Case-Based Learning Model with MathCityMap to Improve Mathematical Literacy

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Abstract

Mathematical literacy is a skill needed to support the current era. However, mathematical literacy in Indonesia is low, as evidenced by the results of PISA 2021 and previous relevant research. The Cased-Based Learning (CBL) model can be a solution to overcome the problem of mathematical literacy. Assisted by learning media using MathCityMap, it is alleged that it can simplify the learning process in the current era where technology is an important part of education. So, the purpose of this study is to find out the improvement of mathematical literacy using the MathCityMap-assisted CBL model. The results of the research obtained a value of $t_{stat}=7,071$ and $t_{(1-\alpha,dk)}=t_{(1-0,05,(33+33-2))}=t_{0,95,64}=1,997$. Because $7,071>1,997$ then $t_{stat}>t_{(1-\alpha,dk)}$. This means that H_0 rejected or accepted H_1. This means that the average increase in mathematical literacy in the MathCityMap-assisted CBL model is more than that of the conventional model. In addition, the math literacy gain value in the MathCityMap-assisted CBL model is 0.528 which is included in the medium category. In CBL learning, students are directed to solve cases related to daily life. Indirectly stimulating the development of students' mathematical literacy. So, the use of the MathCityMap-assisted CBL model can improve mathematical literacy.

Keywords: Mathematical Literacy, Cased-Based Learning, MathCityMap.

Mathematical literacy is still a major challenge in basic mathematics education and is a key issue and trend in mathematics education research. The concept of mathematical literacy emerges as a framework that includes the knowledge and abilities necessary to navigate the mathematical challenges faced in everyday situations (Bolstad, 2023; Geiger et al., 2015; Komarudin et al., 2024; Sumirattana et al., 2017). This is because a person must be able to prepare for his role as a subject who learns independently throughout his life and to solve real-world problems that require him to use the skills and competencies acquired through experience in school and daily life (Hasibuan & Fauzi, 2019; Ojose, 2023; Rizki & Priatna, 2019). As a result, having mathematical knowledge has become very important, as people with these skills not only understand mathematics but also use it effectively to cope with complex situations. (Çakıroğlu et al., 2024).

In the 2022 PISA survey, Indonesia's mathematical literacy only reached level 2 by 18%, significantly lower than the average in OECD countries of 69% (OECD, 2023). This shows that Indonesia's mathematical literacy is much lower than that of other countries. Several previous studies have also highlighted the inadequate mathematical literacy skills of Indonesian students (Komarudin et al., 2024; Thien et al., 2015; Zulkardi & Putri, 2019). It is evident that there is an urgent need to improve students' mathematical literacy through effective and efficient teaching and learning models. In accordance with the importance and problems mentioned above, it is necessary to develop and improve students' mathematical literacy intensively. Teachers play a crucial role in empowering students' math experiences to further apply math into their real-life lives (Sumirattana et al., 2017). Math illiteracy is not the result of the content of teaching but the result of the teaching method applied by the teacher (Martin, 2007). Traditional instructional methods, including memorizing mathematical rules or formulas that are not related to students' real lives or experiences, cannot improve students' mathematical literacy (Genc & Erbas, 2020; Solomon, 2008; Sumirattana et al., 2017). Therefore, to develop and improve students' mathematical literacy, it is necessary to seek better instructional methods or processes.

As mentioned above, researchers are therefore interested in developing an instructional process to improve the mathematical literacy of high school students as a guideline for developing students' mathematical literacy. Cased-Based Learning (CBL) is a model that is considered. CBL is a method that uses clinical cases to prepare students for clinical practice, connects theory with practice and uses an inquiry-based learning approach to apply knowledge (Higashitsuji et al., 2024; McLean, 2016). CBL requires students to actively participate in real-life situations in the form of cases that focus on new and interesting issues (Dhiyazzahra et al., 2023; Putu, 2021). It significantly improves students' abilities compared to traditional methods that do not use cases (Dhiyazzahra et al., 2023; Higashitsuji et al., 2024; Ma & Zhou, 2022).

Future life will require the development of a mathematical mindset (Tong et al., 2021) and the use of technology (Das, 2021). Integrating technology into teaching can facilitate access to resources, promote interactive and multimedia learning experiences, and foster digital literacy skills among students (Qurohman, 2024). In its application, the researcher chose to use MathCityMap to help in the case-based learning process. The context that exists in his real life is designed in such a way through MathCityMap. MathCityMap allows the design of outdoor paths where tasks are placed in specific places and can be tracked with GPS-enabled devices (Lavicza et al., 2020). Mathematical concepts can be transferred directly to the real world (e.g. buildings, places, or art objects) and students must model the assigned tasks with various technological tools (Haas et al., 2023). In addition, solving math tasks in real-world contexts can develop movement, which is most advantageous for math learning (Jablonski, 2021). MathCityMap dapat menjadi salah satu inovasi alternatif untuk meningkatkan literasi matematika siswa (Sadewo & Amidi, 2023a; Wahyuningsih & Amidi, 2023; Widianti & Amidi, 2023).

