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Original Research

The Effect of The Use of Digital Mathematics Comic Media on Students' Mathematical Representation and Resilience

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Abstract: This study is grounded in a document analysis and interviews performed at *SMPN* 33 Bandar Lampung, which indicated that students' mathematical representation and resilience skills remain inadequate. Furthermore, it was noted that the educational tactics utilized were repetitive and had not integrated technology. This study aims to enhance students' positive attitudes toward mathematics learning (mathematical resilience) and their mathematical representation skills via digital mathematics comic learning media. The quasi-experimental study design employed a nonequivalent control group framework. The sample was determined using a purposive sampling technique, in which two intact seventh-grade classes were deliberately selected as the experimental and control groups. The study was performed at *SMPN* 33 Bandar Lampung. The sample comprised 55 seventh-grade students, with 30 participants in the experimental group and 25 participants in the control group. The instruments consisted of a mathematical representation test and a mathematical resilience questionnaire, both developed by the researchers and validated by expert validators prior to use. The data from the pretest and posttest were examined descriptively using the normalized gain (N-gain) score and inferentially via an independent samples t-test. The data analysis results demonstrated that the utilization of digital mathematics comic media substantially enhanced students' mathematical representation abilities and resilience. However, inferential analysis did not indicated a significant increase.

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INTRODUCTION

Mathematical representation ability refers to the capacity to articulate mathematical concepts (such as problems, assertions, and definitions, etc.) across diverse modalities (Syafri, 2017). Mathematical representation skills are necessary for students to understand and communicate mathematical concepts (Mahendra, Mulyono, & Isnarto, 2019). as stated by Rila and Aziz (2020), "Each student uses a different representation to show what they know; ultimately, using these representations helps students understand mathematical concepts." 2022). The National Council of Teachers of Mathematics (NCTM) in Puspandari et al. stated that the ability to represent is very important in mathematics learning at the school level (Puspandari, Praja, & Muhtarulloh, 2019). NCTM in Syafri defines three standards of representational ability as follows: the first standard refers to the use of representations to organize, record, and communicate mathematical concepts; the second standard refers to the selection, use, and translation of representations in problem solving; and the third standard refers to the use of representations to model and interpret physical, mathematical, and social phenomena (Syafri, 2017).

However, research by Nurhayati et al., as cited in Putra et al.'s field shows that students often have low mathematical representation skills. This occurs for various reasons, one being that students often comply with the teacher's directions without grasping the essential concepts required to excel in mathematics (Putra et al., 2024). A lack of deep understanding and confidence when facing problems can hinder students' academic progress. To overcome this, mathematical resilience which involves positive emotions that enchance problem-solving abilities, is needed (Rahmatiya & Miatun, 2020).

Research finding by Kurnia et al. (2018) indicate that students exhibiting high resilience possess strong mathematical problem-solving abilities and demonstrate confidence while confronting challenges. In contrast, students exhibiting moderate resilience demonstrate diminished conscientiousness, reduced confidence, and an increased propensity to give up when confronted with challenges. Based on the results of the initial research in the form of tests and observations with grade VII mathematics teachers and observations at *SMP Negeri* 33 Bandar Lampung, the results of the Final Semester Exam (UAS) for mathematics subjects showed that out of a total of 178 students in grade VII (classes A, B, C, D, and E), 128 students (71.9%) had not completed the *KKTP*, while only 50 students (28.09%) had exceeded it. The high proportion of student scores is below the *KKTP* standard, indicates that student achievement has not met anticipated levels. Furthermore, the findings from the interviews with the seventh-grade mathematics teacher at *SMP Negeri* 33 Bandar Lampung revealed that during the teaching and learning process, most students in the class listened to the explanations, although at times their attention would shift to unrelated matters. The questionnaire results indicated that of the 32 respondents, 21.88% were categorized as low, 56.25% as moderate, and 21.88% as high. The results from the interviews and questionnaires revealed that students' resilience in mathematics is suboptimal, resulting in inadequate effort in problem-solving. Consequently, the objectives of mathematics education, particularly regarding representation skills and mathematical resilience, have not been adequately met.

