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Submission date: 27-Apr-2024 04:11PM (UTC+0700)
Submission ID: 2363471131
File name: 6._JESTEC_SITI_MARYAM_ROHIMAH_Final_paper_after_revisi.docx (346.88K)
Word count: 3076
Character count: 19026

Journal of Engineering Science and Technology
Vol. XX, No. Y (Year) PPP - QQQ

TECHNOLOGY EXPLORATION OF AUGMENTED REALITY MATHCITYMAP TO INCREASE MATHEMATICAL PROFICIENCY

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Abstract

The aim of this study was to investigate the impact of integrating the discovery learning model with MathCityMap (MCM) media on enhancing students' mathematical proficiency, particularly in the areas of surface area and volume. Employing a quasi-experimental design with a pretest-posttest framework, this research evaluated the effectiveness of these innovative teaching tools across four sessions, including an initial assessment of students' understanding, two instructional sessions utilizing Math City Maps, and a concluding posttest to measure learning outcomes. Data analysis through SPSS revealed statistically significant improvements in students' mathematical proficiency. The findings validate the effectiveness of combining discovery learning with MathCityMap media in improving mathematical understanding and skills, underscoring the significance of innovative teaching and technology in education. This study suggests that a deeper conceptual understanding, alongside accommodating diverse learning styles through the use of technology-enhanced tools, practical applications, and differentiated instruction, can significantly enhance the learning experience. Recommendations for educators include the adoption of such tools and strategies to foster an adaptive, engaging, and concept-focused educational environment, emphasizing the need for further research into the diverse impacts of instructional methods and factors influencing mathematical learning.

Keywords: Augmented reality, Mathcitymap, Mathematical Proficiency.

1. Introduction

MathCityMap (MCM) is an innovative educational initiative that leverages mobile technology to enrich mathematics instruction by extending learning beyond conventional classroom environments. Through the establishment of math trails, which are outdoor routes where learners participate in mathematical activities facilitated by the MathCityMap application, students can actively engage with mathematical concepts [1]. This method incorporates augmented reality elements to offer students a distinctive and interactive educational encounter [2]. The utilization of digital resources such as MathCityMap aids in corroborating outdoor modeling outcomes and amplifying outdoor mathematics education [3].

Studies have shown that MathCityMap is successful in boosting students' problem-solving abilities in mathematics [4]. Its application has been adopted across different educational institutions, ranging from primary to high schools, to enhance academic achievements in geometry and other mathematical topics [5]. Apart from offering clues and verifying solutions, the app fosters self-reliant and cooperative learning approaches among students [6].

MathCityMap serves as a pivotal tool in inspiring students to engage with mathematics in practical contexts, thereby fostering the development of critical thinking abilities [7]. Through the provision of customized tasks and exercises that align with students' immediate environment, educators can establish captivating learning opportunities that connect theoretical concepts with real-world scenarios [8]. Furthermore, the application has found utility in programs designed for teacher development, facilitating the shift toward hybrid learning settings and enriching classroom practices [9].

MathCityMap, a mobile technology-supported application, visually represents mathematical concepts to enhance students' problem-solving skills [4]. Widely utilized in elementary schools, particularly for geometry instruction, it aims to enhance educational outcomes [5]. By merging math trails with mobile technology, the app offers a distinctive approach to outdoor math education [1]. Through providing hints and verifying responses, MathCityMap encourages interactive and collaborative learning, fostering student engagement. Moreover, it is acknowledged as a beneficial tool in teacher training programs for transitioning to hybrid learning environments and enhancing classroom practices. Through the amalgamation of technology, outdoor exploration, and gamification, MathCityMap enriches the learning journey, facilitating a deeper comprehension of mathematics for students.

Previous studies have explored the implementation and impact of MathCityMap in educational settings. For instance, research has focused on utilizing MathCityMap in teaching geometry in elementary schools [5]. Additionally, studies have investigated the effectiveness of MathCityMap training for teachers in a hybrid setting [9]. These studies highlight the potential of MathCityMap in enhancing mathematics learning outcomes and teacher training, emphasizing the importance of technology in improving education. However, previous studies on MathCityMap's role in teaching geometry and training teachers underscore its educational potential, yet lack exploration of its effectiveness in enhancing understanding of surface area and volume through a discovery learning model. Therefore, this study aims to investigate the impact of combining the discovery learning model with MathCityMap media on enhancing students' mathematical

proficiency, aiming to offer insights for improving teaching methods and fostering an engaging, concept-focused educational environment.

