



## Implementation of the MathCityMap Application to Increase Students' Mathematical Problem-Solving Skills: A Systematic Literature Review

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### Abstract

The growing research on the use of the MathCityMap application in mathematics education necessitates a summary of its finding. MathCityMap is an application supported by the use of mobile technology to provide real visualization of mathematics concepts to students in order to improve students' mathematical problem-solving skills. This study aims to provide an overview of the application of the MathCityMap application to increase students' mathematical problem-solving skills. A systematic literature review (SLR) was used to synthesize research relevant to the objectives of this study. Research steps using Systematic Literature Review are formulating research questions, applying inclusion criteria, looking for studies related to the topic, selecting some studies to be the main study, analyzing data from the studies' results, and compiling them into research reports. Through Publish or Perish, Google Scholar, *Directory of Open Access Journals* (DOAJ), and Education Resources Information Centre (ERIC) it was obtained that 16 primary studies were published from 2013 to 2023 that fitted the inclusion criteria for further analysis. The results of this study conclude that the MathCityMap application is effective in improving students' mathematical problem-solving skills. The integration of the MathCityMap application with learning models can be used by teachers to help students complete various project-based assignments and improve mathematics problems. The results of this study help teachers and researchers to understand how the MathCityMap application can be applied in learning mathematics to improve students' mathematical problem-solving skills.

**Keywords:** MathCityMap; Problem-Solving Skills; Systematic Literature Review

### Abstrak

Penelitian tentang implementasi aplikasi *MathCityMap* dalam pembelajaran matematika semakin banyak dilakukan, sehingga perlu adanya penelitian yang merangkum hasil temuan penelitian aplikasi *MathCityMap* dalam pembelajaran Matematika. *MathCityMap* adalah aplikasi yang didukung dengan pemanfaatan teknologi mobile untuk memberikan visualisasi konsep matematika secara nyata

kepada siswa guna meningkatkan kemampuan pemecahan masalah matematis siswa. Penelitian ini bertujuan untuk memberikan gambaran penerapan aplikasi *MathCityMap* terhadap kemampuan pemecahan masalah matematis siswa. Metode penelitian yang digunakan adalah *Systematic Literature Review* (SLR). Langkah-langkah penelitian dengan menggunakan *Systematic Literature Review* adalah merumuskan pertanyaan penelitian, menerapkan kriteria inklusi, mencari kajian yang berkaitan dengan topik, memilih beberapa kajian untuk menjadi kajian utama, menganalisis data dari hasil kajian, dan menyusunnya menjadi laporan penelitian. Sintesis studi yang relevan dengan tujuan penelitian ini dilakukan menggunakan *Publish or Perish*, *Google Scholar*, *Directory of Open Access Journals* (DOAJ), dan *Education Resources Information Centre* (ERIC) dimana diperoleh 16 studi primer yang diterbitkan dari tahun 2013 hingga tahun 2023. Hasil penelitian memberikan informasi bahwa aplikasi *MathCityMap* efektif untuk meningkatkan kemampuan pemecahan masalah matematis siswa. Integrasi *MathCityMap* dengan model pembelajaran dapat digunakan guru untuk membantu siswa menyelesaikan berbagai tugas berbasis proyek dan memecahkan masalah. Hasil penelitian ini membantu guru dan peneliti untuk memahami bagaimana aplikasi *MathCityMap* dapat diterapkan dalam pembelajaran matematika untuk meningkatkan kemampuan pemecahan masalah matematis siswa.

