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The Use of Mathematics Comics to Develop Logical-Mathematical Intelligence for Junior High School Students

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Abstract: Logical-mathematical intelligence is highly needed to ease students' understanding of mathematics concepts. Therefore, it is necessary to delivery an innovative teaching approach to enhance students' logical-mathematical intelligence. This study aims to investigate the use of mathematics comics to increase the logical-mathematical intelligence of junior high school students in urban and rural schools. This study employed a quantitative approach with a pretest-posttest control group design. The population of this study were seventh-grade students from a junior high school in Banda Aceh (urban areas) and a junior high school in Aceh Besar (rural areas), Indonesia. The samples of this study were two classes (experimental and control) from each school which were selected randomly. To collect data, we used a logical-mathematical intelligence test and analyzed it by using t-test. This study shows that the use of mathematical comics in urban schools can improve mathematical logical intelligence. However, there was no improvement in students' mathematical logical intelligence in rural schools. Therefore, this study showed that using mathematics comics in different school conditions yield different results in logical-mathematical intelligence. The findings suggest that other learning innovations are required to improve students' logical-mathematical intelligence in rural areas.

Keywords: *Logical-mathematical intelligence, mathematics comics, rural school students, urban school students.*

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Introduction

The development of the world cannot be separated from the role of mathematics. This principle is closely related to the application of mathematics in daily life. Cockroft (1982) reveals that the reason to learn mathematics is that mathematics is always used in all aspects of life. Students' difficulty learning mathematics will also affect their daily lives (Sarama & Clements, 2009).

Mathematical problems in daily life can be solved if someone has logical-mathematical intelligence (Campbell, 2004). One who has good logical-mathematical intelligence can solve mathematical problems well (Martin, 2001). This ability is important in learning so that students easily understand the lesson presented by teachers. Gardner (2011) explains that one with the logical-mathematical intelligence ability can construct a solution before it is articulated. Students with well-developed logical-mathematical intelligence can also observe and recognize patterns and relationships in learning (Gunawan, 2011). This concept also enables students to use and understand abstract relationships and skills in using numbers and logical thinking (Baum et al., 2005).

Students with logical-mathematical intelligence can operate numbers and calculations and possess logical and scientific thinking and patterns (Lwin et al., 2008). In addition to that, students can classify objects into several categories, identify logical relationships between events, and perform quantitative calculations to identify real relationships between events (Korkmaz, 2016; Saban, 2002). Many factors affect students' logical-mathematical intelligence. Sheoran et al. (2019) mention that family type, number of siblings, living environment, school environment, and interactions with teachers have a significant relationship with students' logical-mathematical intelligence.

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Hernández-Torrano's (2018) study on the urban-rural school achievement gap shows that urban students outperform rural students in mathematics learning. One of the intelligences that can be measured in mathematics learning is mathematical logical intelligence (Gardner, 1999). Therefore, the focus of this research is the logical-mathematical intelligence of students in urban and rural areas. It is necessary to provide students with various learning resources that fit their characteristics (Stronge, 2018).

Learning media has important contributions to the learning process, such as facilitating the delivery of messages, making the learning process more interesting and interactive, shortening the duration of learning, improving learning quality, making the learning process effective at anytime and anywhere, building positive attitudes of students towards the lesson as well as improving the learning process and constituting teachers' roles as not the only sources of learning (Kemp & Dayton, 1985). The use of learning media has to be appropriate to overall learning objectives in which this approach can play a good and influential role in learning activities (Arsyad, 2017). Learning media can attract students' attention, foster learning motivation, and generate learning to be easily understood by students so that the learning objectives will be achieved. It also encourages students to be more active and makes learning more visible (Buckingham, 2012). This approach can enhance learning so that it becomes more meaningful. One of the media used in mathematics learning is comics.

The use of mathematics comics can stimulate logical-mathematical intelligence (Smart, 2012). Comics positively contribute to the teaching and learning process (Mamolo, 2019). Comics can be an option for learning media since students' reading preference for entertainment media, such as comics, is higher than textbooks (Kersulov, 2019). Comics are used not only as entertainment media but also as learning media (Hidayah & Fathimatuzzahra, 2019) and help students capture things or abstract concepts (Daryanto, 2016). The use of comics is part of an important strategy that is indispensable in the teaching and learning process. It can lead to an interactive learning atmosphere and makes students easily understand the lesson. Besides, this approach creates an instructional role in promoting students' interest in learning (McGeown et al., 2016).

