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Education of Children on the Recognition of Geometric Shapes Using New Technologies

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Abstract: In today's digital age, new technological tools are increasingly becoming an indispensable part of the educational process, particularly in educating children. The development of technology, including tablet computers, and mobile phones, offers numerous opportunities for enhancing teaching methods and fostering children's development. These technologies offer access to a wide array of digital resources, interactive content, and personalized educational experiences, thereby opening up new methods in education. However, despite the benefits, many studies underscore the potential negative impacts of utilizing new technologies in children's education. For the above reasons, a study was conducted to examine how new technologies influence children's learning of geometric shapes. Forty children, evenly distributed by gender and place of residence, participated in the study, undergoing testing using both mobile phones and Tablet PCs. The results revealed statistically significant differences based on the respondents' gender, place of residence, and the devices through which the tasks were presented, particularly for certain geometric shapes.

Keywords: New technology; Education; Children's learning; Geometric shapes

1. Introduction

As our society becomes increasingly reliant on new technology, understanding its impact on childhood development and education is of great importance, both for parents and children. In this context, examining how children interact with and benefit from new technologies like tablet computers offers valuable insights into their cognitive and behavioral development. In this paper, the impact of new technologies on educating children about the knowledge of geometric shapes was investigated.

1.1 Children and New Technologies

For children growing up today, new technologies are an integral part of daily life, and children embrace technology as a completely natural and unavoidable means. We witness an increasing number of children starting to use computers and mobile phones very early, mostly for playing video games. In addition to negative consequences, the use of new technologies leads to certain improvements in color perception, object recognition, and spatial awareness (Trifunović et al., 2023), which can have significant applications, including in preparing children for participation in traffic, as numerous studies have shown that solving tests accelerates the development of abilities measured by them (Crescenzi et al., 2014; Miletic et al., 2021; Schmid et al., 2008).

Children trained to use computers demonstrate better structural and conceptual knowledge, non-verbal and motor skills, problem-solving abilities, language skills, long-term memory, movement coordination (in drawing), and better intellectual abilities compared to those who did not use technology in learning (Lee et al., 2017; Trifunović et al., 2022a). Perception of space, color, mathematical thinking, creativity, better results on critical thinking tests, and higher levels of motivation are also improved (Papadakis et al., 2016; Trifunović et al., 2022a).

Furthermore, the tactile communication facilitated by touch-sensitive screens closely mimics natural forms of interaction, allowing children of this age to explore and communicate with their environment more effectively. The benefits of this type of education are most pronounced when children engage with computers in pairs or when adults actively participate in their learning process. This collaborative approach fosters cooperative communication and interaction among peers and adults, cultivating positive attitudes towards learning and enhancing overall educational outcomes (Trifunović et al., 2022b). These findings underscore the importance of integrating technology into educational settings and highlight its potential to enrich learning experiences and foster holistic development in children.

1.2 New Technologies and Children's Age

Research results conducted in Barcelona and London (Lanna & Oro, 2019) indicate that children as young as 13 months adjust their gestures to the content displayed on tablet computers. By the age of 2, children can use drawing and coloring palettes presented on tablet computers. A child of this age can manipulate the touch-sensitive screen with their fingers, attempting to draw various geometric shapes (Lanna & Oro, 2019). However, if a child uses a stylus intended for manipulating a touch-sensitive screen, their accuracy and motivation decrease. A stylus for touch-sensitive screens is not adapted to the hand of a child under 10 years old (Mann et al., 2015; Wu et al., 2018).

A study conducted by Sakr (2018) aimed to examine differences in drawing various geometric shapes on paper and tablet computers. The experiment involved five pairs of children aged 5 to 6 years. The results showed that children performed better when drawing on a tablet computer, displaying greater motivation and readiness for group work compared to situations where the same tasks were solved on paper (Sakr, 2018). A study conducted in 2017 (Čičević et al., 2017) aimed to investigate differences in the recognition of 2D and 3D geometric shapes, which were presented to the participants on tablet computers and paper. The experiment involved 180 children aged between 6 and 10 years. The results showed that children exhibited greater motivation and achieved better results in task-solving when using a tablet computer (Čičević et al., 2017).

