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"Marica": A Story-Based Motion-Comic Learning Media to Improve Students' Mathematical Representation

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Abstract: "Marica": A Story-Based Motion-Cartoon Learning Media to Improve Students' Mathematical Representation Ability. This research is based on students' difficulties in presenting mathematical ideas and problem-solving, as well as their generally low positive attitudes towards mathematics. The researchers conducted an experimental study to examine the influence of MARICA media on students' mathematical representation abilities in the field of plane geometry. Additionally, the research aims to improve students' mathematical representation based on various levels of mathematical logical intelligence using MARICA as a learning media. MARICA, an abbreviation for "*Mari Membaca*" integrates literacy concepts, engaging learning media, and story-telling. The quantitative descriptive research involved 56 first-grade elementary school students and measured both the cognitive (mathematical representation ability) and affective domains. Mathematical representation abilities were analyzed using two-way ANOVA, while affective domain data were analyzed descriptively. The results indicate a positive effect of MARICA on the mathematical representation abilities of first-grade students, with higher levels of mathematical logical intelligence correlating with better performance. Student responses to MARICA showed an increase in aspects of independence, critical attitudes, and creativity. It can be concluded that MARICA can be used to improve students' mathematical representation and it works better for students who has good mathematical logical intelligence.

Keywords: MARICA, mathematical representation, mathematical logical intelligence.

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INTRODUCTION

NCTM (2000) has established five standards of mathematical proficiency, one of which is representation abilities. According to NCTM, representation is central to the study of mathematics because through representations students learn how to communicate their thinking while learning mathematics. Students can develop and deepen their understanding of mathematical concepts and relationships as they create, compare, and use various representations. Based on this viewpoint, representation abilities is one of the abilities that should be developed and possessed by students, started from primary education when for the first time students are introduced to mathematical concepts (numbers, geometry, data presentation, knowledge, application, and reasoning) as forms of representation.

The acquisition of pattern reasoning typically starts with inductive reasoning linked to quantitative relationships before advancing to deductive reasoning. The more advanced stages of logical thinking frequently entail abstract concepts, which learners need to depict using tangible objects or suitable symbols. According to Lewis and Mayer (1987), for an overview of the most significant theories on word problem solving,the majority of challenges in problem-solving arise during the representation phase. Therefore, the critical factor determining learners’ ability to effectively solve problems is the process of transforming problems into internal representations. When learners can comprehend various methods of converting mathematical representations, they will be adept at understanding the mathematical concepts entailed (Tang, Nine & Wang, 2023).

Representation is defined as an action in understanding what is obtained and interpreting visual images or symbols into words and ability to explain unclear objects (Puspandari, Praja, & Muhtarulloh, 2019). Meanwhile, according to Meltzer (2000), representation is a broad and varied model, allowing a concept to be understood and communicated in the form of other symbols. Representation abilities is useful in solving problems more easily and for addressing seemingly complex problems (Aisyah & Madio, 2021). One of the examples of representation could be seen in algebra “How to solve $x + x$ = 116 “ 84?” There are several strategies in the form of diagrams to answer this problem, as described in https://davidwees.com/content/mathematical-representations/.

