The Role of MathCityMap in Improving Mathematical Problem-Solving Skill

Santi Rahayu[1], Akhmad Jazuli[2], Nurrina Dyahpuspita[3]
{rahayusanthi90@gmail.com[1] , akhmadjazuli.ump@gmail.com[2], nurrinade@gmail.com[3]}

SD Negeri Karangsalam, Baturraden, Banyumas[1], Postgraduate, Universitas Muhammadiyah Purwokerto[2], SD Negeri 1 Bancarkembar, Purwokerto[3]

Abstract. This study aimed to analyze the mathematics learning process using MathCityMap application to improve math problem-solving skills. The study was conducted in a quasi-experiment method with a post-test only control design. The data population of the study is elementary school students in Karangsalam, Baturraden subdistrict. The random cluster selection technique was used to determine the sample group data of this study. Data analysis performed using an independent t-test formula. The results show a significance value of 0.000 (less than 0.05). Based on the observations of student's problem-solving skill, the scores for the indicator of problem understanding were 92.86, problem planning 91.07, problem solving 82.14, and re-checking 80.95. The study concluded that MathCityMap has a positive impact on elementary school student's math problem-solving skills, particularly on the indicator of understanding the problem. It is recommended for elementary school teachers use the MathCityMap in teaching mathematics to improve student's math problem-solving skill.

Keywords: mathematics, MathCityMap, mathematical problem-solving skills

1 Introduction

Mathematics is one of the lessons whose material is abstract, and feared by the students in Indonesia and several countries around the world. According to a study conducted by Kollosche in 2018 it showed that most groups of students had negative attitudes toward mathematics, which was reflected in statements that they were disappointed, stressed, discouraged, depressed, anxious, tired, and had headaches [1]. Negative attitudes will get worse if mathematics learning activities are often carried out in the classroom and only based on textbooks. There are many curricular topics in elementary school that are closely related to the environment and student's daily lives. Therefore, teachers should continue to try to integrate activities into a learning process that encourage students to explore mathematics in their surroundings in order to understand the world around them better [2].

As a compulsory subject for elementary school students, mathematics should be able to teach problem-solving skills, critical thinking, logical and creative thinking for facing all the challenges of the current era of globalization [3]. Therefore, The ability to solve math problems is an important part of learning math from elementary through middle school. Based on The National Council of Teachers of Mathematics (NCTM), the basic skill students must have is the ability to solve problems [4]. In addition, mathematical problem-solving skills are intended to include the ability to exploration, assume, and reason logically on non-routine problems,

ICONESS 2023, July 22-23, Purwokerto, Indonesia

DOI 10.4108/eai.22-7-2023.2335099

communicate about and through mathematics, and connect ideas within mathematics or between mathematics and other intellectual activities. [5].

Regulation of Minister of Education and Culture number 21 of 2016 on Content Standards for K-12 Education states that one of the skills that must be acquired when learning mathematics is the ability to show a logical, critical, analytical, creative, careful and meticulous attitude, be responsible, responsive, and not give up easily in solving problems [6]. This means that every student must be able to solve math problems. The ability to solve math problems is very important for students, not only to facilitate the learning of math, but also in the study of other subjects and in daily life. [7]. Awareness of the occurrence of various problems in daily life makes problem-solving skills an important thing to pay attention to in the learning process [8]. Therefore mathematical problem-solving abilities need to be trained in mathematics learning in elementary schools, for example, through presenting contextual and non-routine problems for students.

In creating a learning process that can develop problem-solving abilities, it is inseparable from the material to be studied and how to create and process the material so that students can be actively involved in utilizing their minds to form concepts in the problem solving process [9]. It confirms that it is important for teachers to be creative in designing mathematics learning activities and non-routine mathematics problems in order to train the student‘s mathematical problem solving skills. Many experts have studied problem solving, one of which is George Polya, a mathematician who argues that problem solving is an attempt to find a way out of trouble in order to achieve a goal that cannot be achieved immediately [10]. Furthermore, Polya states that solving problems is a practical skill exercise by observing and imitating people who are solving problems [11].