2. Methodology

2.1 Experiment Design

The experiment employs a modern approach, utilizing both tablet computers and mobile phones to test children. Non-verbal tests were administered in a specially designed environment, consisting of three parts. The initial segment gathered demographic data from the children (gender, place of residence). Subsequently, two sets of tests were administered.

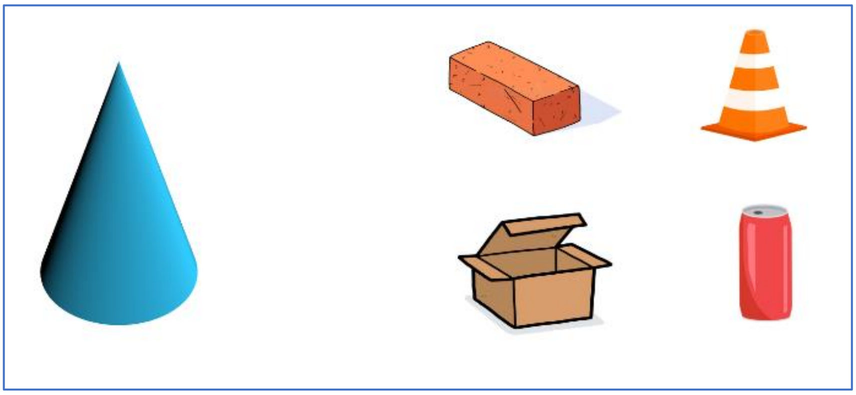

Figure 1. Illustrative examples of Geometric Test 1 (T1)

The first test involved identifying the shapes of geometric objects, as illustrated in Figure 1 (referred to as Geometric Test 1). The geometric shapes that were subject to examination are the cube, prism, cylinder, cone, and pyramid.

The second test required children to recognize a 3D element and match it with the corresponding 2D element (connecting geometric shapes with objects, denoted as Geometric Test 2), as shown in Figure 2.

Each participant completed the tests on both a tablet computer and a mobile phone. The sequence of device usage was randomized for each child.

Testing Duration: Children were not constrained by time limits while completing the tasks.

Timing of the Experiment: The experiment was conducted in both schools during the morning hours, throughout the workweek.

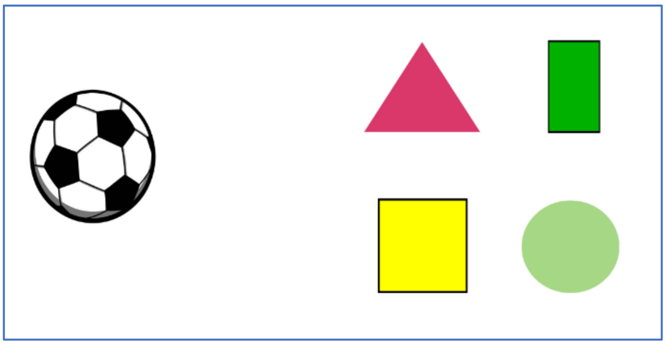

Figure 2. Illustrative examples of Geometric Test 2 (T2)

2.2 Features of the Mobile Phone and Tablet PC

For the purposes of the experiment, a Samsung A54 mobile phone and Samsung Galaxy Tab A7 were used.

Specifications of Samsung A54 mobile phone:

Dimensions: Dimensions of approximately 159.8×75.1×8.4 millimeters, making it a compact device that easily fits in the palm of the hand or pocket.

Screen: The phone comes with an impressive Super AMOLED screen with a diagonal of around 6.5 inches. This screen provides sharp resolution and vibrant colors, making it easier for reading, watching videos, and playing games.

Resolution: The Samsung A54 has a Full HD+ screen resolution, resulting in clear details and sharp images.

Screen protection: To ensure the durability of the screen, the Samsung A54 is equipped with Corning Gorilla Glass protection, which shields the screen from scratches and damage.

Aspect ratio: The phone’s screen has a wide aspect ratio, allowing for a larger display of content and providing a better viewing experience for videos and photos.