Comics used in the teaching and learning process can increase motivation and stimulation in learning activities, as well as deserting psychological effects on students (Buchori & Setyawati, 2015). Toh et al. (2017) have proven that learning mathematics using comics helps teachers develop students' skills and maintain students' interests. Comics can help students learn and make learning more interactive (Özdemir, 2017). Comics are also highly effective in improving students' reading literacy (Surya et al., 2020). Therefore, the use of comics can increase academic success in education.

The mathematics comic utilized in this study is a comic with a disaster context. This context is applied as it is close to students' lives. Disasters that occurred in Aceh, such as earthquakes and tsunamis, have devastated not only rural areas but also urban areas (National Agency for Disaster Management, 2015). Therefore, using mathematics comics with a disaster context seems relevant for schools in urban and rural settings.

Several previous studies about schools in urban and rural settings have been carried out. One of them is a study by Ariyanti and Santoso (2020) on students' attitudes and confidence in science learning: in rural and urban junior high schools. The study showed that students' attitudes and self-confidence in urban schools tended to be higher than students in rural schools. Moreover, Kumar's (2020) study on the emotional intelligence of high school students found no significant difference in emotional intelligence in high school students from urban and rural areas. Furthermore, research on comics has also been carried out in mathematics learning, for example, the research of Toh et al. (2017) on the integration of comic media into mathematics learning. Their study indicated that the use of comics could improve the quality of learning. Besides, teachers can develop 21st-century learning skills and maintain student interest in learning. Then, Wijayanti et al. (2018) researched using whiteboard animation-based comic math media in a mathematics lesson. Their study showed that using math comic media based on whiteboard animation positively impacted students' achievement. Thus, it can be stated that learning utilizing math comic media based on whiteboard animation is effective for mathematics learning. In addition, a study conducted by Nalurita et al. (2021) on mathematical solving abilities in terms of adversity quotient through problem-based learning assisted by electronic mathematics comics. The result revealed that problem-based learning with electronic mathematics comics effectively improved problem-solving skills. Last, the research on the development of digital mathematics comics has been carried out by Rohaizati (2020) to the stage of testing the validity and practicality. However, no research has been conducted on the use of mathematics comics to improve students' logical-mathematical intelligence, especially in comparing students in urban schools to those in rural schools.

The use of comics in mathematics learning can improve students' logical-mathematical intelligence because comics' contexts are related to everyday life. Using familiar contexts for students makes learning meaningful (Akkaya, 2013; Meletiou-Mavrotheris & Paparistodemou, 2015). In addition, comics provide visual images that help students to understand and remember the learning material well (Marianthi et al., 2016).

The comic used in this study can enhance students' logical-mathematical intelligence as students are required to use the logic of mathematics in solving mathematical problems provided in the comic. In solving mathematical problems, students must have skills in relating the problems in comics with everyday life (Korkmaz, 2016). Students with good

logical-mathematical intelligence can use reasoning and logic well (Denig, 2004) and relate it to everyday life from any mathematical problem (Korkmaz, 2016; Saban, 2002).

Therefore, it is crucial to research increasing students' logical-mathematical intelligence, especially those in urban and rural schools using mathematics comics. Finally, this current study intends to answer the following research questions.

1. Is there a significant difference in the increase in logical-mathematical intelligence between students taught using digital comics and students taught without using mathematics comics?
2. Is there a significant difference in the increase in logical intelligence between students in urban schools and students in rural schools taught using mathematics comics?