One alternative medium that can address these problems is the digital mathematics comic, an instructional medium that presents mathematical content through a sequence of illustrated panels, dialogue, and a narrative storyline displayed on a digital platform that students can access independently. This medium was selected because comics combine visual representations with a contextual narrative, allowing abstract mathematical ideas to be introduced gradually through situations that are familiar to students. This approach also makes the learning process more engaging and reduces students' anxiety towards mathematics. The digital mathematical comic developed in this study covers the topic of lines and angles, encompassing the concepts of complementary and supplementary angles, vertical angles, and the angles formed when two parallel lines are cut by a transversal line. This topic was selected because this topic requires students to interpret geometric relationships and is closely related to objects and situations encountered in students' daily live, thereby providing ample opportunities for them to practice multiple forms of mathematical

representation, including verbal, visual, and symbolic representations, while working through realistic problem situations.

Mathematics educators must focus on the elements of representation and mathematical reasoning during the learning process. Moreover, the study of mathematics requires instruction that assist students in improving their abilities in abstract representation by offering opportunities to develop mathematical knowledge and concepts. The purpose of this study was to determine the influence of using digital mathematical comic media on students' mathematical representation skills mathematical resilience.

METHOD

This research was conducted using a quantitative approach within a pre-experimental design structure, specifically the *Nonequivalent Control Group Design*. Experimental quantitative research is a type of research that provides treatment within a specific scope, aiming to examine certain influences and treatments (Sugiyono, 2013). The participants consisted of 55 students, including 30 in the experimental group and 25 in the control group. The research instruments used were tests, questionnaires, and documentation. In this research, pretest and posttest assessment tools were employed as a written examination presented in a descriptive format. Before the intervention with digital mathematics comic media took place, a pretest was administered to evaluate students' representation skills and mathematical resilience in the seventh grade. In this study, the posttest was carried out after students engage with digital mathematics comic media to evaluate their representation skills and mathematical resilience. Table 1. provides an overview of the research design used by the researcher.

Table 1. Research Design

Classes	*Pre-test*	Treatment	*Post-test*
Experiments	*O1*	X	*O2*
Controls	*O1*	Y	*O2*

Description:

O1 : *Pre-test of students'* representational ability and mathematical resilience
X : Treatment in the form of learning using digital mathematics comic media in the experimental class
Y : Treatment in the form of learning using conventional learning media in the control class
O2 : *Post-test of students'* representational ability and mathematical resilience

The sampling technique employed in this study was purposive sampling, in which two intact seventh-grade classes at *SMPN* 33 Bandar Lampung were deliberately selected as the experimental and control groups based on certain considerations relevant to the research objectives, such as the comparability of the two classes' characteristics and the feasibility of implementing the digital mathematics comic media within the available class schedule.

The mathematical representation test was developed by the researchers in the form of five descriptive items on the topic of lines and angles, specifically the relationships between angles formed by two parallel lines cut by a transversal line, constructed to measure three indicators of mathematical representation: (1) verbal representation, namely the ability to answer a problem in the form of words or written text; (2) visual representation, namely the ability to re-present given data or information into a picture, diagram, or table; and (3) symbolic representation, namely the ability to solve a problem by constructing a mathematical expression or model (Santoso & Sari, 2023). The preparation of the test instrument followed several stages, beginning with the construction of an item blueprint that mapped each indicator to specific items together with a scoring rubric and an answer key, followed by an expert validation process to assess the content and construct validity of the items, after which the items were revised based on the validators' suggestions before the instrument was used for data collection.

The mathematical resilience questionnaire was likewise developed by the researchers in the form of 30 statements using a Likert scale with five response categories (strongly agree, agree, undecided, disagree, strongly disagree), arranged based on a blueprint covering six indicators: (1) being persistent, confident, and hard-working, and not easily giving up when facing problems, failure, and uncertainty; (2) the willingness to socialize, help others easily, discuss with peers, and adapt to the surrounding environment; (3) generating new ideas or approaches and seeking creative solutions to challenges; (4) using the experience of failure to build self-motivation; (5) showing curiosity, engaging in reflection and investigation, and making use of various sources; and (6) having the ability to communicate, exercise self-control, and being aware of one's own feelings (Fazriansyah et al., 2025). Each indicator was represented by a balanced combination of positively and negatively worded statements. As with the representation test, the questionnaire was reviewed by expert validators using a structured validation sheet covering aspects of format, language, and content, was revised based on the validators' comments and suggestions, and was declared suitable for use prior to its administration in the pretest and posttest.