Brightness: The Super AMOLED screen technology enables high contrast and deep black colors, making the picture vivid and clear even in bright daylight.

Specifications of Samsung Galaxy Tab A7 tablet PC:

Dimensions: Dimensions of approximately 247.6×157.4×7 mm, making it a compact device suitable for handling and portability.

Display: The tablet comes with an impressive TFT display with a diagonal of around 10.4 inches. This screen provides a clear picture and good contrast, making it suitable for reading, watching videos, and playing games.

Resolution: The Samsung Galaxy Tab A7 has a Full HD+ display resolution, enabling sharp details and clear images.

Screen Protection: To ensure the durability of the screen, the Samsung Galaxy Tab A7 is equipped with protective glass that provides a certain level of scratch resistance and protection against damage.

Aspect Ratio: The tablet’s screen has a wide aspect ratio, allowing for a larger display of content and a more comfortable viewing experience for videos and photos.

Brightness: TFT screen technology provides good brightness and color reproduction, enabling good contrast and a clear picture in various lighting conditions.

2.3 Participants

The study was conducted across two schools. Children attending schools in Kragujevac represent the urban demographic, while those attending schools in the villages of the Municipality of Rača represent the rural demographic. Ethical approval and parental consent were diligently obtained prior to conducting the experiment, underscoring our commitment to upholding ethical principles throughout the research process. It’s important to note that the children engaged in the study without any form of monetary compensation, highlighting their altruistic participation. Their involvement was entirely voluntary, with each child making the decision to take part based on their own interest and willingness. Moreover, to safeguard the privacy and confidentiality of the participants, the research was conducted anonymously, ensuring that no personal data of the children was utilized or disclosed during the study.

2.4 Processing Data

Statistical analysis was carried out in the statistical software packages IBM SPSS Statistics v. 23. The normality of distribution was tested by inspection of histograms and the Kolmogorov-Smirnov test. Since the data for all measured variables were not normally distributed, we used nonparametric methods. To assess the significance of differences a Mann-Whitney, and Cochran's Q tests were used.

In the paper, the null hypothesis (H_0) has been set up saying: there is no statistically significant difference between the groups; and the working hypothesis (H_a) saying: there is a statistically significant difference between the groups. The threshold of the statistical significance (a) has been set up at 5%. Thus, if $p<0.05$, H_0 is rejected, and Ha is accepted. If $p>0.05$, H_0 is accepted (Ivanišević et al., 2022).

3. Results

3.1 Descriptive Statistics

Forty children participated in the study, with an even distribution observed based on gender and place of residence (urban and rural). All children were tested using a mobile phone and tablet computer. Children demonstrated the highest accuracy in the cube task on Test 1, with 72.5% of responses being correct, whereas the pyramid task had the lowest accuracy, with only 20% of responses being correct (Figure 3). The results of the Cochran's Q test show no statistically significant differences between the tested geometric figures ($\chi^2=5.784$, $p=0.216$). When the results of Test 2 were analyzed, it can be concluded that the children have the most correct answers for the cone task (67.5%), and the least correct answers for the cylinder task (50%) (Figure 4). The results of the Cochran's Q test indicate that there are no statistically significant differences among the tested geometric figures ($\chi^2=3.409$, $p=0.492$).