**Kata Kunci:** *MathCityMap*; Pemecahan Masalah Matematis; *Systematic Literature Review*

## Introduction

Mathematics is one of subjects which is related directly to human life. On educational levels, mathematics helps students to develop to be able to contribute in life, including personal life or social life. NCTM (2000) told that five criteria of mathematics competency should be had by students. They are problem solving, connection, reasoning communication, and representation. Based on that, problem-solving skills are an important thing for students in learning mathematics. Problem-solving skills are seen as a process to describe the combination of some rules that can be applied to face certain situations (Rio & Pujiastuti, 2020; Wena, 2009)

Liljedahl et al. (2016) stated that problem-solving is an important aspect of math, mathematics teaching, and mathematics learning. Problem-solving skills involve high and lower-order thinking skills (Erny et al., 2017; Widodo & Kartikasari, 2017). With problem-solving skills, students can improve their thinking ability, procedure application, and deeper conceptual understanding (Das & Das, 2013; Siagian et al., 2019; Weaver et al., 2018). Niskayuna (1993) classified problem-solving into three parts. They are (1) problem-solving as an approach; (2) problem-solving as a goal, related to the statement about goals of mathematics teaching and why mathematics is taught; and (3) problem-solving as a process, an activity that prioritizes procedure, strategy, or method, that will be done by students to solve a problem so that they find an answer.

Building upon PISA's result in 2018, Indonesia was in the lowest 7<sup>th</sup> place, which is 73<sup>rd</sup> out of 79 countries, in terms of mathematical ability (Kemdikbud, 2019). The difficulties experienced by students in solving math problems in the PISA model are because students still do not understand the questions, especially when working on real-world problems. In working on word problems students tend to be in a hurry and are not careful when answering so that it causes them to be wrong in answering questions. It is supported by Bidasari (2017) who suggests that there are students who have difficulty solving problems and there are also students who cannot work on the questions because these students do not understand the problems in the PISA model questions. This problem must be seriously considered by the government in order to improve the quality of mathematics learning, especially students' mathematical problem-solving skills. Students with good problem-solving skills are expected to be able to build new knowledge and solve real problems in their daily life (Mawaddah & Anisah, 2015; Panda & Agarwal, n.d.; Reno et al., 2017)

The use of teaching media is expected to help students to improve their problem-solving skills. Research conducted by (Trisanti et al., 2021) at Vocational High School 1 Jombang concluded that the application of construct-based education games had a positive impact on increasing students' mathematical understanding abilities. Not only that, the use of teaching media that is integrated with learning models is also expected to help increasing students' mathematical problem-solving skills. This is in line with research conducted by (Muhammad, 2015) which concluded that the creative problem-solving learning model with *Maple 11* assisted gives a positive impact on students' mathematical problem-solving skills.

One of the teaching media that can be used by teachers to improve students' mathematical problem-solving skills is MathCityMap. MathCityMap is an application supported by the use of mobile technology to provide real visualization of mathematics concepts to students for improving students' mathematical problem-solving skills (Cahyono, 2018). The MathCityMap (MCM) project is a mathematics trail project implemented around the city which is facilitated by the use of phone application and manual guidance by teachers (A. N. Cahyono et al., 2023; A. N. Cahyono & Ludwig, 2016; Sadewo, 2023). The MathCityMap provides locations as problem points solved by the students (Ismaya et al., 2018; Lubis et al., 2021). The use of the MathCityMap application contains real problems that can trigger students to connect each mathematics concept in order to improve students' mathematical problem-solving skills.

Students often struggle with solving real-world problems due to the unstructured, complex, and diverse nature of such problems. One reason for this

difficulty is insufficient exposure and practice with real-world problem-solving contexts in the classroom, which results in students lacking the necessary problem-solving skills. The challenge for teachers in teaching problem-solving skills is providing authentic problem-solving contexts. Research conducted by (Hakim et al., 2019) concluded that math trail activities assisted by the MathCityMap application encourage students to be able to improve their mathematical problem-solving skills. The increase that occurred was based on two things, namely the use of authentic real-world questions that were carried out outside the room through math trail activities assisted by the MathCityMap application and math trail activities assisted by the MathCityMap application which were expected to be able to increase student learning motivation which would develop logic in solving mathematical problems. Research conducted by Rosanti & Harahap (2022) concluded that the application of Outdoor Learning *Math* with the approach of MathCityMap gives a positive and significant impact on students' mathematical problem-solving skills. The substantial contrast between the results of classes that received MathCityMap application-integrated outdoor learning and those that followed conventional learning methods indicates that the former approach is more effective. Students who engaged in MathCityMap-supported learning exhibited higher levels of mathematical problem-solving skills.

