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Using Digital Technologies in Mathematics Education at Primary and Preparatory Schools

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Abstract

Teachers' teaching practices play a significant role in understanding the mechanisms and strategies for student's mathematics learning. To keep pace with technological development, educational institutions invest in modern teaching aids and technologies to push the educational process to achieve its goals and face challenges. This study aims to verify the possibility of developing methods for teaching mathematics and raising the level of academic achievement among preparatory school students by using some technological applications to teach mathematics. Therefore, in this study, we seek to investigate the impact of using technological programs and applications in teaching mathematics. The study's results indicated positive, statistically significant effects on the increase in the level of mathematics achievement when using technological applications in teaching mathematics.

Key Words: Digital learning, educational applications, gamification, interactive whiteboards, Quiz (Nearpod).

1. Introduction: –

The contemporary period is marked by significant scientific and technological advancements, particularly in education. Embracing these technological innovations is crucial, given their capacity to enhance the educational process and yield remarkable outcomes. Educational institutions recognize the need to integrate these advancements into tailored learning environments that cater to students' diverse abilities and traits, aligning with the demands of the times. Modern technologies reshape various aspects of life and transform educational settings from traditional to electronic formats. Initially hailed as a panacea for educational challenges, e–learning has encountered familiar issues inherited from traditional methods, including rigid curriculum, content delivery, and teaching methodologies. Despite its electronic nature, e–learning often replicates the inflexibility of traditional education. A prevalent issue in e–learning is the static presentation of content, disregarding individual learners' needs and preferences. Extensive research confirms that students vary in their learning speeds and possess distinct physiological, cognitive, and emotional traits. Hence, personalized learning tailored to each learner is imperative for fostering a sustainable society. Recognizing this imperative, the scope of electronic learning environments has expanded to encompass student characteristics, learning styles, and strategies. Adaptive learning technology has emerged, empowering students to pursue diverse educational pathways aligned with their unique attributes and learning pace.

The rapid advancement of technology and the contemporary information revolution, often called the digital revolution, have profoundly influenced various aspects of the educational system. These developments have particularly impacted the roles of educators and learners and the execution of educational tasks within the classroom. Numerous technological innovations have surfaced in education, including information networks and modern communication technologies for teaching and learning purposes. This evolution has led to new learning environments that transcend the conventional classroom setup. In today's digital age, education with technology has assumed increasing significance, offering novel avenues to enrich learning experiences. Technology can complement and enhance traditional educational methods, fostering more interactive and captivating learning environments. An essential advantage of technology in education lies in its capacity to accommodate diverse learning styles and individual needs. Digital platforms enable personalized learning experiences, adaptive assessments, and immediate feedback, all integral to effective learning processes (Means et al., 2009). Moreover, technology fosters collaborative learning and

communication among students and educators, transcending geographical limitations and granting access to vast resources and expertise (Anderson & Dron, 2011). Additionally, incorporating technology into education equips students with the skills necessary for success in today's workforce, where digital literacy and technological adeptness are progressively crucial. Using tools such as virtual reality, simulations, and online platforms, educators can craft immersive and realistic learning experiences that facilitate the integration of theoretical knowledge with practical skills (Johnson et al., 2012).

Technology integration has become indispensable in today's educational sphere, revolutionizing teaching methodologies and enriching learning experiences across various subjects. This transformation is particularly pronounced in mathematics, where technology is a potent tool for exploration, visualization, and problem-solving. Through technology, educators and students access various resources and platforms that facilitate interactive learning experiences. From multimedia presentations to online simulations and virtual laboratories, technology empowers the creation of captivating educational content tailored to diverse learning styles. As a catalyst for educational innovation, technology enables interactive learning, personalized instruction, and the practical application of concepts. In the digital era, educators leverage various technological tools to craft dynamic learning environments conducive to diverse learning styles and abilities (Cowan, 2006). The rapid advancement of modern technology in recent decades has significantly impacted various facets of our lives, including education and the learning of mathematics. This surge in technology, encompassing cloud computing, virtual reality, and artificial intelligence, has profoundly influenced the teaching and comprehension of mathematics by revolutionizing the presentation of educational materials and transforming student interactions with them.