In general, according to Polya, the problem-solving steps are divided into 4 steps as follows: (1) understanding the problem, in this aspect, students need to establish what is known, what exists, how many, the dependencies and associated values, and what they are looking for. (2) make plans, at this stage students identify the operations involved to solve a given problem. (3) carrying out plans, students apply what has been planned previously, then interpret the information provided into mathematical form, and carry out plans during the process and calculations that take place. (4) Re-checking, at this stage, the thing to pay attention to is re-checking important information, checking all the calculations that have been involved, considering whether the solution is logical, looking at other alternatives, and reading the questions again and asking yourself whether the questions are correct -completely missed [12].

Based on the observation, math problem-solving skills of elementary school students in Karangsalam area were still low. Still there’re many students are not used to solving math problems or non routine problems. This is due to the lack of teachers presenting contextual problems in learning mathematics. There are many students experienced the difficulties in mathematics, especially in the area and perimeter of squares and rectangles.

One way that can be done to create contextual mathematics learning is to use the MathCityMap application. MathCityMap is a mobile app project developed by the MATIS I team at Goethe University Frankfurt [13] which aims to motivate students to solve real-world problems using mathematical modeling ideas outside the classroom [14]. The MathCityMap application provides an opportunity for teachers, students, and the general public of all ages to gain experience in their environment in a new mathematical perspective.

The MathCityMap project combines the development of smartphone technology with the didactic idea of a math trail [1]. In other words, MathCityMap is an app that supports GPS-based math trail activities. In this application, it is not only used to find problem areas, but also provides detailed information about problems, tools to use and even feedback on how to fix the

problem and troubleshooting help [15]. Thus, the student's mathematical problem-solving skills can be trained in a more enjoyable way.

According to Shoaf, Pollack and Schneider (2004) Math Trail is a math exploration where one can discuss and solve math problems [16]. Dudley Blaine started the development of the basic math trail concept in 1985 in the city of Melbourne, Australia [17]. The Math trail is a great way for students to see the world through the lens of math. Math trail provides opportunities for students to solve various mathematical problems related to shapes, structures and numbers in the surrounding environment [18]. In other words, the MathCityMap application with its math trail activities is able to help students sharpen their minds about objects or objects they encounter in their surroundings. All shapes, surfaces, slopes, volumes, geometric figures, and many other objects in the surrounding environment can be linked to arithmetic problems that help students gain mathematical experience.

The MathCityMap application contains thousands of math trails from around the world that students can use even without an active internet connection. The use of MathCityMap is able to help authenticate mathematics learning, and create fun, interesting and challenging learning because it connects mathematics with the environment around students. The MathCityMap project has digitized the idea of a math trail with a smartphone app for students to guide math trails and a web portal for teachers to create math trails [19]. Teachers can create, or edit math trail assignments and routes through the web portal. In addition, teachers can also view existing routes and download them as pdf files or use existing assignments and link them into a route of their own.

In some earlier research, MathCityMap is used as teaching and learning media on both of junior high school and senior/vocational high school students. The MathCityMap application supports teachers to facilitate contextual outdoor mathematics teaching and learning process. Through MathCityMap, students can improve their experience and performance in mathematics. The research conducted by Cahyono & Ludwig (2018) concluded that learning mathematics supported by the use of the MathCityMap application can make students learn to solve mathematical problems. In another study conducted by Rosanti and Harahap (2022) reported that student's mathematical problem solving skill were increased through outdoor learning process with MathCityMap.

In this study, MathCityMap is used as learning media for elementary school students. This MathCityMap trail is designed around the school environment in Karangsalam village, Baturraden. It comes with contextual tasks about area and perimeter of squares and rectangles that have to be solved by students.

The contribution this paper can give is by the use of MathCityMap that integrates digital technology with math trail concept can support teaching and learning process in elementary school students. The other contribution is teachers can facilitate contextual and meaningful mathematical outdoor activity for elementary school students so that they can improve their problem-solving skill.

2 Research Methods

The method that used in this study is quasi-experiment with a post-test only control design. The independent variable in this study is MathCityMap while the dependent variable is the math problem solving skill of the students in elementary school in Karangsalam, Baturraden District.

The data population of this study involved 164 elementary school students from the Karangsalam area in the 2022/2023 school year. The data sample was determined by the cluster sampling technique, 14 students were selected as experimental class and 14 students as control class. The data collection instrument is a mathematical test of problem-solving skills which is validated by experts. The data analysis technique used is the two-independent-sample t-test to analyze the effect of MathCityMap on the ability to solve mathematical problems.