Literature Review

Mathematics Comic and Logical-Mathematical Intelligence

Various ways can be carried out to introduce local context to students to promote learning becomes meaningful (Meletiou-Mavrotheris & Paparistodemou, 2015). The integration of context in learning can be done through using a comic into teaching it can be used as a source of learning in education (Berkowitz & Packer, 2001; Cimermanová, 2015; Rajendra, 2015). In the learning proces, it is important to maintain students' interest by presenting information both visually and verbally (Marianthi et al., 2016). Therefore, comics used in learning should contain educational elements (Akkaya, 2013; Joshi et al., 2019). Comics will support student learning if they present an interesting context and connect them with students' real-life experiences (Toh et al., 2016). Furthemore, the use of comics can foster students' interest and create an effective learningenvironmentt (von Vulte, 2014). The advantage of using comics can be adopted in mathematics learning to improve students' achivement such as in the aspect of mathematical logical intelligence.

Logical-mathematical intelligence is one of the eight types of human intelligence (Gardner, 1983). This concept relates to counting or using numbers in daily life (Gardner, 1999). According to Armstrong (2009), logical-mathematical intelligence is the ability to use numbers effectively, sensitivity to logical patterns and relationships, classification, generalization, calculation, and hypothesis testing, and the ability to reason logically on abstract problems and relate them to others.

The comic used in this study contain non-routine mathematical problems developed based on logical-mathematical intelligence indicators proposed by Willis and Johnson (2001), including forming hypotheses, reasoning, mathematical arithmetic operations, classifying, and comparing. This comic uses contexts that relate to everyday life so that students can connect mathematics learning to real situations they encounter in their daily lives. The mathematical problem in the comic and the context of the comic can also help students understand mathematics and enhance their logical-mathematical intelligence. When the students read the comic, they were guided to solve mathematical problems using their logical ways. In addition, students were required to build their mathematical models in solving the problem. Furthermore, the image provided in the comic help students engages with the content of mathematics, therefore, it is easy for them to understand and remember it (Marianthi et al., 2016).

Studies on the use of comics in mathematics education has been widely conducted, such as the study by Lestari et al. (2021). Previous studies indicate that the use of mathematics comics is effective in increasing students' intelligence and character. For example, Ariesta and Purwanti (2019) show that the use of comics in teaching can increase students' critical thinking skill. Furthermore, in the context of mathematics teaching, the use of comics can increase students' motivation and skills of the 21st century (Toh et al., 2017; Trimurtini et al., 2020), encourage students to improve their learning performance (Hosler & Boomer, 2011; Wijayanti et al., 2018), and has a positive impact on student learning performance (Azamain et al., 2020; Puspitorini et al., 2014). However, there has been a lack of research on the use of comics to develop mathematical logical intelligence in students.

Education in Rural and Urban School

It is widely believed that education in rural and urban areas is different where rural areas are generally remote and relatively backward. As a result, many schools in the rural area lack the supporting resources to achieve learning goals (Mulford & Johns, 2004). Students in rural areas find it difficult to get involved in education due toa lack of access to educational resources, which results in lower educational achievement (Taylor & Mulhall, 2001). Furthermore, students in rural schools, especially in remote rural schools, may be limited by the narrow curriculum coverage at their schools (Monk, 2007) and limited practical activities (Howley et al., 2009).

Many factors lead to low participation in education in rural schools compared to an urban school. For instance, the motivation of rural students to go to school is lower than urban students (Lockheed & Verspoor, 1991). In the learning process, rural schools rarely present examples related to daily life, or to connect the curriculum with local needs (Taylor & Mulhall, 2001).

Research on urban and rural school students has been extensively conducted. For instance, Addiniya et al. (2019) studied the comparison of intelligence based on short-term memory tests between urban and rural children. The results of the study show that the quality of the method needs to be improved to develop the intelligence of rural students. Furthermore, Herrera et al. (2015) investigated the socio-emotional intelligence of urban and rural students. Their study showed that the socio-emotional intelligence of urban students is different from that of rural students. However, there has been a lack of study on investigating the mathematical logical intelligence of urban and rural school students. Therefore, this research examines the differences in mathematical logical intelligence of urban and rural students. This study used mathematical comics with mathematical problems that contain indicators of mathematical logical intelligence and integrates contexts that are close to the students' daily life.