One of the most notable benefits of modern technology in mathematics is the enhanced accessibility of online teaching materials and educational resources. With the advent of the internet, students can readily access many lessons, exercises, and explanations, facilitating comprehension and application of mathematical concepts. Additionally, modern technology offers interactive tools and educational applications that inject enjoyment and effectiveness into learning mathematics. For instance, educational software can be leveraged to design interactive games and challenges, enabling students to apply mathematical concepts dynamically and engagingly. Nevertheless, it is essential to acknowledge that technology should complement rather than supplant traditional educational methods. While technology offers numerous advantages, it also presents challenges such as the digital divide, privacy and security concerns, and the necessity for ongoing professional

development for educators (Hargittai & Walejko, 2008). Therefore, adopting a balanced approach that incorporates both traditional and technological components is essential for optimizing the educational journey of learners. Technology integration into education has transformed conventional teaching techniques, introducing innovative methodologies to enrich learning experiences. Especially within the realm of mathematics, technology assumes a crucial role in enhancing comprehension and student engagement. This overview underscores the significance of technology in education, focusing on its application in mathematics instruction.

In mathematics education, technology is instrumental in demystifying abstract concepts and rendering them more accessible to learners. Graphing calculators, mathematical software, and educational applications empower students to experiment with mathematical ideas, visualize intricate relationships, and cultivate a profound understanding of mathematical principles. Moreover, technology is a formidable ally in fostering conceptual understanding and problem-solving skills in mathematics education. Through interactive software, simulations, and digital manipulatives, students can grasp abstract mathematical concepts, explore mathematical relationships, and tackle real-world problem-solving tasks authentically (Estapa et al., 2015). Furthermore, technology empowers educators to tailor instruction, cater to individual learning requirements, and offer immediate feedback, cultivating a more profound comprehension of mathematical concepts (Thurm & Barzel, 2022).

Nevertheless, it is undeniable that integrating technology into mathematics education presents specific challenges and concerns. These include the potential diminishment of interpersonal communication between teachers and students and the risk of students overly relying on technological devices, which could impede the development of their cognitive skills. In summary, modern technology exerts a significant and beneficial influence on the teaching and learning of mathematics by offering novel opportunities and practical tools to stimulate interest in the subject and streamline the learning and teaching processes. However, it is imperative to balance utilizing technology, fostering personal communication, and nurturing the development of students' fundamental cognitive abilities. For more details about the topic of study see, Parenti (2013), Ractham & Chen (2013), Pretto & Curró (2017), and Nicholas et al. (2017).

2. The Theoretical Framework

Digital technologies have become increasingly prevalent in mathematics education, offering new opportunities for teaching and learning. This theoretical framework explores the impact of these

technologies on various aspects of mathematics education, including curriculum design, pedagogy, student engagement, and assessment.

Sense of the Problem

The motivation behind researching digital technologies in mathematics stems from the increasing integration of technology into education and the potential benefits it offers for enhancing learning experiences and outcomes in mathematics. Previous studies and research related to this topic have highlighted various aspects, including the effectiveness of digital tools in teaching mathematical concepts, their impact on student engagement and motivation, best practices for integrating technology into mathematics instruction, and challenges associated with implementation. Understanding these previous studies can provide valuable insights and inform the direction of future research.

Study Problem

The increasing prevalence of digital technologies in mathematics education presents opportunities and challenges. While these tools can enhance learning outcomes and engagement, their effective classroom integration remains complex. This study examines the potential for using digital technologies and technology applications to raise preparatory school students' academic achievement in mathematics, focusing on identifying best practices, addressing barriers to implementation, and maximizing benefits for diverse learners.

Study Objectives

- Determining the impact of using technological applications in teaching mathematics on the academic achievement of preparatory school students.

- Urging mathematics teachers to expand the use of technological and digital applications in teaching mathematics and to combine them with traditional teaching methods to achieve maximum benefit for students and facilitate understanding of mathematics.

- Urging students to use websites for self–learning mathematics and dealing with computers and some technological applications.

Study Importance

- For the student: Research in digital technologies in mathematics enhances learning experiences by providing interactive and personalized learning opportunities. It helps students develop critical thinking, problem–solving, and

digital literacy skills necessary for success in modern society.

- For mathematics teachers: This research offers valuable insights into effective pedagogical strategies and tools for integrating digital technologies into the classroom. It supports teachers in creating engaging and inclusive learning environments, improving teaching effectiveness, and meeting the diverse needs of their students.