3 Results and Discussion

The research was conducted in elementary schools in Karangsalam, with subject matter area and perimeter of square and rectangular shapes. The implementation of learning in the experimental class was carried out by using MathCityMap on the area and perimeter of square and rectangular shapes. Whereas in the control class, the researcher carried out conventional mathematics learning without using a MathCityMap.

The problem-solving indicator used in this research is an indicator of problem-solving skill based on the Polya method. Problem solving means finding a way out of difficulties and obstacles to achieve goals that cannot be achieved all at once [20]. There are 4 indicators of Polya problem-solving including understanding the problem, make plans, carrying-out problem-solving, and re-checking.

The first step of the research is the design of the trail on the MathCityMap portal. The trail contains some activities related to the math trail. The activity materials focus both on the area and perimeter of square and rectangular shapes arranged in a grid to measure student's ability to solve math problems. Figure 1 shows the mathematical trail view in the MathCityMap web portal.

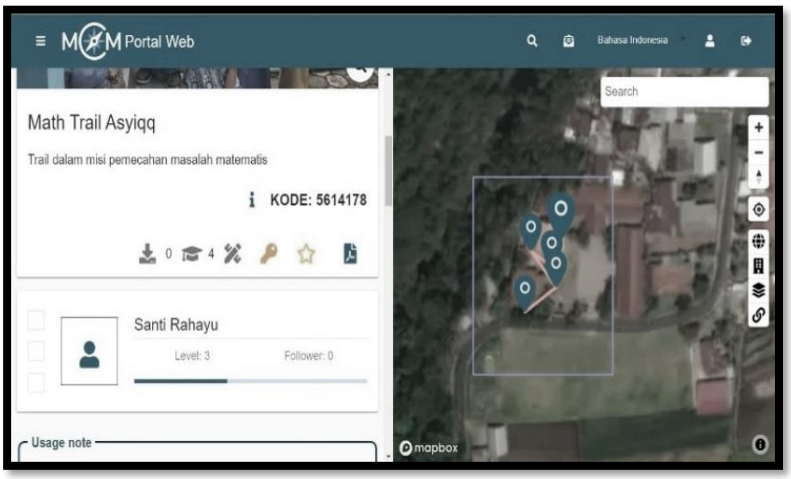

Fig. 1. Trail view on the MathCityMap web portal

The next step is to test the validity and reliability of the trail created on the MathCityMap portal. A validity test is performed to verify that a research instrument is valid. The validity of the tool was tested using Pearson's product-moment correlation analysis. Based on the calculations, it can be concluded that all instrumental elements related to mathematical problem-

solving skill in this study are valid. This is indicated by the product-moment correlation coefficient according to Pearson, which was in the high category with a significance value of less than 0.05.

The next step is reliability test to see if the research instrument can provide consistent results when tested multiple times on the same topic. The reliability test used Cronbach's alpha formula, which was created with SPSS Statistics 26 software. The value of the reliability coefficient obtained was 0.856, so it can be said that the mathematical problem-solving instrument is valid and suitable for the collection of this research data.

Furthermore, at the data collection stage, the experimental class consisting of 14 students learned mathematics using MathCityMap. Students access the trail through the MathCityMap application on their own devices by entering the code distributed by the teacher. The trail carried out by the experimental class students was around the school environment with 5 assignments for an hour. Students were doing tasks along the way and note steps to solve the problem according to the polya method. In implementing the trail on the MathCityMap, students are free to start the trail from any task stop, see figure 2.

Fig. 2. Students are observing the place that is at one of the assignment stops

Based on the data collected during the study, it can be said that the student's math problem-solving skill was changed compared to the control class. The results of the t-test calculation for two independent samples show a significance value of 0.000 (less than 0.05). This suggests that there are significant differences in the mathematical problem-solving skills of students in the experimental and control classes. At the mean of the experimental class, which is 86.36, it is higher than the mean of the control class, which is only 74.21. From this it can be concluded that the math learning supported by MathCityMap is more effective than traditional math learning. Below is Table 3.1.