The data analysis techniques used were *the N-gain score* (referring to Formula (1)) test and the independent-samples t-test, using SPSS for Windows version 22. The dataset analyzed in this study was gathered during the research and later evaluated for comparison.

$$N - Gain = \frac{Skor\ Postest - Skor\ Pretest}{Skor\ Ideal - Skor\ Pretest} \quad (1)$$

The criteria for *the N-Gain* test are presented in Table 2.

Table 2. Score Breakdown N-Gain

N-Gain Value	Interpretation Criteria
$G \geq 0{,}7$	Height
$0{,}3 \leq G < 0{,}7$	Medium
$G < 0{,}3$	Low

Source: Adapted from Supriadi (2021)

RESULTS

Mathematical representation

The description of students' mathematical representation scores before and after treatment for each control class and experiment in Table 3. and Table 4.

According to Table 3. and Table 4., the pre-test outcomes for the two groups exhibited minimal disparity, with the control group achieving an average score of 20.29 and the experimental group 18.57. An analysis of the post-test scores indicates that the control class achieved an average of 51.56, while the experimental group attained an average of 60 in student representation. Although descriptive, this indicates an increase following the treatment. The improvement was subsequently assessed utilizing the Normalized Gain (N-Gain) test, yielding an average N-Gain of 0.38 for the control group and 0.49 for the experimental group. The N-Gain classification is presented in Table 5.

Table 3. Description of The Mathematical Representation Score of The Control Class Students

Description	Control Class		
	Pre-test	*Post-test*	N-Gain
Minimum	7,14	16,67	-0,13
Maximum	32,14	77,78	0,73
Red	20,29	51,22	0,38
Standard Deviation	6,89	15,02	0,2
Number of Participants	25	25	25

Table 4. Description of The Mathematical Representation Score of The Students of The Experimental Class

Description	Experiment Class		
	Pre-test	Post-test	N-Gain
Minimum	3,57	27,78	-0,12
Maximum	35,71	88,89	0,85
Red	18,57	60	0,49
Standard Deviation	9,76	16,86	0,24
Number of Participants	30	30	30

Table 5. Categorization of The Increase in Student Representation Scores Based on N-Gain

N-Gain	Criteria	Number of Students	
		Controls	Experiments
$G \geq 0,7$	Height	2	8
$0,3 \leq G < 0,7$	Medium	17	17
$G < 0,3$	Low	6	5

The data in Table 5. indicate that the gain in student representation within the control group included 2 students in the significant improvement category, 17 individuals in the moderate category, and 6 individuals in the minimal category. In the experimental class, there were 8 individuals in the significant improvement category, 17 students in the moderate category, and 5 students in minimal category. This suggests that the efficacy of digital mathematics comic media in improving students' mathematical representation skills is quite robust. Moreover, inferential analysis will ascertain the significance of the increase in student representation. However, the normality and homogeneity tests of the data were conducted initially to determine the appropriate statistical methods for the inferential analysis, with the results presented in Table 6. and Table 7.

Table 6. Normality Test of Representation Data

Data Source	*Kolmogorov-Smirnov*		
	Statistic	df	Sig.
N-Gain class control	0,138	25	0,200
N-Gain Experimental Class	0,090	30	0,200

Table 7. Homogeneity Test of Representation Data

Data Source	*Living* Statistics	Sig.
N-Gain Mathematical Representation of Students	0,667	0,418

According to Table 6., the Sig. values for both classes (control and experiment) exceeded the significsnce level ($\alpha = 0.05$). Based on the established evaluation criteria, the N-Gain data can be considered normally distributed, as shown in Table 7. It also shows a larger sig value when compared to the significance level (α). The conclusion indicates that the N-Gain data for both the control and experimental classes exhibit the same or homogeneous variance. Consequently, the analysis relied on parametric statistical methods, specifically the independent samples t-test, to investigate the significance of the increase in student representation in both groups and to ascertain the more effective medium between conventional learning and digital mathematics comics. The results of the calculation are presented in Table 8.