Based on the explanation above, the use of the MathCityMap application is expected to give the impression of fun learning to students. Teachers can use the MathCityMap application to develop students' mathematical problem-solving skills. Therefore, this Systematic Literature Review (SLR) article was used to give information to teachers about the implementation of the MathCityMap application to increase students' mathematical problem-solving skills. This study aimed to systematically describe the implementation of the MathCityMap application to increase students' mathematical problem-solving skills.

## Method

This research utilizes a systematic literature review (SLR), which is a method of reviewing groups of literature in a transparent and reproducible manner. This approach involves a rigorous process of searching, assessing the quality of literature, and synthesizing evidence, with a high degree of objectivity (Kraus, 2020; Xiao & Watson, 2019). The goal of the SLR method is to help identify journals with established structure and rules.

On the implementation of the use of the MathCityMap application, Systematic Literature Review is used to help identify, evaluate, and summarize findings from all relevant research that describe mathematics learning using the MathCityMap

application. Research steps using Systematic Literature Review are formulating research questions, applying inclusion criteria, looking for studies related to the topic, selecting some studies to be the main study, analyzing data from the studies' results, and compiling them into research reports (Mengist et al., 2020; Thovawira et al., 2021).

Two research questions (RQs) formed the basis of this review: RQ 1. How is the implementation of the MathCityMap application towards improving students' mathematical problem-solving skills?. RQ 2. How does the integration of MathCityMap with learning models towards improving students' mathematical problem-solving skills?

### Inclusion Criteria

The inclusion criteria used in this research are articles discussing about the implementation of MathCityMap towards an improvement of students' mathematical problem-solving skills, articles discussing about the integration of MathCityMap with learning models towards an improvement of students' mathematical problem-solving skills, and articles published in international or national indexed-journal. Types of research that are used are quantitative and qualitative research, proceedings, undergraduate thesis, thesis, and dissertation. The primary study is published from 2013 until 2023.

### Study Search Strategy

To collect previous studies, researchers use Publish or Perish, Google Scholar, Directory of Open Access Journals (DOAJ), and Education Resources Information Center (ERIC). The keywords used are "MathCityMap", students' problem-solving skills, "MathCityMap, *kemampuan pemecahan masalah*", "MathCityMap, learning models", "MathCityMap, *model pembelajaran*".

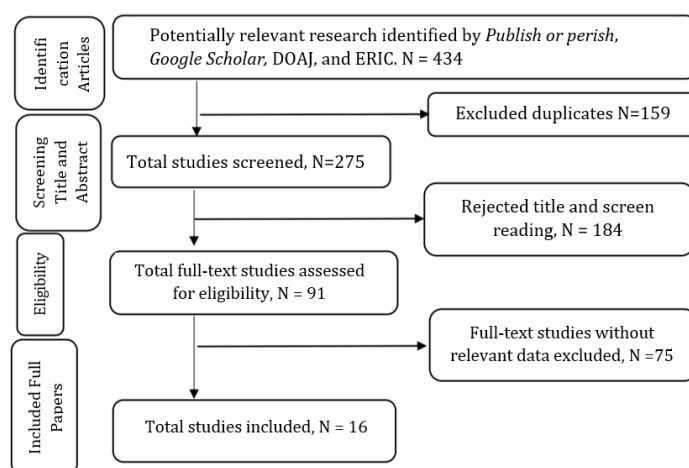


Figure 1. Stages of Systematic Review

### *Selection and Study Evaluation*

In this research, 75 selected studies were found according to the research topic. Nevertheless, only 16 articles fulfilled the inclusion criteria which would then be analyzed further.

### *Data Analysis and Reporting Research Results*

The data obtained and selected are then analyzed and reported to get comprehensive and obtain knowledge.

## **Results**

### *Implementation of the MathCityMap Application to Improve Students' Mathematical Problem-Solving Skills*

MathCityMap is an application that provides a visualization of math problems in the real world so it motivates students to learn mathematics. Students will be given a map where there are math problems in it. While students walk to the place on the math trail, the question and problem will arise and they have to find the solution to solve it. Table 1 shows the implementation of the MathCityMap application to increase students' mathematical problem-solving skills.