Table 3.1. The independent two sample t test

	Levene's Test for Equality of Variances								
	F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed	1.175	.288	4.608	26	.000	12.143	2.635	6.727	17.559
Equal variances not assumed			4.608	23.729	.000	12.143	2.635	6.701	17.584

Mathematics learning assisted by MathCityMap guides students in experiencing mathematics in their surrounding environment. The tasks in the trail are related to objects and buildings around the school, which are square and rectangular in shape. By direct observation of objects around students can sharpen their minds to solve existing problems. This is important because when students learn math in separated way from real-world experiences, they quickly forget it and are unable to apply the math [21]. The following is a photo of students' work in solving mathematical problems, see figure 3.

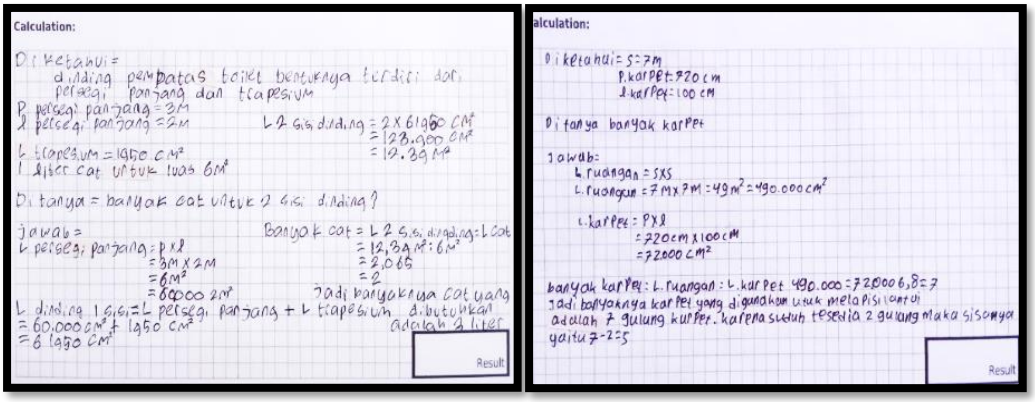

Fig. 3. Examples of student work in solving mathematical problems

The increasing in student's mathematical problem-solving skill happens because MathCityMap allows students to explore mathematical problems in their surrounding environment by following the trails that have been made previously. Each task on the trail is completed with its instructions and tools that can assist students in completing the trail. In this exploration activity, students can formulate, discuss, and solve interesting math problems at each point of exploration [22]. The following shows a graph of the recapitulation score for each of student's mathematical problem-solving skill indicator, see Figure 4.

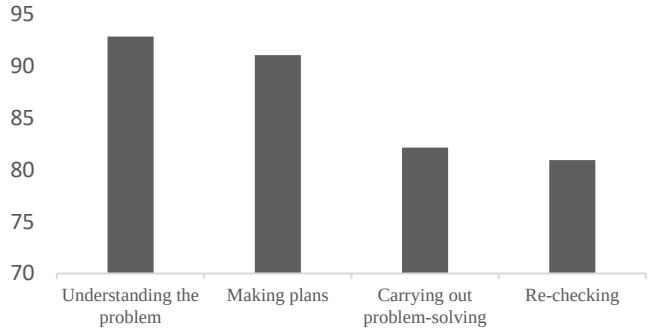

Fig. 4. Graph of indicator achievement score of math problem-solving skill

Based on the observations of student's problem-solving skill, the mean scores for the indicators of problem understanding were 92.86, problem planning 91.07, problem solving 82.14, and re-checking 80.95. It can be seen that the highest average score is on the indicator of problem understanding.

The results of this study are consistent with research by Adi Nur Cahyono and Matthias Ludwig (2018) that found the use of MathCityMap technology in mathematics learning has a positive impact on student's skill to solve math problems. It shown in the mean of pretest and post-test scores of the experimental class, which are higher than those of the control class [23]. The differences were in the subject matter of the study and also the research approach that is used. This study used quantitative approach with experimental method and elementary school students as the research subject. The previous studies used a qualitative approach and the research subjects were middle school students from the Semarang area.

This research is also in line with the previous research by Fani Rosanti and Amin Harahap (2022) who found that the MathCityMap approach in learning mathematics influences the mathematical problem-solving skill of vocational students. It shown in the increasing ability to solve mathematical problems among the students in the experimental class, who use MathCityMap better than the control class [24].