Methodology

Research Design

The present study is quantitative research and a continuation of developmental research conducted by Rohaizati (2020) related to the development of digital mathematics comics situated in the disaster context for seventh-grade students of junior high school. The comics used in this study were developed by Rohaizati (2020). Then we redeveloped several parts of the comic according to the needs of the research and the comic was added several parts. We then carried out the stages of testing the validity and reliability. The comic used a disaster context for three lessons. It consists of 48 pages and 3 parts. Part 1 contains material for comparison of value, part 2 for comparison of value and scale, and part 3 for comparison and scale. This study used a pretest-posttest control group design in which the group was randomly chosen (Creswell, 2014). In this research design, two groups were randomly chosen, then given a pre-test to investigate their initial ability. According to Creswell (2014), this design is depicted as follows.

Experimental Group : O_1 X O_2

Control Group : O_1 O_2

Where:

O_1 : Pre-test

X : Learning using a mathematics comic.

O_2 : Post-test

Sample and Data Collection

The population in this study involved seventh-grade students in one of the junior high schools both in Banda Aceh and Aceh Besar. Those schools are located in disaster-prone areas and are Disaster Preparedness Schools (DPS). Besides, one of the junior high schools in Banda Aceh is located in the city, while those in Aceh Besar are located in rural areas. Samples were randomly chosen that consisted of four classes–two experimental classes and two control classes. Each school had one experimental class and one control class. The characteristics of the respondents are presented in Table 1.

Table 1. Descriptive Statistics of Respondent

Items	Type	Frequency	Percentage
Gender	Male	60	49.18%
	Female	62	50.82%
Age	12	122	100%

The experimental and control classes consisted of students with the same mathematical ability. To ensure this, we conducted the normality and homogeneity tests.

The Logical-mathematical intelligence test was given before (pre-test) and after learning (post-test). The post-test used to assess students' logical-mathematical intelligence was developed by Fatimah (2020). Meanwhile, we develop the pre-test test questions with the same level as the post-test question. The test was designed using essay questions and met five indicators: forming hypotheses and rechecking hypotheses that have been made, comparing, inductive and deductive reasoning, mathematical operations, and classification (Willis & Johnson, 2001). Table 2 shows indicators of post-test and pre-test questions.

Table 2. Indicators of Test Question

No.	Indicators of logical-mathematical intelligence	Indicators of questions	Questions
1.	Forming hypotheses and rechecking hypotheses that have been made	Given data, students are expected to be able to predict the time and present the data into a graph and interpret it	3
2.	Comparing	Given a map of an area, including walking tracks, students are expected to be able to compare the tracks and choose the shortest one.	4
3.	Inductive and deductive reasoning	Given information about food, students are expected to be able to do a comparison and reasoning	1
4.	Mathematical operations	Given information about salary, students are expected to be able to determine the time required to get the highest salary	2a, 2b
5	Classification		

> Mangrove forests can be used to reduce the impact of tsunamis. After the 2004 tsunami in Indonesia, 30 million mangroves have been planted with the height of 60 cm in 2006. Within five years, the mangrove reached 110 cm. Mangrove with the height of 6 meters are able to break 3 meters tsunami waves. Please predict the ability of the mangrove to reduce the impact of tsunamis if it happens this year in the same location.

Below is one of the questions that were given to the students.

Before being administered to students, the test was validated based on the data obtained from Fatimah's (2020) study to evaluate the accuracy and validity of the instrument. Further, to maintain the equivalence of the questions, the pre-test was validated by three experts (lecturers). The experts suggested that the test can be used with minor revision. The result of the validity test is presented in Table 3.

Table 3. The Validity Test for Logical-Mathematical Intelligence Test

Question	Correlation coefficient (r_{xy})	Obtained value	Critical value	Remark	Interpretation
1.	0.94	14.64	1.6991	valid	Very high
2.	0.95	16.75	1.6991	valid	Very high
3.	0.92	12.45	1.6991	valid	Very high
4.	0.82	7.76	1.6991	valid	High

Table 3 shows that the four questions of the logical-mathematical intelligence test have very high interpretation. We may conclude that all items of the test can be employed to assess logical-mathematical intelligence.