Table 1. Implementation of the MathCityMap Application on Students' Mathematical Problem-Solving Skills

No	Researchers	Name of Journal	Results
1.	Rosanti, F. (2022)	Jurnal Cendekia	Based on the research, it was concluded that the application of Outdoor Learning Math with the MathCityMap had a positive impact on increasing mathematical problem-solving skills in class XII at SMK'S YAPIM Pinang Awan.
2.	Hakim, A. R., Asikin, M., & Cahyono, A. N. (2019).	Prosiding Seminar Nasional Pascasarjana (PROSNAMPAS)	The use of math trail assisted by the MathCityMap application was able to develop students' logic and learning motivation and was expected to be able to improve students' mathematical problem-solving skills.
3.	Sholikhakh, R. A. S., & Priatna, N. (2022).	Integral	The use of the MathCityMap application motivated students to solve problems in real life.
4.	Cahyono, A. N., Ludwig, M., & Marée, S. (2015).	Proceedings of the 7th ICMI-East Asia Regional Conference	This study indicated that using the MathCityMap application could facilitate students to have

		on Mathematics Education	mathematical problem-solving skills based on visualization results in their surroundings.
5.	Hartmann, L. M., & Schukajlow, S. (2021).	Mathematical modelling education in east and west. Cham: Springer International Publishing.	This study indicated that the MathCityMap application could improve students' mathematical problem-solving skills and students had an authentic experience in learning mathematics. It also increased students' interest and motivation in learning mathematics.
6.	Hakim, A. R., Rochmad, R., & Isnarto, I. (2022).	PRISMA, Prosiding Seminar Nasional Matematika	This study showed that the MathCityMap could increase mathematical problem-solving skills. In this case, male students tended to be more creative and able to solve problems faster than female students.
7.	Anggraini, I., Chikita, G. D., & Febrianti, S. A. (2023)	ProSANDIKA UNIKAL	The results indicated that students' problem-solving skills increased after implementing the ethnomathematics and the MathCityMap application.
8.	Martínez-Jiménez, E., Sualdea, A. B., & de Celis, Á. N. (2022).	<i>Handbook of Research on International Approaches and Practices Gamifying Mathematics</i>	Math trail with the MathCityMap application affected on students' problem-solving skills and helped students to increase their motivation in learning mathematics.
9.	Cahyono, A. N., & Miftahudin, M. (2018)	<i>Unnes Journal of Mathematics Education</i>	Math trail with the MathCityMap application could help students to connect, communicate, and discuss ideas with their teammates. They also could use their reasoning and problem-solving skills to solve the problem.
10.	Barbosa, A., & Vale, I. (2020).	Research on Outdoor STEM Education in the Digital Age	Forty-eight students who used MathCityMap to do a math trail in the city centre of Viana do Castelo showed that they valued the experience and highlighted the possibility of solving real problems.
11.	Bočková, V., Pavlovičová, G., & Čeretková, S. (2020).	ICERI2020 Proceedings	This study indicated that students' mathematical problem-solving skills increased after implementing the MathCityMap application in mathematics learning, especially in Geometry.

*Integration of the MathCityMap with Learning Model to Improve Students' Mathematical Problem-Solving Skills*

Table 2. Integration of the MathCityMap with Learning Model on Students' Mathematical Problem-Solving Skills