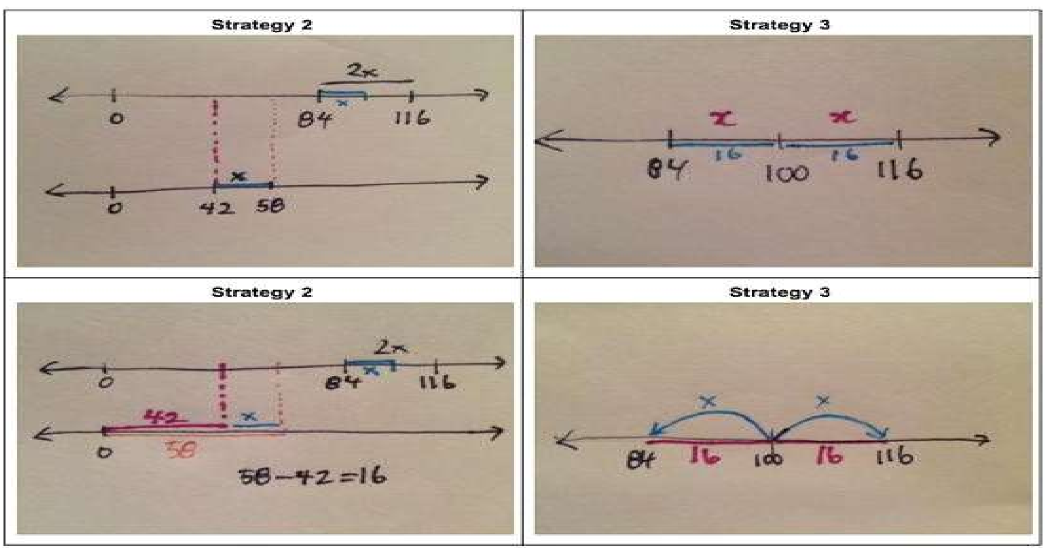

Figure 1. Mathematical representation in algebra

The students’ abilities to create visual depiction to present their ideas such as in the Figure 1, both verbally and visually, aids in problem-solving process, and this ability is referred to as representation. An individual’s representation ability is influenced by the format of representation, concepts, age, and individual differences.

In addition, one of these individual differences is influenced by intelligence (Ainsworth, 1999) that can be measured by Intelligent Quotient (IQ). One of the components of the IQ is mathematical logical intelligence. Therefore, the authors also intended to investigate the effect of students’ mathematical logical intelligence (as part of intelligence) on their mathematical representation abilities, particularly among elementary school students. Considering that students' learning achievements in elementary school according to the Merdeka curriculum fall within levels A-C, it is important for teachers to develop students' mathematical representation abilities during their golden age. It is crucial for teachers to incorporate the development of mathematical representation abilities into their instructional design. Teachers should be able to facilitate meaningful and enjoyable learning experiences while enhancing students' cognitive abilities. Additionally, fostering the right attitude is equally important. Teachers' instructional designs should be able to accomodate the demands of 21st-century academic abilities, such as literacy, through various means, including the use of instructional media. MARICA (*Mari Membaca*) is an example of instructional media that combines the concepts of literacy, fun learning media, and story telling in the form of motion comics methods. As we know, research findings indicate that children have a continuous liking for playing games because games are enjoyable, exciting, and present challenges that stimulate problem-solving abilities (Gerkushenko & Gerkushenko, 2014; Dalton & Devitt, 2016). Further studies propose that games contribute to fostering a sense of independence and capability in children (Godwin., 2014; Mouws & Bleumers, 2015). Within the context of in-game scenarios, children derive satisfaction when they perceive themselves as competent in handling challenges (Gerkushenko & Gerkushenko, 2014; Dalton & Devitt, 2016). About games,the maturity of the child's age is positively correlated with the achievement of the game, but it is negatively correlated with the number of times of willing to play (Tang, Nine, & Wang, 2023)

So why don't we optimize children's preferences for playing games but still learning? Many considerations come into play for a teacher in facilitating their students' learning process. Among the available options, incorporating game-based activities is a popular choice, especially in the fields of mathematics and science education. However, determining the suitability of using games compared to other equally engaging mathematical tasks prompts natural inquiry. As stated by Bernier and Zandieh (2024), intuitively, it seems reasonable that a meticulously crafted game would enhance students' enjoyment, fostering increased participation and deeper learning compared to other mathematical assignment activities.MARICA is an innovative digital learning environment that offers various products, including interactive instructional videos, educational games, and a social media menu. Educational games serve as learning media crafted in the form of games to assist students in comprehending the fundamental concepts of the presented subject matter. Mathematics is the subject most frequently employing educational game learning media, as it is characterized by a high level of difficulty in understanding among students (Puspita Dhaniawaty, Supatmi, & Fitriawati, 2023). It is developed by integrating storytelling theory and games-based learning, using Indonesian local wisdom themes. MARICA is specifically designed to enhance the interdisciplinary basic literacy abilities of Indonesian students across the six forms of literacy outlined by the Indonesian government. MARICA follows a TV Magazine concept, where each lesson is packaged in a video format consisting of storytelling videos, explanatory videos, activity sheets, mini-games, and challenges. The media platform is developed by PT Sebangku Jaya Abadi in collaboration with Farida Nurhasanah as the third author. The following is MARICA display in geometry topic:

