except for correct answers, there were no wrong ones, but some children responded with 'I don't know'. No child from the group refused to answer any of the questions.

Second task

The second task was to examine whether children in kindergarten are able to compare four given models of the same figure that had different size and colour. We asked them to pick the image that showed the model of the smallest geometric figure. Different colours were used as a tool for deception (something that would mislead their perception) because we used the colour that was used in the application from the first task. The first set of applications consisted of applications with models of balls in different colours (yellow, red, blue, green). Most of the children recognised the model of the smallest ball in size. Several children said that that is a model of a yellow ball, and same is the number of the children that said the model is red. The yellow ball was the first in a sequence of applications during the presentations, while the second one was red, and this most likely influenced the children's choice. The effect of deception, for which we thought would influence children's choice, did not have any effect. The second set of applications consisted of applications with models of cubes in different colours (green, blue, red, yellow). Most of the children recognised the model of the smallest cube. However, there were some children who said that it was yellow or green (equal number). In this case, the deception was the yellow cube, and along with this it was the first one in the sequence of presentation, while the green one was the last one. This indicates that in this case both the colour and the order of presentation may influence the choice in some children. The third set of applications consisted of applications with models of cylinders in different colours (green, blue, red, yellow). Almost all children recognised the smallest cylinder in size. Only one child said that it was a yellow cylinder. In this case deception was the yellow colour, as well as the yellow cylinder being presented last, and with it being the final image in children's minds, it might mean that there are indications that colour and the order of presentation might influence some children's decision. The fourth set of applications consisted of applications with models of cuboids of different colours (yellow, red, blue, green). Almost all children recognised the smallest cuboid, with one child saying it was yellow and another one saying it was green. The deceptive factor here was blue colour, and with the yellow cuboid being first in the sequence of presentation, and the green being the last one, this might indicate that the order of presentation influences the children's decision. The first presented shape might be something the child forgets most easily, but since the application is in front of the child, it is what the child sees as the first in the sequence all the time. Similarly, the green cuboid might be the final one being presented, but if the child looks at the sequence from the right-hand side, it may be the first.

Third task

The third task was to examine whether children can recognise the required shape among different figures (cuboid, cylinder, ball, cube) of different colours (red, green, yellow, blue). This task was completed after a short pause in order for children not to lose their interest in cooperation. Contrary to the first task where the children were asked to name different shapes, they were now asked to recognise the figure among other figures. They were offered a set of applications with models of red cuboid, green cylinder, yellow cube and blue ball. First, the children were asked to show the application with the ball. All children successfully completed the task. This indicates that the current way of understanding the term of a ball (i.e., ball for children) has been successful. Furthermore, the children were asked to show the application of a cube. All children completed the task successfully. It should be noted that the model of a cuboid was clearly presented as a cuboid, and not as a cube, in order to avoid confusion. The results indicate that the current way of understanding the term of a cube is correct. After this, the children were asked to show the application of a cylinder. All children completed the task successfully. The results indicate that the current way of understanding the term of a cylinder is correct. Finally, the children were asked to recognise the application of a cuboid. All children completed the task successfully. However, most of them said it was a red cuboid, while a small number of them said it was a yellow cube. Mathematically, that answer is correct, although at that age children are taught that the scope of terms square and cuboid are disjunctive sets (which, of course, is not correct because every cube is a cuboid, but not every cuboid is a square).

Fourth task

In the fourth task, the children were asked to say what does a certain shape have or to draw something that has that shape.
First group of children had a task with the ball. The children made a list: lamp (wall), snowman, ball for playing, apple, floating ball for swimming, the colourful ones. Some of them decided to draw (Figure 1).