No	Researchers	Name of Journal	Results
1.	Ismaya, B. F., Cahyono, A. N., & Mariani, S. (2018).	Seminar Nasional Pendidikan Matematika Ahmad Dahlan	The result indicated that Project Based Learning (PjBL) with the MathCityMap application could increase students' mathematical reasoning skills. In the advanced thinking stage, reasoning was a skill in the problem-solving process.
2.	Barlovits, S., Baumann-Wehner, M., & Ludwig, M. (2020).	Mathematics Education in the Digital Age (MEDA)	This study showed that the MathCityMap application integrated with Project Based Learning effectively improved students' problem-solving skills. It is because students could directly experience the application of mathematical problem-solving in their daily lives.
3.	Barlovits, S., & Ludwig, M. (2020).	Research on Outdoor STEM Education in the Digital Age	The MathCityMap application integrated with Discovery Learning affected on students' mathematical problem-solving skills.
4.	Wulandari, M. (2019).	Skripsi	The results concluded that Contextual Teaching and Learning (CTL) with the MathCityMap application had differences in problem-solving skills between experimental and control classes. In this case, the mathematical problem-solving abilities of the experiment class students got higher scores than the control class.
5.	Putri, N. D., Putri, Z. Y., & Mardikaningsih, D. (2023).	ProSANDIKA UNIKAL	The result of this study indicated that problem-based learning models with contextual activities based on the MathCityMap application could improve students' problem-solving skills and positive attitudes toward mathematics.



## Discussion

### *Implementation of the MathCityMap Application to Improve Students' Mathematical Problem-Solving Skills*

Based on Table 1, the implementation of MathCityMap is able to develop students' mathematical logic so that it has an impact on increasing students' mathematical problem-solving skills (Anggraini et al., 2022; Hakim et al., 2019; Rosanti & Harahap, 2022). Bočková et al (2020) stated that the use of the MathCityMap application in Geometry material had an effect on increasing students' mathematical problem-solving skills.

Hakim et al (2022) concluded that female students tend to choose simpler solutions to solving problems than male students. It is because female students need more time to understand problems and are not detailed in writing things that must be known. The use of the MathCityMap application can help students to communicate and discuss ideas with their teammates to solve problems (Cahyono & Miftahudin, 2018).

It is crucial for students to develop their mathematical problem-solving abilities. Mathematical problem-solving is an activity that requires an individual to link various cognitive actions, some of which require some knowledge and skills that are sometimes non-routine with the aim of reducing the intensity of the lack of meaningful representations to support calculations. Problems that can train problem-solving skills must be related to the real world which is non-routine (Polya, 1975). In addition, optimism and motivation in solving problems also support creativity and logic in solving problems (Vidermanova & Vallo, 2015). Problems related to the real world that require critical and creative thinking are problems that are categorized as non-routine problems. Students who can solve non-routine problems will improve their mathematical problem-solving skills. The math problems given in the MathCityMap application are authentic problems related to the real world. So, it is known that the problems given in the MathCityMap application are non-routine problems. Therefore, the use of the MathCityMap application in learning mathematics can help improve students' mathematical problem-solving skills.

The MathCityMap application is helpful for students as a tool that bridges the gap between mathematical concepts and real-world situations (Cahyono et al., 2015; Sholikhakh et al., 2022). Besides being able to help improving students' mathematical problem-solving skills, the outside learning experience using the MathCityMap application can increase students' interest and motivation in learning

mathematics (Barbosa, 2020; Hartmann & Schukajlow, 2021; Martínez-Jiménez et al., 2022).

### *Integration of the MathCityMap with Learning Model to Improve Students' Mathematical Problem-Solving Skills*

MathCityMap is an application designed for outside learning where students have to complete assignments from the mathematics problems, they encounter using the maps provided. Based on Table 2, the MathCityMap application which is integrated with the learning model is expected to be able to improve students' problem-solving skills.

Project Based Learning (PjBL) is a learning model that allows students to learn by doing and applying their ideas they have. The MathCityMap application, which is integrated with the PjBL model is effective in improving students' problem-solving skills because students can directly experience the application of mathematical problem-solving in their daily lives (Barlovits et al., 2020; Ismaya et al., 2018). The PjBL model integrated with the MathCityMap application provides active learning activities, improves students' problem-solving skills, and increases students' positive attitudes to mathematics. Integrating the MathCityMap application with the PjBL learning model creates a constructivist environment that fosters student engagement and knowledge-building. This approach encourages deep thinking and problem-solving, allowing students to construct their own understanding of the subject matter. The PjBL model and MathCityMap application effectively promote active participation and autonomous learning, resulting in a more enthusiastic approach to learning and the application of knowledge to real-world situations.