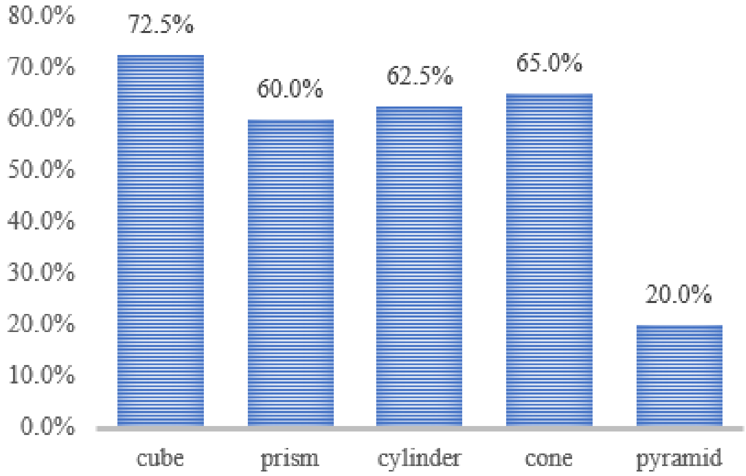

Figure 3. Results of descriptive statistics for T1

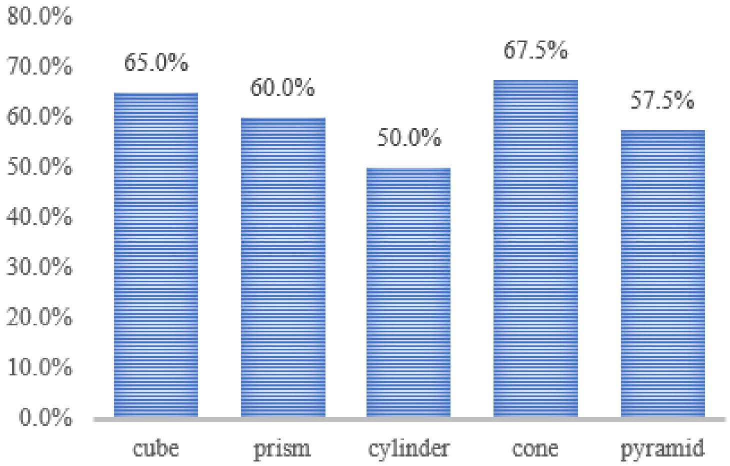

Figure 4. Results of descriptive statistics for T2

3.2 Gender Difference

Figure 5 shows the results of test 1, from which it can be concluded that male respondents have a higher percentage of correct answers for the cube, cylinder and pyramid tasks (95%, 65% and 85%, respectively), while female have a higher percentage of correct answers for the cone task (70%). The results of the Mann-Whitney test show statistically significant gender differences for the cube (Z=-3.147, p=0.014). The results of test two show that men have a higher percentage of correct answers for the cube and pyramid (85% and 60%, respectively), while female have a higher percentage of correct answers for the circle and cup (55% and 75%, respectively) (Figure 6). Statistically significant gender differences for the cone task are indicated by the results of the Mann-Whitney test (Z=-2.619, p=0.030).