2. Method

The research methodology employed a quasi-experimental design with a pretest-posttest framework to evaluate the effectiveness of the discovery learning model and Math City Maps in enhancing students' understanding of surface area and volume concepts [10-12]. The study consisted of four sessions: an initial pretest, two instructional sessions utilizing MathCityMaps, and a posttest to measure learning outcomes [13-15]. The data analysis was conducted using SPSS to identify statistically significant improvements in students' mathematical proficiency [16-18].

3. Results and Discussion

The technological exploration of augmented reality MathCityMap (MCM) begins with creating a trail which is the point of the problem that will be solved by students. The steps for creating a trail in MCM are described in Table 1.

Table 1. Steps for creating a trail in MathCityMap.

No.	Steps	Description
1.	Download the MCM platform application on your smartphone	The MCM application can be downloaded on Google Play or the App Store
2.	Take photos of objects that will become problems for students	Activate map location when photographing objects
3.	Make questions related to the objects that have been photographed	The questions are in the form of story problems related to material in the mathematical concepts
4.	Create clues to answer questions	The maximum number of instructions that can be given is 3 instructions
5.	Measure objects to determine solutions	Measurements are carried out as a process in creating solutions
6.	Create a solution	Solutions are written in numerical form
7.	Create tasks from predefined objects	One task consists of one predetermined photo
8.	Create a trail that will be tested on students	Combines all tasks that have been created

The trail created in the research, namely at SDN 066 Halimun, Bandung city, West Java, Indonesia, consists of four tasks related to spatial material and the points on the trail can be seen in Figure 1. The first task is to calculate the surface area of the plant pot between the sides. the outer and inner sides which are in front of the IC class. The second task is to determine the costs needed to paint the block-shaped prayer room cupboard. The third task is to calculate the volume of the six bookshelf boxes in the prayer room. The fourth task is to determine the difference in volume of the trophy box in the school corridor.

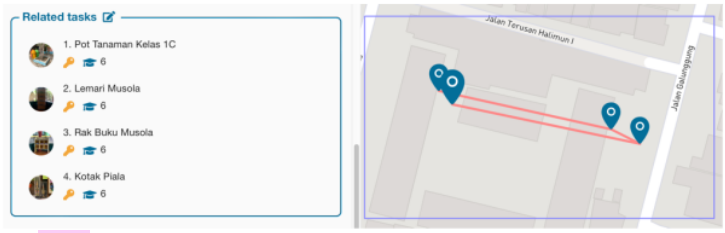
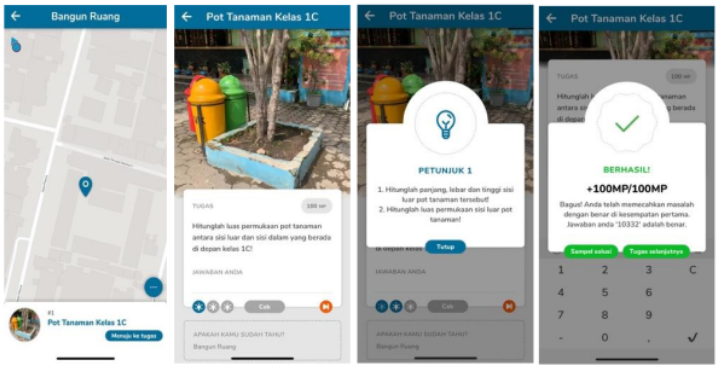


Fig. 1. Space building trail at SDN 066 Halimun, Bandung, Indonesia

Furthermore, the trail can be accessed by the student's MCM account by entering the trail code, namely 0518350. Students will be directed to each task with the help of maps (Figure 2a). Students must arrive at the map point for each assignment to work on the questions on that assignment (Figure 2b). After the student reaches the point where the object in the task is located, the student can answer the question by first clicking on the clue (Figure 2c). Students take measurements and write answers in the solution column provided in the application (Figure 2d). If students answer with the correct solution they will be directed to the next task. However, if the student answers incorrectly then the student must rewrite the answer until they find the correct answer.