- For curriculum planners and Developers: Research in this area informs the design and development of mathematics curricula incorporating digital technologies. It ensures that curriculum content is relevant, up-to-date, and aligned with educational standards, preparing students for the demands of the digital age.

- For researchers: Research on digital technologies in mathematics contributes to advancing knowledge in mathematics education and educational technology. It provides opportunities to explore emerging trends, investigate the impact of technology on learning outcomes, and develop innovative approaches to teaching and learning.

- For the Local Community: Research in this area benefits the local community by promoting access to quality mathematics education and fostering digital literacy skills among students. It can also support community engagement initiatives by providing resources and tools for lifelong learning and skill development.

Study Limits

- Academic subject limits: The topics taught in this project from [Areas] unit for the second year of preparatory school are "Lesson three: Equality of the areas of two triangles (Theorem (2) and its corollaries)", Lesson four Follow: Equality of the areas of two triangles (Theorem (3), and Lesson five: Areas of some geometric figures, in a group of three classes.

- Human limits: A sample of mathematics students at the second preparatory.

- Spatial boundaries: Saqr Quraish School for boys and girls for the Preparatory stage, Al-Waili Administration, Cairo Governorate year 2023/2024.

- Time limits: The research was applied during the academic year 2023/2024.

Research Materials and Tools

- **Interactive whiteboards**.
- **Computers**.
- **Tablets**.
- **Internet**.
- **Tests of Nearpod**.
- **Video Scripe**.
- **Google Form**.
- **Microsoft Power point**.

Study Terms

- ***Digital platforms*** **encompass various online resources and tools designed to facilitate the teaching and learning of mathematics. They typically involve interactive learning environments, virtual manipulatives and simulations, math games and puzzles, problem-solving and practice, graphing and visualization tools, collaborative learning platform resources, and professional development. These digital platforms offer diverse opportunities for students to engage with mathematics in interactive, personalized, and collaborative ways, enhancing their learning experience and understanding of mathematical concepts.**

Mathematics apps and software **are applications and programs designed to assist with learning, practicing, and exploring mathematical concepts. They typically involve problem-solving and step-by-step solutions, geometry and visualization software, data analysis, and statistics tools. Mathematics apps and software provide many tools and resources for learning, teaching, and exploring mathematical concepts across different proficiency levels and interests.**

- ***Nearpod*** **is an educational platform that offers various interactive features, including tests and exams. In Nearpod, tests and exams are interactive assessments designed to evaluate students' understanding of a particular topic or concept. These assessments can include multiple-choice questions, open-ended questions, true/false questions, and other question types. Nearpod's tests and exams feature allows educators to create, customize, and deliver assessments directly to students' devices during lessons. Students can complete the assessments in real time or at their own pace, depending on the instructor's**

preference. Teachers can track students' progress and performance in real time, providing immediate feedback and adjusting instruction accordingly. Nearpod's testing and assessment tools help promote engagement, interactivity, and formative assessment in the classroom or virtual learning environment.

Study Question

What is the impact of using technological programs and applications in teaching mathematics on the academic achievement of preparatory school students?

3. Study Methodology and Procedures

The study aims to determine the effect of the independent variable, the use of technological programs and applications in teaching preparatory school mathematics, on the dependent variable (the academic achievement of preparatory school students in mathematics) to achieve maximum benefits from the use of digital technologies in teaching mathematics courses to students in the intermediate stage.

Therefore, the study question was: What is the impact of using technological programs and applications in teaching mathematics on the academic achievement of preparatory school students?

Which resulted in the following hypothesis:

There are statistically significant differences at the level of significance ($\alpha = 0.05$) between the average scores of the students of the experimental group who studied using digital technologies and the average scores of the students of the control group who studied using traditional.

Study Methodology

The study followed a quasi-experimental approach to achieve its objectives, as it was applied to a group of second-year preparatory school students, as in experimental research (Bryman & A, 2015). Table (1) summarizes the methodological design of the study.