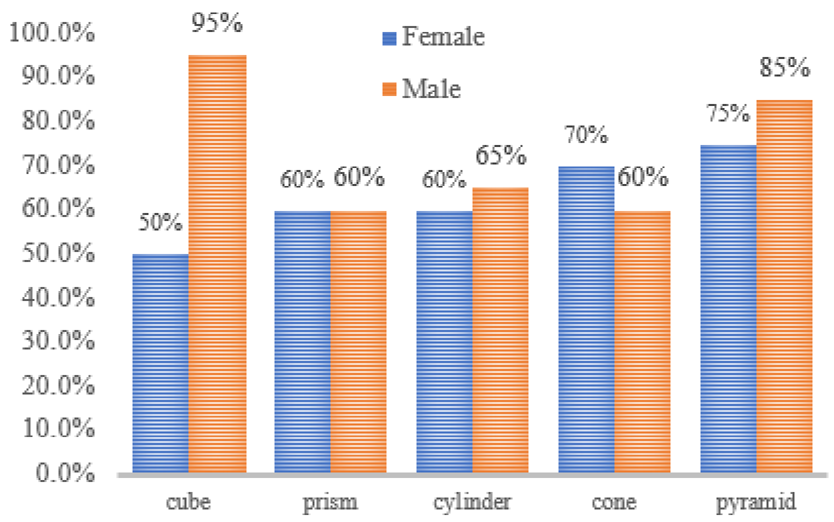

Figure 5. The results of gender differences for T1

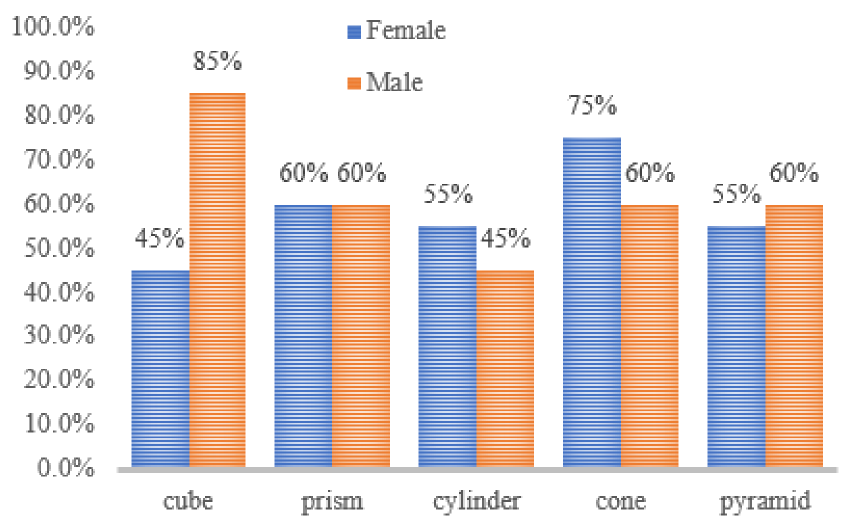

Figure 6. The results of gender differences for T2

3.3 Place of Residence

When it comes to place of residence, children from urban areas have a higher percentage of correct answers for the cube and cylinder (75% and 65%, respectively), while children from rural areas have a higher percentage of correct answers for a prism, cone, and pyramid (85%, 75% and 85%, respectively) (Figure 7). Significant statistical differences based on the place of residence, according to the Mann-Whitney test, are present for the cup in Test 1 (Z=-3.187, p=0.006). Figure 8 shows the results of children's achievement for Test 2, according to place of residence. Children from an urban environment record more correct answers for the cube, while children from rural areas answer all other tasks more accurately. In Test 2, the Mann-Whitney test indicates significant statistical differences for the cup based on the participants' place of residence (Z=-3.824, p=0.001).