Moreover, the instrument tested its reliability to ensure its consistency. The results showed that the reliability of the test items has a value of $\alpha = 0.843$, which implies that the four items have high reliability. Thus, the test items have a good consistency even though they were solved by any other people with a similar level of ability.

In this study, we design a mathematical comic in full colour. This comic sets a story about a boy named Richo who has a holiday in Indonesia with his father, Mr. Richard, a researcher at the States Geological Survey (USGS), and Mr. Kaoy, a village leader where Richo and his father stay. The title of the comic is Holiday in Aceh. In this comic, we include the contents of mathematics for comparing and scaling topics. Figure 1 shows one of the problems provided in the comic.

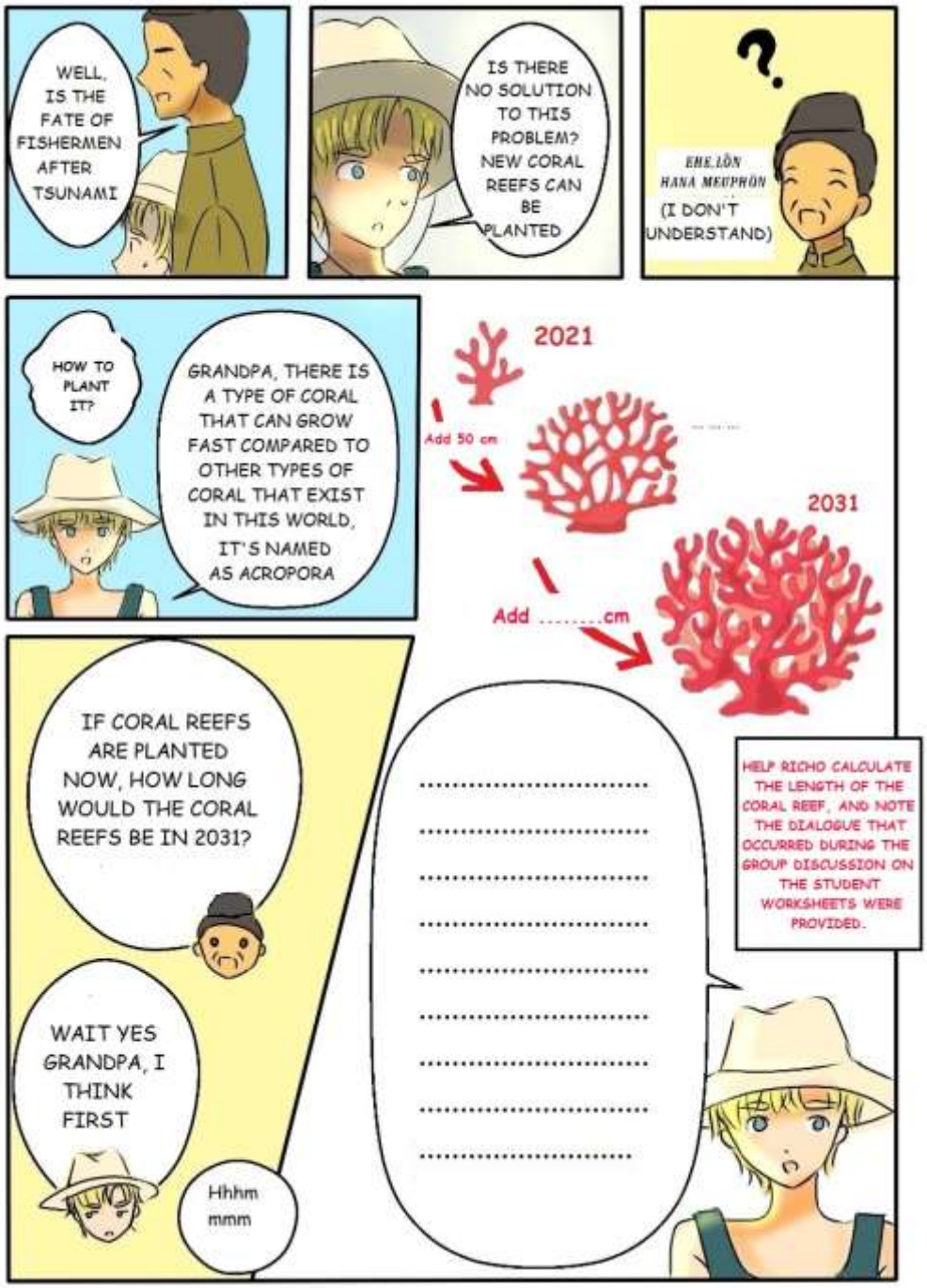

Figure 1. One of The Problems Presented in The Comic

We distributed the comic to students before the teaching and learning process. Students already read the comic at home. Also, the students continue reading the comic in the classroom during the lesson. Students worked in a group and discussed the problem presented in the comic in the classroom. The problems presented in the comic promote logical intelligence on the topic of comparison and scale. Before solving the problems, students were assigned with readings related to the problems. Furthermore, the students presented their work in front of the class.

The information obtained by students in the control class is the same as that of students in the experimental class. However, students in the control class were not given comics while studying. They learning through direct instruction by the teacher. The control and experimental group were assigned with the same assignment. Before the group assignments were assigned, the teacher in the control class distributed reading materials to make it easier for students to work on group assignments. Furthermore, control class students also discussed the problems and presented the results of group work.

Data on the logical-mathematical intelligence of students were obtained through pre-test and post-test carried out before and after learning both in the experimental and control groups. In the experimental class, before learning began,

students were given a mathematics comic to read at home since the time available at school was limited. During the learning, the comic was read briefly. The learning was carried out for three meetings, and two meetings were allocated to administer the pre-test and post-test.