Tools / Groups	Pre-measurement	Processing	post-measurement
Experimental group	Achievement test	Teaching the subject using the digital technologies	Achievement test
Control group		Teaching the subject using the traditional teaching method	

Table (1): Methodological design of the research

Study Sample

The study sample included 93 students from Saqr Quraish School in Al-Waili Administration, Cairo Governorate. They were divided into two groups: control and experimental groups. The experimental group included 46 students, and the control group included 47 students. They were divided randomly, such that the equality of the two groups was considered by conducting the pre-exam and applying the t-test between the two groups to ensure that there were no significant differences in their levels before applying the experiment. Here, we do not need to apply the Levene test because there are equal students in the two groups. (Norušis,2006) It is noted from Table (2) that there are no significant fundamental differences between the averages of the students in the two groups, which indicates that the two groups were equal before the experimental treatment of the study.

The tool	T-test (Pre-test)	
Groups	Control Group (Traditional Group)	Experimental Group (Technology Group)
The number	45	46
Degree of Freedom	91	
Average	14.93617	14.28261
Standard deviation	3.830111	3.304294
The value of statistic	0.88028	
p-value	0.381	

Table (2): Results of t-test analysis of the pre-test scores of the study groups.

The results in Table (2) indicate that there are no differences between the averages of the experimental and control groups before applying the experiment, where ($p - value = 0.381 > \alpha = 0.05$).

Achievement Test

The achievement test was built considering the learning outcomes required to study the areas of shapes in the curriculum. The achievement test was constructed according to the relative weight of the topics. Accordingly, the number of test items was eight questions, six multiple-choice questions, and two essay questions (two items), and their total scores were 20 points; the multiple-choice rate is two marks each, and the essays are four marks each. To verify the validity of the test content, it was presented to six teachers who specialized in

mathematics, and the required changes were made.

The Experiment

In the experiment, the subject of the study (Areas) was presented in a total of three study lessons for the experimental and control groups, which is the time allocated for teaching the subject within the study plan for the course for second-year intermediate students, where the experimental group was taught using digital technologies which are Tests of Nearpod and PowerPoint and Video Scripe. The same subject was taught to students in the control group using the traditional method.

Statistical Treatment

Students' grades were entered in the statistical analysis program R. Then a t-test was conducted between independent groups after verifying the test assumptions: normality and equal variances. The normality assumption was verified by conducting the Shapiro-Wilk normality test. The p-values of the Shapiro-Wilk normality test for the control and experimental groups were 0.1806 and 0.06014, respectively (i.e., two samples follow the normal distribution). Furthermore, the equal variance assumption was verified by conducting the F test. The p-value of the F test was 0.1284 (i.e., accepting the hypothesis: True ratio of variances is equal to 1).

4. Study Results

The study aimed to verify the possibility of developing methods for teaching mathematics and raising the level of academic achievement at the preparatory level in mathematics by making the most of the use of digital technologies in mathematics education at the preparatory level. Therefore, the study sought to determine the effect of using digital technologies in mathematics on the academic achievement of preparatory school students and verify the following hypothesis: There are statistically significant differences at the level of significance ($\alpha = 0.05$) between the average scores of the students of the experimental group who studied using digital technologies and the average scores of the students of the control group who studied using traditional.

The arithmetic mean and standard deviation were obtained for the experimental and control groups for the post-test to verify the validity of the hypothesis (i.e., there are statistically significant differences at the significance level ($\alpha = 0.05$) between the means for the two groups) using t-tet for independent groups. Its results are shown in Table(3).

The tool	T–test (Post–test)	
Groups	Control Group (Traditional Group)	Experimental Group (Technology Group)
The number	45	46
Degree of Freedom	91	
Average	16.2766	17.17391
Standard deviation	2.123391	1.690553
T–Value	2.2515	
p–value	0.01338	

Table (3): Results of t–test of the post–test scores of the study groups

The results in Table (3) indicate that there are differences between the averages of the experimental and control groups after applying the experiment, where ($p - value = 0.01338 < \alpha = 0.05$). Therefore, we reject the null hypothesis of the study.

5. Interpretation of Results

The results of the study indicated a higher level of achievement of students who were taught using digital technology in light of the concept of content–related teaching knowledge compared to their peers who were taught in the traditional method, which confirmed the assumption of the study, which was based mainly on previous studies that used digital technology to teach some courses and did not explain its impact on Academic achievement, despite its positive impact on the ability to solve problems and develop higher–order thinking skills.