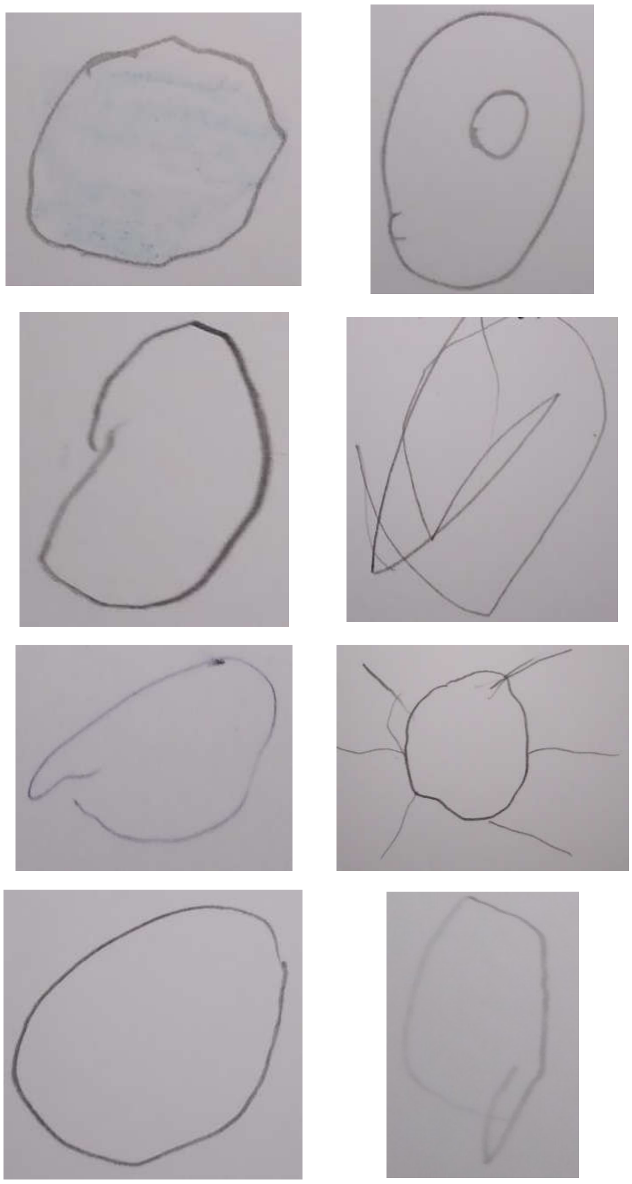

Figure 1. Drawings of the 'ball'

However, some children decided not to do neither of the activities. Until this task, there had been no situations where children refused to do something they were asked to, however, this happened in this phas. The reason could be that this was already a demanding task for children and it is where they refused to cooperate. In the beginning, it was noted that the children's decisions were not influenced anyhow. If the child did not want to do something or respond, it was not insisted. It should be noted that the children who decided to draw turned out to be quite successful at it. The second group of children had a task related to the cube. Children from this group did not know what real-life objects had the shape of a cube. Only one child tried to demonstrate how does a cube look with their hands and describe it as 'a shape of a cube'. Most of other children tried to draw something that is cube-shaped. It should be noted that this task was too difficult for this age and that their drawings are appropriate their age and what was expected of them (Figure 2). Some children responded with 'I don't know' or that they don't want to say anything or draw it. Although the cube is an attractive shape to children due to its 'regular' and 'perfect' shape, we cannot find the shape of a cube in everyday life that often, which is why it was expected that children would not be able to remember some examples from their environment.

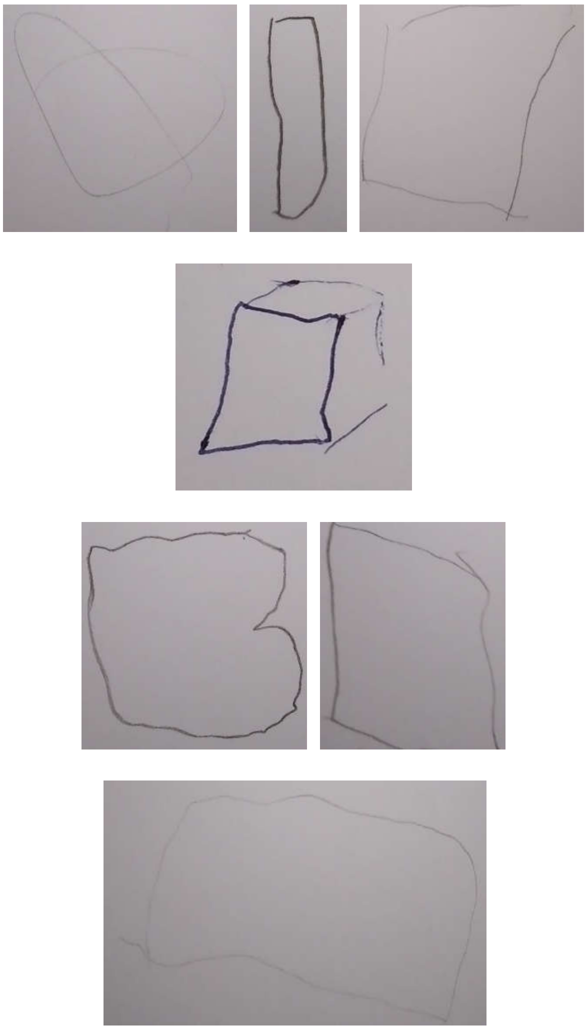

Figure 2. Drawings of the 'cube'