In summary, the theoretical framework of this research provides a comprehensive and integrated approach to improving mathematical literacy. By referring to relevant theories and principles, this study aims to promote students' mathematical literacy on the CBL model with MathCityMap.

Method

Research Design and Participants

The quantitative approach applied in this study is the conclusion of the data of the research results, which is illustrated through statistical formulas. The purpose of quantitative quasi-experimental research is to determine the effectiveness of the treatment. Researchers (Baye et al., 2021; Sahara & Hartono, 2021; Tong et al., 2021) most commonly use pre-test and post-test control group designs. The design of this research is included in the methods used for behavioral science research, as mentioned by Gravetter et al. (2009) and Privitera (2024). As illustrated in Table 1, the empirical sequence of pedagogy is followed.

Table 1. The Study Design.

Group	Pre-test	Treatment	Post-test
Class 7G (experimental group, 33 students)	test	X	test
Class 7F (control group, 33 students)	test		test
Note. Experimental group: EG; Control group: CG. X: The teaching process is oriented to developing students' mathematical literacy.			

An independent t-test was used in this investigation to see the difference in mean scores between the experimental and control groups. In addition, this t-test allows the application of the average of the two pre-tests for the above two groups to determine the equivalence between the groups. It is stated that the degree of effect represents the magnitude of the impact. In terms of impact, the degree of influence is a good indicator of the extent of the effect. The t-test showed significant differences in the mean; the magnitude of the effect then tells us how big the effect was.

This research was conducted at SMP N 20 Semarang. The sample used in this study used purposive sampling, the sample used was 33 students in class 7F and 33 in class 7G with the topic of similarity and congruence.

Data Collection Technique

In this study, there are several data collection techniques applied, namely through and teacher interviews, classroom observations, pre-test and post-test. Through interviews, researchers aim to learn about the methods they use to assist students in developing their mathematical literacy and their attitudes towards better learning to understand the material. On the other hand, observations are made to witness the learning process firsthand, which then becomes the basis for analyzing research needs. Prior to learning with the CBL model with MathCityMap, students in two classes took a pre-test consisting of six questions about the common that they were instructed to learn before learning. In this study, the post-test instrument is a description that contains six items related to the prevalence of sickness, each of which is a case in daily life. When dealing with these math problems, it is expected that students need adequate mathematical literacy. Each of the two classes is given a test instrument at the beginning and end of the lesson.

Data Analysis Technique

The data analysis techniques used in evaluating the quality of the CBL model with the developed MathCityMap consider two main aspects: sustainability and effectiveness. Product sustainability evaluation involves expert assessment and user (teacher) response. Meanwhile, the effectiveness of the product is observed through the results of operational field trials that have been carried out.

Results And Discussion

The normality test of pre-test and post-test of students' mathematical literacy is a prerequisite for conducting a follow-up test of improving student literacy. The results of the calculation of the normality of the student ability scale data are presented in the Table 2.

Table 2. Results of the normality test of mathematical literacy

Data		Shapiro Wilk			Description
		Statistic	Df	Sig	
Pre-test	EG	0,959	33	0,245	Normal
	CG	0,967	33	0,408	Normal
Post-test	EG	0,975	33	0,617	Normal
	CG	0,953	33	0,161	Normal

Based on table 2, the pre-test and post-test in the experimental class and the control class were distributed normally. Furthermore, an independent t-test was used to test the hypothesis that the pre-test scores of the experimental and control classes did not differ significantly. Tables 3 and 4 show the descriptive statistics and t-test of the average score of mathematical literacy from the experimental and control classes through SPSS 25.

Table 3. Descriptive statistics of pre-test result.

	N	Minimum	Maksimum	Mean	Std. Deviation
Pretest- EG	33	54	76	64,09	4,705
Pretest- CG	33	50	76	65,27	5,685

Table 4. Independent t-test of pre-test results.

Independent degree: df	t Stat	Sig. (2-tailed)	Mean Difference
64	0,906	0,368	1,182

To determine whether or not the mean difference between the experimental and control groups was statistically significant, an independent t-test was performed on both groups. With a significance level of α = 0.05 and a degree of freedom df = 64, the critical value (Sig.) is equal to 0.368 greater than 0.05. Thus, the difference in average scores between the experimental class and the control class was not significant. In other words, the test findings show that the levels of the experimental class and the control class are equivalent.