6. Conclusion

The conclusion regarding using digital technologies in mathematics education at preparatory schools is that it offers numerous benefits but also comes with challenges. Overall, integrating digital tools enhances engagement, facilitates personalized learning, and provides access to many resources. However, addressing issues such as access to technology and digital literacy among students and teachers and ensuring that technology supplements rather than replaces traditional teaching methods is crucial. A balanced approach that combines digital tools with effective pedagogy is critical to maximizing the potential of technology in mathematics education. In conclusion, integrating technology in education, particularly mathematics instruction, offers promising avenues for enhancing teaching and learning experiences.

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8. Future Work

"Digital technologies" encompass a wide range of possibilities, from artificial intelligence and blockchain to virtual reality and quantum computing. Future work in this field could include developing these technologies, exploring their applications across education, and addressing ethical and societal implications.

9. References and Sources

Means, B., Toyama, Y., Murphy, R., Bakia, M., & Jones, K. (2009). Evaluation of evidence-based practices in online learning: A meta-analysis and review of online learning studies. Project Report. Centre for Learning Technology.
From: -
http://repository.alt.ac.uk/629

Anderson, T., & Dron, J. (2011). Three generations of distance education pedagogy. The International Review of Research in Open and Distributed Learning, 12(3), 80-97.
From: -
https://www.erudit.org/en/journals/irrodl/2011-v12-n3-irrodl05132/1067616ar/

Johnson, L., Adams, S., & Cummins, M. (2012). Technology Outlook for Brazilian Primary and Secondary Education 2012-2017: An NMC Horizon Project Regional Analysis. Austin, Texas: The New Media Consortium.
From: -
https://eric.ed.gov/?id=ED595171

Cowan, P. (2006). Teaching Mathematics: A Handbook for Primary and Secondary School Teachers. Routledge.
From: -
https://www.taylorfrancis.com/books/mono/10.4324/9780203416013/teaching-mathematics-pamela-cowan

Hargittai, E., & Walejko, G. (2008). The participation divide: Content creation and sharing in the digital age. Information, Communication & Society, 11(2), 239-256.
From: -
https://www.tandfonline.com/doi/abs/10.1080/13691180801946150

Estapa, A., & Nadolny, L. (2015). The effect of an augmented reality enhanced mathematics lesson on student achievement and motivation. Journal of STEM education, 16(3), 40-48
From: - https://www.learntechlib.org/p/151963/

Thurm, D., & Barzel, B. (2022). " Teaching mathematics with technology: a multidimensional analysis of teacher beliefs. Educational Studies in Mathematics, 109, 41-63.
From: -
https://link.springer.com/article/10.1007/s10649-021-10072-x

Parenti, M. A. (2013). Student perceptions of asynchronous and synchronous web based tools and perceived attainment of academic outcomes. Journal of Educational Technology, 9(4), 8-14.
From:-
https://eric.ed.gov/?id=EJ1101722

Ractham, P., & Chen, C. (2013). Promoting the use of online social technology as a case-based learning tool. Journal of Information Systems Education, 24(4), 291–298.
From: –
https://aisel.aisnet.org/jise/vol24/iss4/4/

Pretto, G., & Curró, G. (2017). An approach for doctoral students conducting context-specific review of literature in IT, ICT, and educational technology. New Review of Academic Librarianship, 23(1), 60–83.
From: –
https://www.tandfonline.com/doi/abs/10.1080/13614533.2016.1227861

Nicholas, M., McKenzie, S., & Wells, M. (2017). Using digital devices in a first year classroom: A focus on the design and use of phonics software applications. Journal of education and learning, 6 (1), 267–282.
From: –
https://dro.deakin.edu.au/articles/journal_contribution/Using_digital_devices_in_a_first_year_classroom_a_focus_on_the_design_and_use_of_phonics_software_applications/20865247/1

Bryman, A. (2015). Social Research Methods. Oxford university press.
From: –
https://books.google.com.eg/books?hl=ar&lr=&id=N2zQCgAAQBAJ&oi=fnd&pg=PP1&dq=Bryman,+A.+(2015).+Social+research+methods.+Oxford+university+press.&ots=dqJuKQI4uk&sig=JUa5KIpIRIly9Nj6vFVPiNFnUWk&redir_esc=y#v=onepage&q=Bryman%2C%20A.%20(2015).%20Social%20research%20methods.%20Oxford%20university%20press.&f=false

Norušis, M. J. (2006). SPSS 14.0 Guide to Data Analysis. Upper Saddle River, NJ: Prentice Hall.
From:–
http://sutlib2.sut.ac.th/sut_contents/H105753.pdf