The third group of children had a task related to a cylinder. One child gave an example of a rolling pin, another one tried to describe it as something that 'has a ball above and beneath', 'and in the middle something that dough can be rolled with' (while speaking, they demonstrated rolling with their hands). Most of other children only drew something, and only one child said they didn't know. The drawing of a cylinder is a bit too complex at this age, therefore we consider the drawings successful because the children were able to draw some parts of the cylinder correctly.

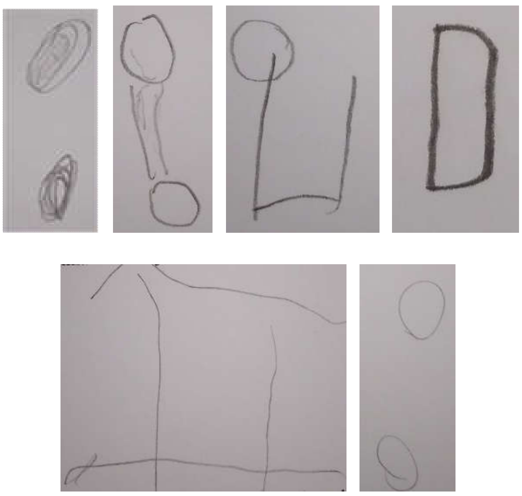

Figure 3. Drawings representing a 'cylinder'

The fourth group of children had a task related to a cuboid. One child gave an example of a building, while another child tried to describe it as 'something that has cubes up and down'. Most of the other children from the group drew something, while only one child did not one to respond and they talked about something else. We consider all of the drawings successful for this age.

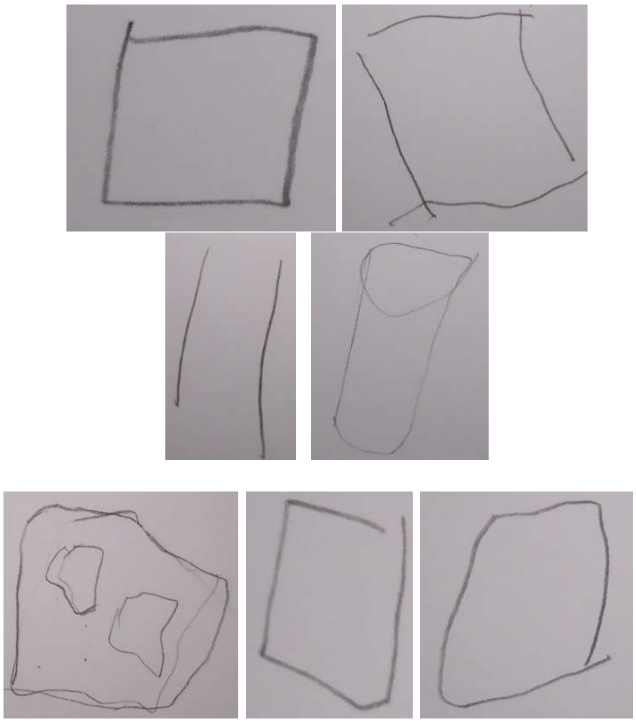

Figure 4. Drawing of a 'cuboid'

Fifth task

In the fifth task, children were asked to name each shape shown in each of the four offered applications. All children that participated in this case study were offered the same applications in the same order: red cuboid, green cylinder, yellow cube, blue ball. However, we differentiate the responses by groups because certain terms have already repeated in each group. The first group of children that had a question related to the ball did not give correct responses for the application of a ball. One answer was a 'circle' and some of them said they didn't know. This was not expected, but it is assumed that the problem here is the application which is two-dimensional, and not three-dimensional, and that this may have caused issues for some children. When it comes to the cuboid application, none of the children said it was a cuboid. The answers they gave were: cube, rectangle, cylinder, triangle, and some said they didn't know. This indicates that, considering that the shape of a cuboid is very represented in our environment, children should be introduced to many more examples from the environment than now. When it comes to the cylinder application, except those who named it correctly, the answers included: cube, rectangle, as well as not knowing. This indicates that this example, too, shall be given more attention in working with children because the shape of a cylinder is very present in our everyday life. When it comes to the application of a cube, almost all children named it correctly. One child said it was a square, and another child said they didn't know. If all responses of this group are analysed, just a bit above 50% of the answers are correct. This is not really a satisfying result.