Figure 2. MARICA media

Based on the initial stage, the enhancement of controlled manipulation abilities with various concepts taught in Zoltan P Dienes' theory provides an opportunity to help learners discover methods and engage in discussions about their findings. According to Dienes, the next step is to motivate students to abstract concrete materials into simple drawings, graphs, maps, and eventually integrate symbols with those concepts. These steps serve as a way to provide learners with opportunities to actively participate in the process of discovery and formalization through mathematical experimentation. These considerations led the researcher to choose MARICA as the media for the experimental learning model. This platform incorporates visual presentations, inquiry-based questions, cooperative attitudes, and fair competition.

Based on the background and introduction there are three research questions need to be addressed in this study: (1) to ascertain the comparative effectiveness between mathematics instruction utilizing MARICA and PowerPoint-based media, in terms of enhancing students' mathematical representation skills in plane geometry concepts; (2) to determine whether varying levels of mathematical logical intelligence yield differing outcomes in students' mathematical representation skills regarding plane geometry concepts, specifically examining low, moderate, and high levels of mathematical logical intelligence; and (3) to investigate potential interactions between levels of mathematical logical intelligence and differential utilization of instructional media on students' mathematical representation abilities concerning plane geometry concepts.

In addition to assessing students' representation abilities, the researcher also aims to examine students' responses from an affective perspective, as mandated by the curriculum. It acknowledges that an individual's abilities are not only measured cognitively but also through attitudes and abilities. Many studies indicate a correlation between an individual's attitudes towards learning and their learning outcomes. The learning attitude is one of the factors that influence the learning process and has a significant impact on students' learning outcomes (Rumajar, 2020). According to Ramayani (2016), the indicators of learning attitude are preparation for lessons, learning atmosphere, participation in learning, and tendencies in action. In this study, the observed attitudes included critical thinking, student autonomy, and creativity in learning activities, discussions, and problem-solving using the student's worksheet.

■ METHOD

The population of this study comprised all first-grade students at SDIT MTA Sukoharjo (in the 2023 academic year). Samples were drawn from classes 1A and 1C, each consisting of 28 students, and were selected using a cluster random sampling technique.

This research adopts a quantitative descriptive approach conducted through a quasi-experimental design. The use of a quasi-experimental design is deemed necessary due to the impracticality of controlling all variables influencing the dependent variable, which in this case is the mathematical representation ability. The independent variables under investigation include the learning models (with and without MARICA instructional media in the classroom) and levels of mathematical logical intelligence (categorized as low, moderate, and high). This study was conducted in from February until December 2023 in Surakarta, Indonesia.

Data were collected through a mathematical representation ability test (consisting of 6 items designed based on CP phase A, encompassing visual, symbolic, and verbal representation aspects in geometry, composition, and decomposition of plane figures) and a mathematical logical intelligence test (comprising 20 items). The mathematical representation ability test and mathematical logical intelligence test instruments underwent validation processes by professional judgment from mathematics education lecturers at UNS, psychologists, and teachers, as well as reliability tests using the KR-20 formula (resulting in a KR-20 value of 0.787 for the mathematical representation test, and for the mathematical logical intelligence test items taken from the book "How to multiply your child's intelligence" written by Lwin (2008)).

Two way ANOVA was used to analyzed the data from mathematical representation ability test , and mathematical logiical intelligence test. A simple factorial design of 2x3 was employed to analyze the effects of the two independent variables on the dependent variable, followed by post hoc multiple comparisons utilizing Scheffe's method with a significance level of 5%. Descriptive analysis was employed to present on students' attitudes towards the learning process.