An independent t-test was used to test the hypothesis that the average score of the experimental class's post-trial test was higher than that of the control class. Tables 5 and 6 reveal descriptive statistics and independent t-tests of post-test scores from experimental and control classes via SPSS 25.

Table 5. Descriptive statistics of post-test result.

	N	Minimum	Maksimum	Mean	Std. Deviation
Posttest- EG	33	74	92	82,91	4,065
Posttest- CG	33	64	85	76,30	5,394

Table 6. Independent t-test of post-test results.

Independent degree: df	t Stat	Sig. (2-tailed)	Mean Difference
64	5,619	0,000	6,606

To see if the experimental and control groups had different ways, an independent t-test was used. With a significance level of α=0.05 and a degree of freedom df = 64, the critical value (Sig.) is equal to 0.000 less than 0.05, so the difference in the average score value between the experimental control classes is statistically significant. Therefore, the null hypothesis is rejected, allowing us to accept alternative hypotheses. Therefore, the test results show that the post-test results of the experimental class and the control class have a significant difference. In particular, the test results of the experimental class were higher than those of the control class.

The next step after the prerequisite test and hypothesis test is to find the normalized gain value (n gain) of the experimental class and the control class. The purpose of the n-gain value search is to measure the improvement of students' mathematical literacy. The difference test of two one-sided averages (right) was used to find out whether the average increase in mathematical literacy in the experimental class was greater than that of the control class.

Table 7. Average normalized gain test

N gain- EG	N gain- CG	t_{stat}	$t_{1-\alpha,dk}$	Testing criteria	Description
0,528	0,320	7,071	1,997	$t_{value} > t_{1-\alpha,dk}$	H_0 rejected

Based on table 7, with the level of significance α = 0,05 obtained a value t_stat=7,071 and t_(1-α,dk)=t_(1-0,05,(33+33-2))=t_0,95,64=1,997. Because 7,071>1,997, then t_stat>t_(1-α,dk). This means that H_0 rejected or accepted H_1. Thus, the average increase in mathematical literacy in the experimental class was greater than that of the control class. In addition, the mathematical literacy gain value in the experimental class was 0.528 and was included in the medium category.

Learning by applying the MathCityMap-assisted CBL model is going well overall. The learning process with the MathCityMap-assisted CBL model is student-centered. This is in line with Syarafina et al. (2017), that the CBL model requires students to actively participate in problem scenarios that simulate real-world situations and the field they are studying. This is supported by Werdiningsih & Wahyuni (2021), that the CBL framework encourages students to take responsibility for learning, learning, and solving mathematical problems. This is strengthened by Arianto & Fauziyah (2020), that the CBL model provides a good stimulus for students to be active in solving the problems given. Through the CBL model, students are given various life cases that are relevant to the material they are learning (Anwar & Junaidi, 2022).

Learning with the MathCityMap-assisted CBL model makes students more active in learning in the classroom because it is carried out in groups and each member has their own role. This is in line with research Simbolon (2022) that the use of the CBL model makes students more creative and motivated to learn. It can be supported Bansal & Goyal (2017), that students feel satisfied because CBL learning is an effective and student-centered learning method, because it involves and motivates students so that it can improve students' knowledge and thinking skills in solving problems. CBL creates more conducive learning activities that make students more enthusiastic and motivated. This is in line with Widyagesti & Subekti (2023), that CBL provides interesting learning activities and has a positive influence on students. This is supported by Asfar et al. (2019), students are more interested during the learning process when implementing CBL and students are helped in improving their mathematical literacy. This is in line with research Chandra et al. (2023) that learning with the CBL model is effective in improving students' mathematical literacy.

In addition, MathCityMap also takes part in providing a positive response for students. Activities involving MathCityMap make students more active in teaching mathematical concepts through the exploration of the environment associated with the case. This is in line with Ismaya et al. (2018), that the use of MathCityMap can provide active learning activities. This is supported by Sadewo & Amidi (2023), that its use requires students to be able to explore, assess, interpret, synthesize, and information to produce various forms of learning outcomes. According to Sadewo & Amidi (2023), Students' mathematical literacy can also be improved by using MathCityMap in the CBL model. In the going outdoor step, students will be given the opportunity to walk outside the classroom to do tasks cooperatively in a team, which will make a new experience that is very motivating for students. The context of the objects in the school environment that is outlined in the case of CBL learning makes the cases that students will solve easier for students to understand because they are close to the life around them, thus making the learning carried out more meaningful.