Analyzing of Data

The data involved quantitative data obtained from students' logical-mathematical intelligence test results. The analysis process includes 1) calculating pre-test, post-test, and gain scores; and 2) calculating the increase in students' logical-mathematical intelligence derived from the pre-test and post-test scores using the normalized gain formula (N-Gain). According to Hake (1999), the gain index criteria are presented as follows.

Table 4. Normalized Gain Score Criteria

Normalized Gain Score	Interpretation
$0{,}70 < g$	High
$0{,}30 \leq g \leq 0{,}70$	Medium
$g < 0{,}30$	Low

Results

Mean and N-Gain Scores of Logical-Mathematical Intelligence

Pre-test, post-test, and N-gain scores for students' logical-mathematical intelligence were analyzed. The pre-test score was attained from the test before learning, while the post-test score was obtained from the test after learning. Since the pre-test aims to find the score before learning, we could notice the improvement in students' intelligence after the post-test. The difference between the pre-test and post-test will result in a gain score. The mean scores for pre-test and post-test are presented in Table 5 below.

Table 5. Logical-Mathematical Intelligence Scores

School	Score	Experimental		Control	
		N	$\bar{X}$	N	$\bar{X}$
The school is located in the urban area	Pre-test	27	50.49	27	46.01
	Post-test	27	70.17	27	58.68
The school is located in the rural area	Pre-test	34	45.15	34	43.03
	Post-test	34	55.65	34	52.79
Ideal maximum score = 100					

Based on Table 5, the experimental group who studied at the school located in the city gained a mean score of 50.49 in the pre-test, and the control group obtained 46.01. Meanwhile, the experimental group who studied at the school located in a rural area attained the mean score of 45.15 in the pre-test, and the control group achieved 43.03 out of 100 ideal maximum scores. This finding indicates that the pre-test scores of experimental and control groups from both schools were relatively similar. On the other hand, the post-test mean score of the experimental group from the school located in the city was 70.17, while the control group's was 58.68. In the rural school, the experimental group had a post-test mean score of 55.65, and the control group earned a score of 52.79. These scores show that there is an increase in logical-mathematical intelligence of students at urban and rural schools after learning, even though the increase is different.

N-gain scores of logical-mathematical intelligence of students in experimental and control classes are listed below.