■ RESULT AND DISCUSSION

The initial analysis of the data involved testing whether the two classes were balanced, so that if there were any effects or differences in the students' mathematical representation ability, it could be attributed to the instructional factor. The data from students' mid-semester examination scores were used to assess the initial equivalence between the two groups. And the data descriptive of main data is summarized by table 2 below (that we can see about mean, standard deviation of each classes and each categories of math logical intelligence):

Table 1. Descriptive data of the sample based on level of logical mathematics intelligence

CLASS	Level of Logical Mathematics Intelligence	Number of Students	Mean of Mathematical Intelligence Test	Standard Deviation of Mathematical Intelligence Test
Experimental Class	High	11	87.64	8.947
	Moderate	13	81.08	0.622
	Low	4	79.00	8.246
	Total	**28**	**83.36**	**9.546**
Control Class	High	5	81.40	7.021
	Moderate	14	75.79	10.047
	Low	9	69.56	8.413
	Total	**28**	**74.79**	**9.727**

This study involved two classes, each consisting of 28 students. In the MARICA media class, there were 11 students in the high mathematical logical intelligence category, 13 students in the moderate category, and 4 students in the low category (with a mean of 83.36 and a standard deviation of 9.546). Meanwhile, in the control class (using PowerPoint as the learning media), there were 5 students in the high mathematical logical intelligence category, 14 in the moderate category, and 9 in the low category (with a mean of 74.779 and a standard deviation of 9.727). For the box plot representation, please refer to the following figure:

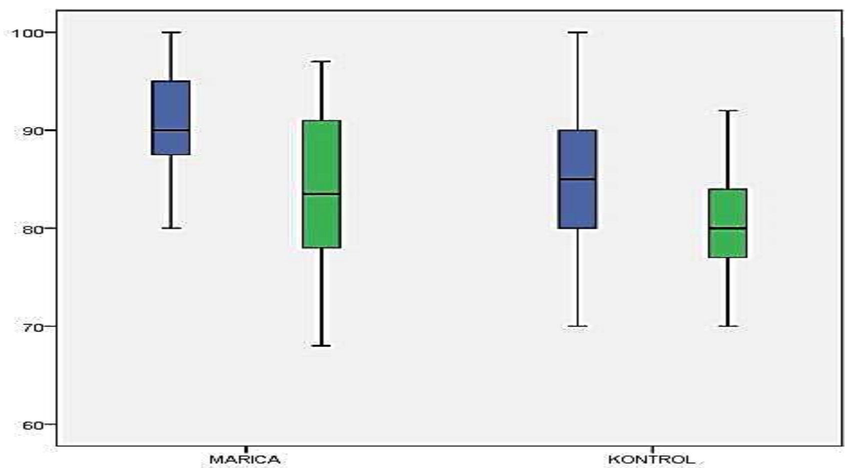

Figure 4. Boxplot of students' data. Logical intelligence and representational ability are represented by blue and green color, respectively

Based on the descriptive data from the boxplot above, it is evident that the class using the MARICA instructional media for mathematical representation ability has a higher upper quartile and maximum data value compared to the control class. The same pattern can be observed for students' mathematical logical intelligence. However, the control class exhibits a more balanced boxplot shape, and the minimum achievement value for students is higher.

For the subsequent analysis, in line with the research objectives, a two-way analysis of variance (ANOVA) was conducted to examine the effect of the treatment on students' mathematical representation ability. The prerequisite test for analysis of variance (normality test and homogeneity test) already used in this research. Prior to the ANOVA analysis, the assumption test was performed using SPSS, and the results concluded that the hypothesis for the data on students' mathematical representation ability, for each class and level of mathematical logical intelligence, indicated that the data followed a normal distribution and exhibited homogeneous variances. The results of the two-way ANOVA with unequal cell sizes can be seen in the table below:

Mathematical representation is the dependent variable in this study with R Squared .307 with adjusted R Squared is .237. As shown in the table above, in the "Corrected Model" row, the model including all independent variables (class, mathematical logical intelligence, and the interaction between class and mathematical logical intelligence) simultaneously affect the dependent variable, i.e., students' mathematical representation ability. This is indicated by the significance value (sig) < 0.05.