The second group of children that had questions related to a cube all gave correct answers related to the application of a cube. In case of the application of a cuboid, there were no correct answers. Several children said it was a rectangle, some of them said it was a cube, one of them said it was a cylinder, while others said they did not know. Therefore, we have a very similar situation as in previous group. When it comes to the application of cylinders, there happened to be several correct answers, as well as some that were wrong: circle, and the ones who said they didn't know. Again, it was a very similar situation to the one in the previous group. When it comes to the application of the ball, there was an equal number of correct answers and the ones who said it was a circle. There happened to be several children who said they didn't know. Therefore, similar problems may be noted in the application of the cube and the application of a ball. The third group of children that had questions related to a cylinder named the object correctly in almost all of the cases, while only two of the children from the group said they didn't know. This condition may be seen as acceptable. When it comes to the application of a cuboid, there was not a correct answer, and the wrong ones included: rectangle, square, as well as that they didn't know. As it may be noted, similar situation happened here too, when it comes to a cuboid. When it comes to the application of a cube, almost all answers were correct. Precisely, only one child said it was a square. Again, a very similar situation to the previous groups. When it comes to the application of a ball, most of the responses were correct, but there happened to be some that gave 'circle' as an answer. Therefore, another very similar situation to the previous groups. The fourth group of children that had questions related to the cuboid did not give any correct answers related to the application of a cuboid. Although this group was exposed to the questions related to a cuboid, it turned out not to be sufficient for children to grasp the concept correctly. When it comes to the application of a cylinder, almost all of the responses were correct and some of them said they didn't know. Again, a very similar situation to the previous ones. When it comes to the application of a cube, only two children said they didn't know, while others answered correctly, which is again a very similar situation to the previous groups. When it comes to the application of a ball, there was an almost equal number of those who said it was a circle, as well as those who said it was a ball. Again, a very similar situation to the previous ones.

CONCLUSION

If we could systematically sum all obtained data in this case study, several points could be made. Regardless of this work method not being usual to work in kindergartens, children did not refuse to cooperate. The only cases where they did not want to give an answer and when additional pauses were made were the situations where children did not know the answer, which is why they refused to cooperate at that point. Most usually, children accepted to continue where they stopped with questions before the pause. Although it was not a lot of questions, the study itself took several months because we did not want children to be separated all day, as well as working with children every day consecutively. The study was conducted when the responsible educators said that the children were most open to working and it sometimes took one, sometimes two children during the day. Although the children talked about what we had asked them and they shared their answers, we believe that the time period between arrivals took the influence of the answers we had already heard from the child to minimum. However, it should be noted that we sometimes had a feeling like this influence might be present (such as saying for a cylinder that it is a cube). Every wrong answer was observed from several aspects. One of them was the age of a child. We did not notice that the children of a certain age gave more wrong answers than others, which is another indicator that the causes of wrong answers are something else. Furthermore, we could not notice that child's gender influenced the correctness of the answers. This remains as a suggestion to be examined in a larger research study where obtained results could be generalised. What we did notice is that regardless of what group of tasks the children had been exposed to, that did not influence the correctness of other answers. The greatest problem turned out to be in the case of a cuboid. It should be noted that there is a lot of reasons that may have led to this. Some of them may be: children are not offered enough examples for the model of a cuboid; not enough time is devoted to understanding the term, in spoken language the term is often misused, and a lot of confusing terms may be used for this age (e.g., it is said that the house has a shape of a cuboid, the part without a roof, and then the house is drawn as a rectangle and a triangle), etc. We also noticed that the greater number of wrong answers is related to two-dimensional shapes which may as well be a consequence of that we used applications or that in working with children more shapes are represented simultaneously and then, children are not able to abstract the adequate properties of a certain shape. In this case study several important indicators were found that could be used for further research that could improve the future curricula of preschool education.

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