The provision of worksheet also has a positive impact. Students will find it easier to understand and apply their mathematical knowledge if they are given worksheet questions and relevant to daily life. This is supported by Widyagesti & Subekti (2023), that the provision of worksheets helps students to utilize their mathematical knowledge if students get similar cases in their daily life situations. CBL is more emphasized on the process of discovering material concepts by themselves so that students can learn more about the material. Because understanding can be developed from what is learned, students become central to learning activities, and teachers only guide.

MathCityMap-assisted CBL model is in line with Vygotsky, Piaget, Bruner, and Gagne. Vygotsky's theory is relevant to the CBL model because this model involves students to interact socially with peers to teachers in solving the cases presented. In the CBL model, there is scaffolding with the provision of assistance using MathCityMap media and guidance assistance and in accordance with the student's initial ability. Teachers provide guidance and support in accordance with Vygotsky's theory of social support. This model is also in line with Piaget's theory because it emphasizes the role of students to participate actively, so that experience and manipulation of the environment are an important part of building the development of skills. Discussions in mathematical case solving refer to Bruner's learning theory, students are encouraged to actively participate in discussions to explore and understand the concept of equality through MathCityMap which encourages exploration and creativity, then students are directed to discovery with relevant mathematical cases (linking Vygotsky's theory, students are given real cases or situations involving the concept of equality to apply their understanding in a context that relevance, fostering a culture of deeper understanding). This model also has a step to present the results. According to Gagne's social learning theory, group presentations allow students to share their understanding of mathematical concepts and enrich their learning experience, creating a culture of knowledge sharing (Qurohman, 2024). The process in learning is what spurs the development of students' abilities in communication, mathematization, representation, reasoning and argumentation, designing strategies, using language and mathematical tools, so that students' mathematical literacy increases.

The above explains that the MathCityMap-assisted CBL model can improve mathematical literacy. According to Asfar et al. (2019), students are more interested during the learning process when implementing CBL so that through the learning process they can improve their mathematical literacy skills. This is supported by Safira et al. (2024), that there was a significant difference in improvement between students who obtained the CBL model and conventional models, both in terms of descriptive analysis and statistical tests. This is in line with research Chandra et al. (2023) that learning with the CBL model is effective in improving students' mathematical literacy. Through the results, the researcher found that the average increase in mathematical literacy of the CBL model was greater than that of the conventional model. In addition, the mathematical literacy gain value in the experimental class is 0.528 which is included in the medium category, so it can be interpreted that through CBL, students will have the ability to actively participate during learning activities, and indirectly improve their mathematical literacy.

Limitations and Challenges

Although the results are promising, the study faces some limitations and challenges. First, the MathCityMap-assisted CBL model is limited to one school in Indonesia, which has the potential to limit the generalization of the findings. In addition, the duration of the study may not be sufficient to capture the long-term impact on mathematical literacy. Additionally, logistical constraints, such as resource availability and scheduling conflicts, may have impacted data collection and implementation fidelity. Finally, the subjective nature of some data collection methods, such as interviews and observations, introduces the possibility of bias. Addressing these limitations and challenges will be crucial for future research to provide a more comprehensive understanding of the effectiveness and application of the CBL model in various educational settings across Indonesia.

Conclusion

The findings of this study are that the average increase in mathematical literacy in the MathCityMap-assisted CBL model is more than that of the conventional model. In addition, the mathematical literacy gain value in the MathCityMap-assisted CBL model is 0.528 which is included in the medium category. This means that the MathCityMap-assisted CBL model is quite good at improving students' mathematical literacy compared to the conventional model. In CBL learning, students are directed to solve cases related to daily life. Indirectly stimulating the development of students' mathematical literacy. Thus, the use of the MathCityMap-assisted CBL model can improve mathematical literacy and offer practical implications and recommendations for educators and policymakers in Indonesia. First, integrating the CBL model into the math curriculum throughout high school can significantly improve mathematical literacy. Teachers must receive adequate training and support to effectively implement this model in their classrooms. In addition, education policymakers should consider incorporating elements of the CBL model into national education policies and frameworks, and pay attention to supporting resources such as MathCityMap or other media. In addition, collaboration between schools, educational institutions, and communities can facilitate the adaptation of the model to diverse local contexts, ensuring its effectiveness in different regions of Indonesia. In addition, ongoing research and evaluation efforts are needed to continuously refine and improve the CBL model, address emerging challenges and further increase their impact on mathematical literacy. By prioritizing these recommendations, stakeholders can collectively contribute to the advancement of mathematics education in Indonesia, fostering a generation of confident and competent learners in mathematics.

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