Table 2. The result of the two-way ANOVA

Sources	Type III SUm of Square	df	Mean Square	F	FSig.
Corrected Model	1852.466[a]	5	370.493	4.420	.002
Intercept	281253.178	1	281253.178	3355.244	. 000
Class Model	549.526	1	549.526	6.556	.014
Math Logic	673.111	2	336.556	4.015	.024
Class * Math Logic	34.034	2	17.017	.203	.817
Error	4191.248	50	83.825		
Total	356172.000	56			
Corrected Total	6043.714	55			

For the class variable, the significance value (sig) is also less than 0.05, indicating that the MARICA instructional media affects students' mathematical representation ability. Looking at the marginal means, it can be observed that the mean mathematical representation ability in the class using the MARICA instructional media (83.36) is better than the control class, which utilizes other visual instructional media such as power point or others (74.79). From the results, it can be stated that the MARICA media, which utilizes video animation, interactive educational games, and social media menus, is developed by combining storytelling theory and enjoyable games-based learning. The development, designed by researchers and incorporating themes of local Indonesian wisdom, is capable of enhancing student engagement and activity during learning. This is achieved by presenting a series of visually realistic displays equipped with various motion effects, combining text, images, and sound in a presentation. These findings are consistent with research related to educational game media, as discussed in Wilujeng & Kuswanto (2023). The use of power point media in the control class is likely to make students focus on what the teacher explains, thus making the dominance of the teacher in delivering verbal material more apparent. The learning activities of elementary school students, who are still in the learning and playing stages, are fully controlled by the teacher, and this is also evident in the indicators of critical thinking in the affective domain, which are also researched. It appears that in the MARICA class, students' creative and critical reasoning skills are better than those of students in the control class. The character of the MARICA class as a learning media allows students to learn and play, exploring fraction concepts from the content of the visually realized games. MARICA games, which are also accessible to everyone, help parents to learn together with their children with the correct fraction concept delivery flow, because not all parents understand mathematical concepts. Don't we still often encounter the understanding that "the denominators of fractions must be equal first" is still often used as a doctrine when teaching addition of fractions without providing visual explanations to students (because elementary school students are still at the level of understanding real mathematics).

Regarding the variable of mathematical logical intelligence, the significance value (sig) is also less than 0.05, indicating that students' levels of mathematical logical intelligence affect their mathematical representation ability. Logical-mathematical thinking is an ability or cognitive approach that utilizes the principles of logic and mathematics to analyze problems, solve them, and make decisions. On the other hand, mathematical representation ability pertains to an individual's capacity to comprehend, interpret, and communicate mathematical concepts in various forms, such as graphs, diagrams, or models. Given these two definitions, there is evidently a strong correlation between logical-mathematical intelligence and mathematical representation ability. This can be considered in research or instructional planning related to mathematical representation abilities, taking into account the level of students' mathematical logical intelligence. Individuals with high levels of logical-mathematical intelligence tend to exhibit better mathematical representation skills. They may find it easier to grasp mathematical structures, connect concepts, and apply mathematical knowledge in real-world situations. While logical-mathematical intelligence can provide a solid foundation for mathematical representation ability, it is not the influencing factor

But in Class*Mathematical logical intelligence, sig value bigger than 0.05, that means there is no interaction of these variables. No intersection among the three lines in the data plot was noticed, suggesting the absence of interaction between the instructional approach employed by the teacher, students' mathematical logical intelligence on students's mathematical representation ability. Based on these three results, post hoc test of students' mathematical logical intelligence should be conducted.