Table 6. N-gain Scores for Students' Logical-Mathematical Intelligence

School	Experimental				Control			
	N	N-gain	Mean	Criteria	N	N-gain	Mean	Criteria
The school is located in the urban area	27	10.63	0.39	Medium	27	6.65	0.25	Low
The school is located in the rural area	34	6.27	0.18	Low	34	5.76	0.17	Low
Ideal maximum score = 100								

Table 6 indicates that the experimental groups from urban and rural schools that used a mathematics comic for learning had a greater N-gain score in total compared to the control groups that employed conventional learning without the mathematics comic. The total N-gain score of the experimental group in the urban school is 10.63, and the control group is 6.65, which has a difference of 3.98. The total N-gain score of the experimental group in the rural school is 6.27, and that of the control group is 5.76, with a difference of 0.51. These findings indicate that there is an

increase in the N-gain score for students' mathematical logical intelligence in urban and rural schools after the treatment.

Mean Scores of Logical-Mathematical Intelligence based on Each Indicator

The results show that the mean scores of students' logical-mathematical intelligence in urban and rural schools for each indicator are different. The mean score of students in the urban school for each indicator is described as follows.

Table 7. Mean Scores of Logical-Mathematical Intelligence of Students in the Urban School per Indicator

Class		Indicator				
		Forming Hypotheses and Rechecking Hypotheses	**Inductive and Deductive Reasoning**	**Mathematical Operations**	**Classifications**	**Comparing**
Experimental	Pre-test	12.61	13.59	4.62	7.06	14.00
	Post-test	17.5	15.4	5.20	13.3	21.50
	Difference	4.87	1.85	0.59	6.24	7.50
Control	Pre-test	9.98	11.2	4.04	7.84	15.40
	Post-test	11.2	13	5.79	10.4	21.10
	Difference	1.17	1.85	1.75	2.53	5.65

Based on Table 7, the logical-mathematical intelligence score of the experimental group students in the urban school for each indicator is greater than that of the control group in terms of forming hypotheses and rechecking hypotheses, inductive and deductive reasoning, classifications, and comparing. The mean score of students' logical-mathematical intelligence in the rural school for each indicator is depicted as follows. Furthermore, Table 8 describes that the experimental group from the urban school performed a better score in logical-mathematical intelligence compared to the control group in terms of inductive and deductive reasoning, mathematical operations, and comparing.

Table 8. Mean Scores of Logical-Mathematical Intelligence of Students in the Rural School per Indicator

Class		Indicator				
		Forming Hypotheses and Rechecking Hypotheses	**Inductive and Deductive Reasoning**	**Mathematical Operations**	**Classifications**	**Comparing**
Experimental	Pre-test	12.78	12.22	3.06	5.83	13.33
	Post-test	15.27	14.17	3.89	6.11	18.61
	Difference	2.49	1.95	0.83	0.28	5.28
Control	Pre-test	11.94	11.38	2.50	7.50	11.67
	Post-test	13.89	12.78	4.44	8.61	16.11
	Difference	1.95	1.40	1.94	1.11	4.44

Prior employing the t test, the N-Gain score had satisfied normality and homogeneity. The following table presents the results of the difference test in the average N-gain score of logical-mathematical intelligence.

Table 9. The t-test results of N-Gain Score of Logical-Mathematical Intelligence

School	t-test for Equality of Means			Conclusion
	f	df	Sig.	
Schools located in the urban areas	0.293	52	0.018	Significant
Schools located in the rural areas	0.000	66	0.670	Not Significant

Table 9 illustrates that the urban and rural schools obtain significance values of 0.018 and 0.670, respectively. The urban school has a significance value of less than α=0.05, meaning that there is a significant difference. One may conclude that in the urban school, students' logical-mathematical intelligence taught using a mathematics comic is better than students' who learned without the comic. The rural school has a significance value greater than α=0.05, meaning that there is no significant difference. Therefore, in the rural school, there is no difference in logical-mathematical intelligence between students given a mathematics comic and those who are not.