In general, the difference between previous studies and this study are the use of MathCityMap that is able to improve the problem-solving skill, not only on junior high school/ senior high school/ vocational students but also elementary school students. Further researchs are needed in order to improve the potential of mobile technology with MathCityMap for supporting contextual mathematics learning of elementary school students. This is important to increase the student's performance in math, especially math problem-solving skill.

4 Conclusion

Based on the analyzed data, it can be concluded that MathCityMap has a positive impact on the math problem-solving skill of elementary school students in Karangsalam region, especially on the problem understanding indicator. Research hypothesis are analyzed with two independent t-sample tests. It revealed that there was a significant effect between the experimental class that received MathCityMap-supported math learning and the control class that did not receive the MathCityMap-supported math learning treatment.

Based on the study result, the researchers suggest using MathCityMap to learn mathematics. MathCityMap helps students develop math problem-solving skills by experiencing math in their local environment in a fun, engaging, and challenging way. More research is required for development and implementation across different sites and research topics.

References

[1] Gurjanow, I., Zender, J., & Ludwig, M. (2020). MathCityMap – Popularizing Mathematics Around the Globe with Maths Trails and Smartphone. In *Research on Outdoor STEM Education in The Digital Age. Proceedings Of the ROSETA Online Conference in June 2020* (Pp. 103–110). WTM-Verlag. Https://Doi.Org/10.37626/Ga9783959871440.0.13.

[2] Lavicza, Z., Haas, B., & Kreis, Y. (2020). Discovering Everyday Mathematical Situations Outside the Classroom with MathCityMap and Geogebra 3D. In *Research on Outdoor STEM Education in The Digital Age. Proceedings Of the ROSETA Online Conference in June 2020* (Pp. 23–30). WTM-Verlag. Https://Doi.Org/10.37626/Ga9783959871440.0.03

[3] Firdaus, Aulia, Lulu Choirun Nisa, And Nadhifah Nadhifah. "Kemampuan Berpikir Kritis Siswa Pada Materi Barisan Dan Deret Berdasarkan Gaya Berpikir." *Kreano, Jurnal Matematika Kreatif-Inovatif* 10.1 (2019): 68-77.

[4] August, F. M., & Ramlah, R. (2021). Analisis Kemampuan Pemecahan Masalah Matematis Siswa Berdasarkan Prosedur Polya. *Jipmat*, *6*(1), 43-59.

[5] Rahmawati, P., & Apsari, N. (2019). Analisis Kemampuan Pemecahan Masalah Matematika Siswa Perbatasan Entikong (Indonesia-Malaysia). *Jurnal Pendidikan Dasar*, *7*(1), 1–14. Https://Doi.Org/10.46368/Jpd.V7i1.153

[6] Permendikbud. 2016. Permendikbud No 21 Tahun 2016 Tentang Standar Isi Pendidikan Dasar Dan Menengah, Jakarta:Permendikbud.

[7] Noviantii, E., Yuanita, P., & Maimunah, M. (2020). Pembelajaran Berbasis Masalah Dalam Meningkatkan Kemampuan Pemecahan Masalah Matematika. *Journal Of Education and Learning Mathematics Research (Jelmar)*, *1*(1), 65-73.

[8] Özreçberoğlu, N., & Çağanağa, Ç. K. (2018). Making It Count: Strategies for Improving Problem-Solving Skills in Mathematics for Students and Teachers' Classroom Management. Eurasia Journal of Mathematics, Science and Technology Education, 14(4), 1253–1261. Https://Doi.Org/10.29333/Ejmste/82536

[9] Mulyati, T. (2016). Kemampuan Pemecahan Masalah Matematis Siswa Sekolah Dasar. *Eduhumaniora| Jurnal Pendidikan Dasar Kampus Cibiru*, *3*(2).

[10] Purba, D., Nasution, Z., & Lubis, R. (2021). Pemikiran George Polya Tentang Pemecahan Masalah. *Jurnal Mathedu (Mathematic Education Journal)*, *4*(1), 25-31.