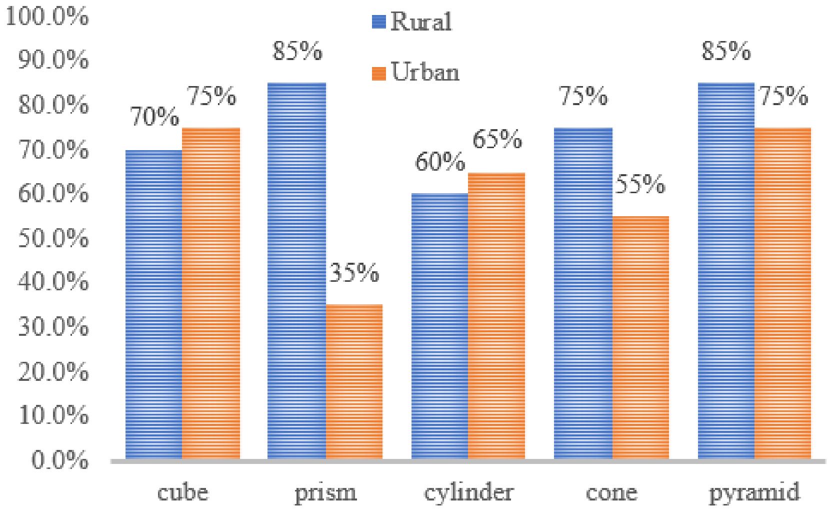

Figure 7. Results by children's place of residence for T1

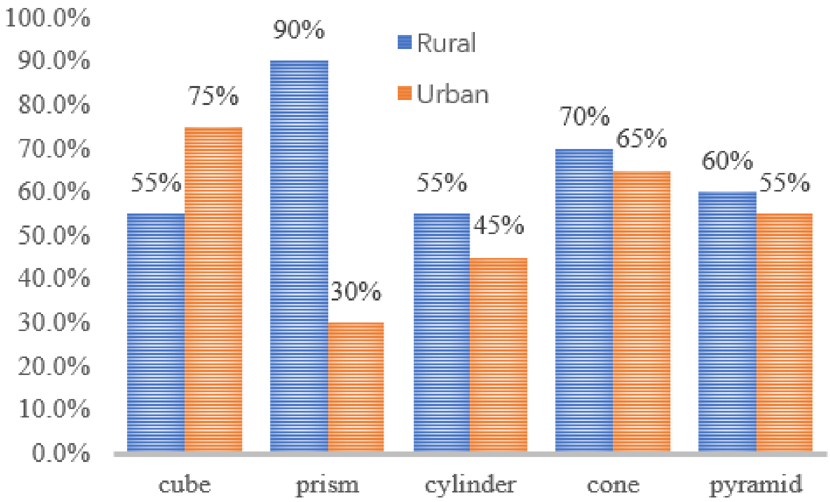

Figure 8. Results by children's place of residence for T2

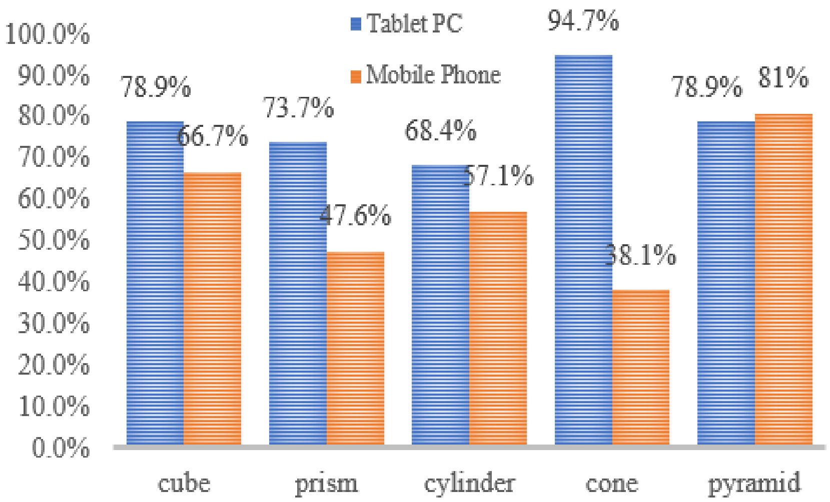

Figure 9. Results by presentation media for T1

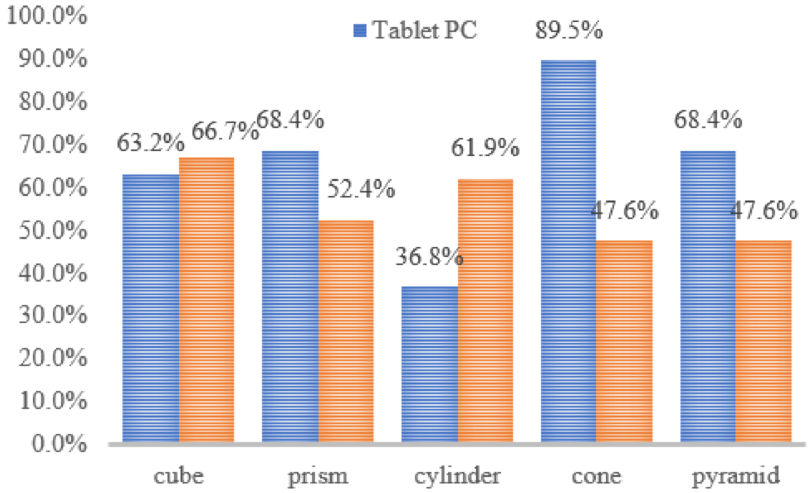

Figure 10. Results by presentation media for T2

3.4 Tablet PC vs Mobile Phone

When analyzing differences among children in solving geometric tasks for Test 1, it can be concluded that children perform better on Tablets PC for all tasks, except for the pyramid task, where they slightly perform better on mobile phones (Figure 9). According to the results of the Mann-Whitney test, statistically significant differences exist only for responses to the pyramid task ($Z=-3.187$, $p=0.006$). When examining variations in children's ability to solve geometric tasks in Test 1, it is evident that they exhibit superior performance on Tablet PCs across all tasks, with the exception of a cylinder and cube tasks, where slightly better performance is observed on mobile phones (Figure 10). Statistically significant differences, as indicated by the Mann-Whitney test, are solely present for responses to the pyramid task ($Z=-2.787$, $p=0.023$).