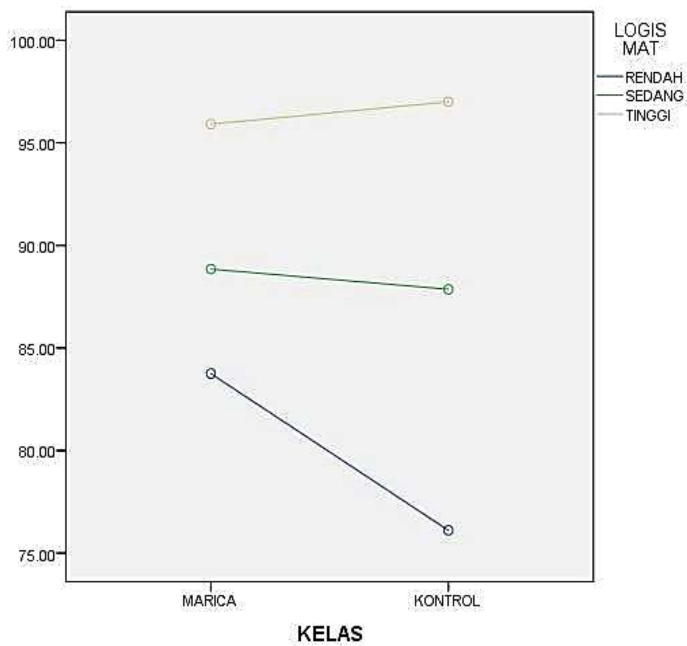

Figure 5. Estimated marginal means of students' mathematical representation ability

Table 3. Analisys results from post hoc test

Math Logic Intelligence		**Mean Differences**	**Std. Error**	**Sig.**	**Confidence Interval**	
					Lower Bound	**Upper Bound**
High	Moderate	7.35*	2.889	.047	.07	14.64
	Low	13.23*	3.419	.001	4.60	21.85
Moderate	High	-7.35*	2.889	.047	- 14.64	-.07
	Low	5.87	3.091	.175	-1.93	13.67
Low	High	-13.23*	3.419	.001	-21.85	- 4.60
	Moderate	-5.87	3.091	.175	- 13.67	1.93

From the table 3 above, with the error term is Mean quare (Error) = 83.825 and it is evident that all differences in levels of students' mathematical logical intelligence are significant. This means that when looking at the means, the mean mathematical representation ability of students with high levels of mathematical logical intelligence is better than those with moderate levels, and similarly, the mean mathematical representation ability of students with moderate levels is better than those with low levels. This finding is consistent with the research conducted by Mutianah, Indiati, and Endahwari (2021), which indicates that students with high levels of mathematical logical intelligence demonstrate proficiency in all indicators of mathematical representation ability and are able to utilize various representations, such as symbolic representation, visual representation, and verbal representation, compared to students with moderate levels of mathematical logical intelligence. However, students with low levels of mathematical logical intelligence tend to struggle in pattern recognition and problem modeling. This may be attributed to a bias, considering the research subjects are first-grade elementary school students, who may still rely on reading questions aloud while answering mathematical representation tests. This is in line with the research conducted by Hui & Mahmud, M. S. (2023), the study results demonstrate that Game-Based Learning (GBL) has a positive impact on students' mathematics learning. It encompasses two cognitive domains (knowledge and mathematical skills) and five affective domains (achievement, attitude, motivation, interest, and engagement). The findings of this study are expected to inspire educators to be more effective in classrooms. However, there is an interesting observation regarding the mathematical representation ability of students with moderate levels of mathematical logical intelligence, which shows comparable results to students with low levels of mathematical logical intelligence in the topic of plane geometry.

Data on students' positive attitudes towards learning is displayed in the following histogram:

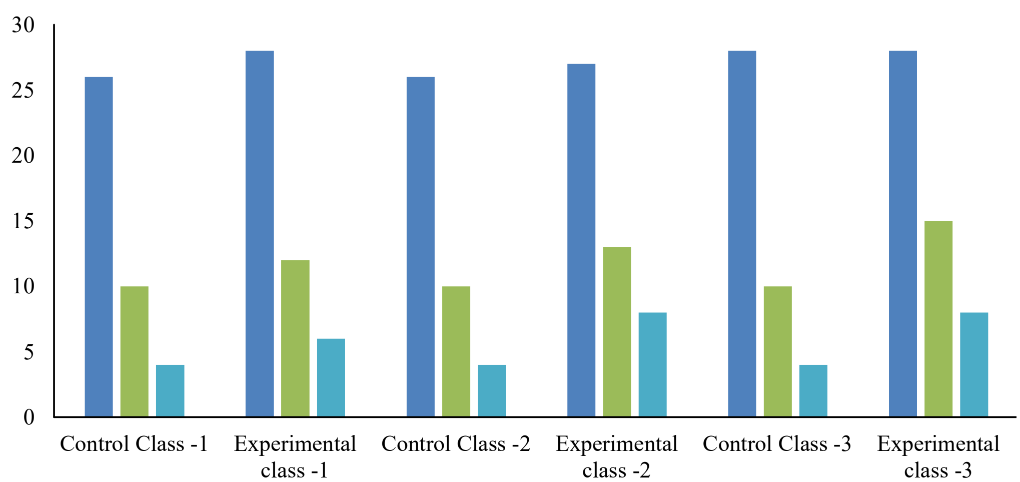

Figure 6. Data on students' positive attitudes

This data is based on the number of students who show a positive attitudes. The histogram presents an interesting finding regarding independent attitude of students, where there is almost no difference level between the control and class that using the MARICA instructional media. A difference was noticed in terms of students' critical thinking and creativity when studying concepts of plane geometry. In both aspects, the class using the MARICA shows better attitude scores compared to the control class. This may be attributed to the characteristics of elementary school students, particularly in lower grades, where the facilitation and teaching style of the teacher are not rigid, creating a comfortable learning environment. The competitive nature within the classroom also tends to dominate among all students. However, there is a noticeable difference in terms of critical thinking, as demonstrated through the ability to ask questions, express opinions, and exhibit creativity in processing/answering the student worksheet provided by the authors. In the control class, students still struggle with differentiating between different types of plane figures, such as considering a square and a rectangle to be the same as a square box. The characteristics of elementary school- aged children, who tend to prefer moving images, especially when designed with animation and sound, result in an educational video game that emphasizes reasoning skills, problem-solving, and the courage to express opinions based on MARICA video assistance. Surprisingly, this approach proves effective in eliciting positive responses from students in the learning process. The diversity of thinking activities and interactions in the MARICA media available in the online games presented here provides opportunities for students to explore abstract mathematical concepts and healthy competition. Moreover, the use of this media in mathematics classes is a new experience for students. A new experience where students learn the concept of fractions without feeling like they are under direct instruction from the teacher, receiving definitions or concepts from the teacher, practicing exercises; it provides an enjoyable alternative for learning while also cultivating a sense of joy in students and fostering

healthy communication between teachers and peers. As a result, students show a positive response to the media and their learning and there are differences in showing creative attitudes and critical reasoning.

This is in line with the research results that stated that concerning the enthusiasm for mathematics, the examination revealed that the low-achieving students demonstrated a comparable level of interest to the entire sample, encompassing aspects such as attitude, initiative, and confidence (Yeh et al., 2019). For the students, the game-based user interface not only made them feel like they were engaging with mathematics but also provided a sense of accomplishment akin to participating in a competition when they successfully completed a task that the low-achieving students demonstrated a comparable level of interest to the entire sample, encompassing aspects such as attitude, initiative, and confidence. For the students, the game-based user interface not only made them feel like they were engaging with mathematics but also provided a sense of accomplishment akin to participating in a competition when they successfully completed a task. Similarly, in the study by Cankaya & Karamete (2008), it was found that students' attitudes towards both mathematics course and educational computer games became positive.

■ CONCLUSION

Based on the results and discussions above, the following conclusions can be drawn that the using of the MARICA instructional media affects students' mathematical representation ability in the topic of plane geometry. And differences in levels of mathematical logical intelligence affects students' mathematical representation ability. Regarding levels of mathematical logical intelligence (high, moderate, and low), it is found that students with high levels of mathematical logical intelligence have better mathematical representation abilities compared to students with moderate and low levels of mathematical logical intelligence. Similarly, students with moderate levels of mathematical logical intelligence exhibit better mathematical representation abilities compared to students with low levels of mathematical logical intelligence.

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