According to Svinicki (1998), Discovery Learning is a learning model that is easier to learn for students because most of the discovery tasks are based on real problems or real situations. The Discovery Learning model that is integrated with the MathCityMap application offers an interesting approach to the process of learning mathematics. This is because, in the learning process, MathCityMap offers visualization of real objects to students. Barlovits & Ludwig (2020) in their research concluded that the Discovery Learning learning model assisted by the MathCityMap application is effective in increasing students' mathematical problem-solving skills.

Another study conducted by Wulandari (2019) concluded that the Contextual Learning and Teaching (CTL) learning model assisted by the MathCityMap application was effective for students' cooperative abilities and problem-solving. This is shown by the difference in student learning outcomes that

are given learning with the CTL model assisted by the MathCityMap application with students who are given conventional learning models. Students with the CTL model assisted with the MathCityMap application had higher learning outcomes than students who did not receive that. The CTL model learning assisted by the MathCityMap application helps students to have experience in real-world situation so that learning becomes more meaningful. This meaningful learning is able to improve students' mathematical problem-solving skills.

Problem-Based Learning (PBL) is a learning model that can grow and develop a level of ability in solving problems that are directly related to students' lives and higher-order thinking skills. Meanwhile, the MathCityMap application is an application that is able to give an impression when the teaching and learning process becomes more impressive for students. The integration of the MathCityMap application with the PBL model has a positive influence on students so that it has an impact on students' mathematical problem-solving skills (Putri et al., 2023). MathCityMap which is integrated with the PBL model provides visualization of a series of problem-based learning activities so that in the learning process students not only memorize learning material, but students can actively think, communicate, search and process data, and draw conclusions from the problems they get in the MathCityMap application.

### *The Effectiveness of The MathCityMap Application on Improving Students' Mathematical Problem-Solving Skills*

MathCityMap is a GPS-based application. Mathematics learning assisted by MathCityMap will help students to apply their knowledge. The quality of learning in real situations will give an impact on students' academic achievement through the objects studied as well. The analyzed-primary study informed that the MathCityMap application increases motivation and interest in learning mathematics that will affect the improvement of students' problem-solving skills (Anggraini et al., 2022; Cahyono, 2018; Cahyono et al., 2015; Hakim et al., 2019; Hartmann & Schukajlow, 2021; Rosanti & Harahap, 2022; Sholikhakh et al., 2022; Martínez-Jiménez et al., 2022).

In solving the problem, a good mathematical understanding will be very helpful. However, in real life, mathematics studies in school are often not directly related to students' daily lives. Learning models are a basic guideline for teachers and students during teaching implementation. Based on a primary study analysis, the MathCityMap application integrated with some learning models, such as Project Based Learning (PjBL), Discovery Learning, Contextual Learning and Teaching (CTL), and Problem-Based Learning (PBL) is effective to improve students'

mathematical problem-solving skills (Barlovits & Ludwig, 2020; Barlovits et al., 2020; Ismaya et al., 2018; Putri et al., 2023; Wulandari, 2019).

Building open the findings from the analyzed primary studies, the MathCityMap application is known effective to improve students' mathematical problem-solving skills. In line with Chikiwa & Ludwig (2023) in the book entitled "Visualization and Epistemological Access to Mathematics Education in Southern Africa" which stated that the MathCityMap application gives impact to the improvement of students' mathematics problem-solving skills. This is because mathematics learning using the MathCityMap application provides meaningful learning and increases students' studying motivation.

## Conclusion

Based on the results of a systematic literature review, the implementation of MathCityMap was found to be effective in improving students' mathematical problem-solving skills. Not only that, MathCityMap integration with learning models gives a positive impact towards students' mathematical problem-solving skills. The limitation of this research is there are still few experimental studies about the implementation of the MathCityMap application integrated with learning models towards students' mathematical problem-solving skills.

This is a recommendation for future researchers to conduct individual studies about relevant problems. The results of this SLR can be continued to conduct a meta-analysis study with various characteristics that have been described to obtain a stronger conclusion about how to influence MathCityMap on improving students' mathematical problem-solving skills.

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