(a) (b) (c) (d)

Fig. 2. The process of completing one of the tasks on MathCityMap

This study utilized the discovery learning model and MathCityMap media to teach the surface area and volume of cubes and blocks, with students initially assessed through a pretest [19]. The activities included greetings, prayers, singing the national compulsory song, and grouping based on cognitive ability. Previous research has shown that the discovery learning model enhances students' mathematical reasoning and understanding by allowing them to independently explore and manipulate concrete objects to build knowledge [19-21]. Additionally, the use of discovery learning has been linked to improved mathematical communication skills and problem-solving abilities [22-23]. These findings support the effectiveness of incorporating discovery learning and technology like MathCityMap in mathematics education.

The study observed varying levels of students' ability to use surface area and volume formulas for cubes and blocks. While some students provided correct answers, they struggled with including units in their responses. The volume formula activities mirrored those of a previous meeting, with additional emphasis on volume concepts. Although most students could use the formula correctly, some faced challenges in providing definitive answers. Previous research has shown that students' proficiency in mathematics can be influenced by factors such as language proficiency, motor skills, and the use of technology in teaching methods [2, 24, 25]. These studies emphasize the importance of considering various aspects that can impact students' mathematical abilities and the effectiveness of instructional approaches.

The posttest assessed students' progress in comprehending surface area and volume concepts, highlighting difficulties in calculating painting costs for a cupboard and offering comprehensive solutions [26-27]. Studies have indicated that students' conceptualization of geometric principles may differ depending on their mathematical skills [27]. Moreover, the integration of technology such as robots in math education has been proven to boost students' ability to represent concepts effectively [28]. These findings emphasize the significance of addressing students' diverse learning requirements and the influence of instructional approaches on their mathematical comprehension.

Based on Table 2, with $\alpha = 5\%$, it results that the value of Sig. = 0.000 < α = 0.05 then H_0 is rejected and H_1 is accepted, meaning that there is a difference in the average mathematical proficiency of students in mathematics learning before and after using mathcitymap media.

Table 2. Paired sample t-test.

Paired t-test	Sig. (2-tailed)	Assumption
Pretest-Postest	0.000	There is a significant mean difference

In addition, the improvement of pretest and postest can be seen in Table 3. It can be seen the difference in the average pretest and posttest mathematical proficiency scores of students in learning mathematics using mathcitymap media. The increase in students' mathematical proficiency can be seen from the results of N-gain results of 0.62 and is included in the medium category.

Table 3. Mean of score and n-gain

Mean score	Pretest	Postest
	38	76
Mean of N-gain	0,62	
N-gain Category	Moderate	

The statistical analysis conducted indicates a significant difference in students' mathematical proficiency before and after using mathcitymap media, as the obtained significance value of 0.000 is less than the set alpha value of 0.05, leading to the rejection of the null hypothesis and acceptance of the alternative hypothesis [29]. This finding aligns with research showing that there are statistically

significant differences in math proficiency attributed to academic achievement [30]. Additionally, studies have highlighted the importance of teaching practices in enhancing students' mathematical proficiency [31]. The relationship between English reading proficiency and academic achievement has also been noted as a predictor of success in science and mathematics studies [32].

Differing perspectives on the impact of learning media on mathematical proficiency are evident in the literature. highlighted the importance of matching learning media with students' characteristics [33], while evaluating professional development in mathematics education using various approaches, emphasizing the complexity of assessing educational interventions [34]. These studies underscore the need for a comprehensive understanding of the effectiveness of mathcitymap media beyond just N-gain outcomes to determine its true impact on students' mathematical proficiency.

4. Conclusions

This study validates the effectiveness of combining the discovery learning model with MathCityMap media to enhance mathematical proficiency in surface area and volume concepts, with significant improvements observed through pretest and posttest analyses. These findings underscore the importance of innovative teaching and technology in mathematics education, promoting a deeper conceptual understanding and accommodating diverse learning styles. Recommendations include wider use of technology-enhanced tools, practical applications, conceptual focus, differentiated instruction, teacher development, and further research on diverse instructional impacts and factors affecting mathematical learning. This approach not only boosts mathematical skills but also enriches the learning experience, highlighting the need for adaptive and engaging education strategies.

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