4. Discussion

Our study examines the impact of using new technologies to educate children about geometric objects. Literature suggests that children today are exposed to new technology at a very early age, with Tablet PCs and mobile phones often being used for gaming purposes. Although concerns exist about the overuse of these devices, research indicates some positive effects on children's cognitive development.

The results of our study show that children have difficulties recognizing geometric shapes. Additionally, children face greater challenges solving tasks when they need to identify 3D objects in a 2D environment. Our study also examines differences in children's performance based on gender and place of residence. Findings reveal disparities in task performance between male and female subjects, as well as between children living in urban and rural areas. On the other hand, children demonstrate a higher percentage of correct answers when solving tests on a Tablet PC compared to a mobile phone. These findings underscore the need for tailored educational strategies that consider these differences.

Furthermore, our study underscores the importance of integrating technology into the educational process to enhance educational practices and foster the holistic development of children. However, careful planning and implementation of these technologies are required to maximize benefits while minimizing potential negative effects.

5. Conclusions

In conclusion, this study involved forty participants, evenly distributed based on gender and place of residence (urban and rural). All participants underwent testing using both a mobile phone and tablet computer. Results from Test 1 revealed that children achieved the highest accuracy in the cube task, with 72.5% correct responses, while the pyramid task had the lowest accuracy at 20%. Cochran's Q test showed no statistically significant differences among the tested geometric figures. Analysis of Test 2 results indicated that children performed best in the cone task (67.5%) and least effectively in the cylinder task (50%). Similarly, Cochran's Q test for Test 2 found no statistically significant differences among geometric figures.

Further analysis revealed gender-based performance differences. Males demonstrated higher accuracy in cube, cylinder, and pyramid tasks (95%, 65%, and 85% correct responses, respectively), while females outperformed in the cone task (70% correct responses). Mann-Whitney tests confirmed statistically significant gender differences in the cube and cone tasks.

Regarding place of residence, children from urban areas scored higher in cube and cylinder tasks (75% and 65% correct responses, respectively), while children from rural areas scored higher in prism, cone, and pyramid tasks (85%, 75%, and 85% correct responses, respectively). Mann-Whitney tests revealed significant differences in cup task performance based on place of residence in Test 1, and for Test 2, significant differences were found in cup task performance based on urban or rural residence.

Additionally, when considering the device used for testing, children generally performed better on Tablet PCs, except for the pyramid task, where slight superiority was observed with mobile phones. Mann-Whitney tests confirmed statistically significant differences only for responses to the pyramid task.

In summary, this study underscores the importance of considering various factors, including gender, place of residence, and device used for testing, in understanding children's performance on geometric tasks. These findings provide valuable insights for educators and policymakers in developing tailored educational strategies to address diverse learning needs and optimize learning outcomes. The findings of this study may have important implications for educational practices and policies. Understanding how technology impacts children's cognitive development can help in creating better educational programs that utilize technological tools effectively. Additionally, tailoring educational strategies to the specific needs of children, such as differences in performance between genders or places of residence, can contribute to improving education and ensuring equal access for all children.

One of the main *limitations of this study* is the relatively small sample size of participants, which may limit the generalizability and applicability of the results to the overall population. Additionally, the use of only two tested devices (mobile phone and Tablet PC) may restrict the generalization of results to other technological devices present in today's children's environment. Furthermore, this study did not take into account other factors that could affect test results, such as family socioeconomic status or individual differences in development.

Further research could examine in more detail the mechanism of learning geometric shapes in children and how different factors, such as age, parents' level of education, and length of exposure to new technologies affect it. It is necessary to expand the sample, include various technical devices (e.g., virtual reality), take a larger number of stimuli, including the color of the objects. It would also be beneficial to explore how these factors may interactively influence test results. Moreover, future studies could investigate how the use of different technological devices may impact various aspects of children's cognitive development.

Data Availability

The data used to support the research findings are available from the corresponding author upon.

Conflicts of Interest

The authors declare no conflict of interest.

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