[11] Christina, E. N. (2021). Analisis Kemampuan Pemecahan Masalah Tahapan Polya Dalam Menyelesaikan Persamaan Dan Pertidaksamaan Linear Satu Variabel. *JPMI (Jurnal Pembelajaran Matematika Inovatif)*, *4*(2), 405-424.

[12] Yuwono, T., Supanggih, M., & Ferdiani, R. D. (2018). Analisis Kemampuan Pemecahan Masalah Matematika Dalam Menyelesaikan Soal Cerita Berdasarkan Prosedur Polya. *Jurnal Tadris Matematika*, *1*(2), 137-144.

[13] Hakim, A. R., Asikin, M., & Cahyono, A. N. (2019). Aktifitas Math Trail Berbantuan Aplikasi Mobile Untuk Meningkatkan Kemampuan Pemecahan Masalah Matematika. In *Prosiding Seminar Nasional Pascasarjana (PROSNAMPAS)* (Vol. 2, No. 1, Pp. 109-114).

[14] Ariosto, A., Ferrarello, D., Mammana, M. F., & Taranto, E. (2021). Math City Map: Provide and Share Outdoor Modelling Tasks. An Experience with Children. *Aapp Atti Della Accademia Peloritana Dei Pericolanti, Classe Di Scienze Fisiche, Matematiche E Naturali*, *99*. Https://Doi.Org/10.1478/Aapp.99s1a13

[15] Ludwig, M., & Jablonski, S. (2019). Doing Math Modelling Outdoors- A Special Math Class Activity Hakim, A. R., Asikin, M., Cahyono, A. N. 114 Designed with MathCityMap. 5th International Conference on Higher Education Advances (Head'19), 1–8. Https://Doi.Org/10.4995/HEAD19.2019.9583

[16] Ludwig, M., Jablonski, S., Caldeira, A., & Moura, A. (2020). Research on Outdoor STEM Education in The Digital Age – Background and Introduction. In *Research on Outdoor STEM Education in The Digital Age. Proceedings Of the ROSETA Online Conference in June 2020* (Pp. 5–9). WTM-Verlag. Https://Doi.Org/10.37626/Ga9783959871440.0.01

[17] Edi, T. M., & Nayazik, A. (2019). Penerapan "Rute Emas" Sebagai Salah Satu Desain "Math Trail" untuk Meningkatkan Kemampuan Pemecahan Masalah Matematika. Journal Of Medives : Journal Of Mathematics Education IKIP Veteran Semarang, 3(2), 273–292.

[18] Chen, H.-W. (2013). Applying Social Networking And Math Trails To Third Grade Mathematic Class. *International Journal Of Innovation, Management And Technology*. Https://Doi.Org/10.7763/Ijimt.2013.V4.422

[19] Baumann-Wehner, M., Gurjanow, I., Milicic, G., & Ludwig, M. 69 (2020). Analysis Of Studentteacher Chat Communication During Outdoor Learning Within The MCM Digital Classroom. Research On Outdoor STEM Education In The Digital Age, 63.

[20] Chapman, O. (2015). Mathematics Teachers' Knowledge for Teaching Problem Solving. *LUMAT: International Journal on Math, Science and Technology Education, 3*(1), 19-36.

[21] Khusna, H., & Ulfah, S. (2021). Kemampuan Pemodelan Matematis Dalam Menyelesaikan Soal Matematika Kontekstual. *Mosharafa: Jurnal Pendidikan Matematika*, *10*(1), 153-164.

[22] Cahyono, A. N., Sukestiyarno, Y. L., Asikin, M., Ahsan, M. G. K., & Ludwig, M. (2020). Learning Mathematical Modelling with Augmented Reality Mobile Math Trails Program: How Can It Work? *Journal On Mathematics Education*, *11*(2), 181-192.

[23] Cahyono, A. N., & Ludwig, M. (2018). Teaching And Learning Mathematics Around the City Supported by The Use of Digital Technology. *Eurasia Journal of Mathematics, Science and Technology Education*, *15*(1), Em1654.

[24] Rosanti, F. (2022). Pengaruh Outdoor Learningmath Dengan Pendekatan Math City Mapterhadap Kemampuan Pemecahan Masalah Pada Kelas XII SMK YAPIM Pinang Awan. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, *6*(2), 1387-1402.