Discussion

This study aims to investigate the increase in logical-mathematical intelligence of junior high school students through the use of a mathematics comic, which focuses on examining differences logical-mathematical intelligence of students from urban and rural schools. Three important findings need to discuss. First, the logical-mathematical intelligence of students in urban and rural schools improves after learning using the mathematics comic. The logical-mathematical intelligence of experimental students in the urban school is better than that of the control group students in terms of generating hypotheses, reasoning, classifying, and comparing indicators. The finding is consistent with previous studies (Chen, 2012; Hernández-Torrano, 2018; Lounkaew, 2013; Stout, 2002; Williams, 2005), stating that students in urban schools have better mathematical ability compared to those in rural schools. It is also aligned with a study conducted by Graham and Provost (2012) and Xu and Qi (2019), revealing that students in rural schools do not perform well in mathematics than those in urban schools. Chianson (2012) reported that the ability of urban school students is better than that of students in rural schools. Tanti et al. (2020) also showed that students' in urban schools have stronger critical thinking that thoses in rural schools.

Second, in the urban school, in terms of mathematical logical intelligence, students in experimental groups performed better than those in the control groups. This finding is relevant to Shadiq's (2016) study on the integration of disaster context into mathematics learning had positive impacts on the learning process and mad it meaningful. Simamora et al. (2019) also revealed that the use of context in mathematics teaching can improvestudents' mathematical problem solving ability and self-efficacy. The use of context in teaching can promote meaningful learning as it is related to students' life. (Nizar et al., 2018; Yansen et al., 2018; Pratiwi et al., 2019; Jannah et al., 2019; Rawani et al., 2019; Efriani et al., 2019). In addition, Paraol and Stormowski (2022) also argued the important of meaningful context in learning of mathematics.

Third, in the rural school, on the other hand, there was no difference in the increase in logical-mathematical intelligence between students given a mathematics comic and students taught conventionally. However, the logical-mathematical intelligence of students in the experimental class is better than students' in the control class on several indicators: inductive and deductive reasoning, mathematical operations, and comparing. The results of interviews with students in the experimental class revealed that students not given a mathematics comic (the control class) read the comic belonging to their friends in the experimental class. In the same way, the interviews with several students in the experimental class reported that some students in the control group had read the comic provided to the experimental class. This evidence may contribute to why there is no difference in the increase in logical-mathematical intelligence between students taught using the mathematics comic and students who are not. Such an event is known as the diffusion of treatments. According to Cambell and Stanley (as cited in Ross & Morrison, 2004), diffusion of treatments occurs when the control group learns from the experimental group, either intentionally or not. As such, there was a pervasiveness of learning from the experimental class to the control class.

The condition happens because the variables outside the control class affect the dependent variables, commonly called extraneous variables. The extraneous variables are uncontrolled independent variables that may affect the experiment. According to Frankel et al. (2012), extraneous variables are independent variables that have not been controlled, that is, variables that cannot be manipulated by the researchers but have a significant influence on the dependent variables. This variable is an aspect in the research that allows influencing the dependent variables, but its existence is unknown.

Conclusion

The study investigated the use of mathematics comics to enhance students' logical mathematic intelligence. Therefore, it enhances the literature on using comics for teaching and learning mathematics. The study is the first empirical study to investigate comics' use to enhance students' logical mathematics intelligence. This study suggests that the use of comic in learning mathematic effectively improve students' mathematical logical intelligence of students in urban schools. The findings revealed that using a mathematics comic in schools with different conditions gives different results in logical-mathematical intelligence. Therefore, it is essential to consider a school setting when implementing innovation in the teaching and learning process.

Recommendations

The present study has revealed that the use of mathematical comics in teaching mathematics significantly improved students' logical-mathematical intelligence of students in urban schools. On the other, this teaching innovation did not have significant impact on students in rural schools. Therefore, we suggest for teachers and educator to promote the use of comics with a context related to students' life in teaching mathematics. Furthermore, for a future study, it is necessary to investigate why this innovation did not work well for students in rural schools and propose a different innovation for them.

Limitations

This study had two limitations. First, it is challenging to develop mathematical task with logical-mathematical intelligence indicators. Second, this study was conducted during the COVID-19 pandemic. Therefore, time for data collection is limited.

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Authorship Contribution Statement

Johar and Mailizar were involved in planning and supervised the work, Safitri processed the experimental data, performed the analysis, Johar, Mailizar and Safitri drafted the manuscript and designed the figures. Zubainur and Suhartati aided in interpreting the results and worked on the manuscript. All authors discussed the results and commented on the manuscript.

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