Table 8. Independent Sample Test, T-Test Data, N-Gain, and Mathematical Representation of Students

Data Source	T	Sig.
N-Gain control & experiments	1,936	0,058

Table 8. indicates that the significance value (2-tailed) exceeds 0.05. The average N-Gain score in the control group did not substantially differ from that of the experimental group. The results suggest that H_0 is accepted, concluding that there is no significant difference in N-Gain ratings between the experimental and control groups.

Mathematical resilience

The description of students' mathematical resilience scores before and after treatment for the control and experimental classes is presented in Table 9. and Table 10. As explained in the Method section, the resilience scores presented here were measured using the questionnaire developed by the researchers and validated prior to data collection.

Table 9. Description of The Mathematical Resilience Score of The Control Class Students

Description	Control Class		
	Pre-test	Post-test	N-Gain
Minimum	69	71	-0,14
Maximum	88	92	0,11
Red	81,4	82,4	0,01
Standard Deviation	5,17	5,83	0,06
Number of Participants	25	25	25

Table 10. Description of The Mathematical Resilience Score of Experimental Class Students

Description	Experiment Class		
	Pre-test	Post-test	N-Gain
Minimum	75	102	0,14
Maximum	99	122	0,59
Red	83,9	113,77	0,44
Standard Deviation	6,21	4,83	0,1
Number of Participants	30	30	30

Based on Table 9. and Table 10., the pre-test findings showed that students' resilience in both the control and experimental groups was relatively similar, with mean scores of 81.4 and 83.9, respectively. The post-test results indicate a significant disparity in student resilience, with the control class attaining a mean score of 82.4, while the experimental group reached 113.77, implying a notable enhancement following the intervention. The improvement was subsequently assessed utilizing the Normalized Gain (N-Gain) metric, resulting in an average N-Gain of 0.01 for the control group and 0.44 for the experimental group. The N-Gain classification is presented in Table 11.

Table 11. Categorization of Student Resilience Score Improvement Based on N-Gain

N-Gain	Criteria	Number of Students	
		Controls	Experiments
$G \geq 0,7$	Height	0	0
$0,3 \leq G < 0,7$	Medium	0	27
$G < 0,3$	Low	25	3

The results in Table 11. reveal that all enhancements in student resilience within the control group were classified as low, comprising 25 students. The experimental group had 27 students in the medium improvement category and 3 students in the low category. This indicates that the efficacy of digital mathematics comic media in enhancing students' mathematical resilience skills is commendable. Furthermore, the significance of the increase in student representation is resillience through inferential analysis, preceded by normality and homogeneity testing of the data to determine the appropriate statistical methods, with the results presented in Table 12. and Table 13.

Table 12. Normality Test of Resilience Data

Data Source	Kolmogorov-Smirnov		
	Statistic	df	Sig.
N-Gain class control	0,245	25	0,028
N-Gain Experimental Class	0,169	30	0,000

Table 13. Test The Homogeneity of Resilience Data

Data Source	*Living* Statistics	Sig.
N-Gain students' mathematical resilience	3,371	0,072

Based on Table 12., the Sig. values for both the control and experimental groups were below the significance level ($\alpha = 0.05$). Based on the established test criteria, the N-Gain data can be concluded to be non-normally distributed. Table 13. shows a larger Sig. value when compared to the significance level (α). The conclusion is that the N-Gain data for both the control and experimental classes exhibit identical or homogeneous variance. Accordingly, non-parametric statistical analysis was applied, specifically The Mann–Whitney U test, to evaluate the significance of improvements in students' resillience in both the control and experimental groups, to determine the most effective learning medium between traditional methods and digital mathematics comics. The results of the calculation are presented in Table 14.

Table 14. Mann-Whitney U Test of Student Mathematical Resilience N-Gain

	Results of the mathematical resilience questionnaire
Mann-Whitney U	0,000
Asymp. Sig. (2-taied)	0,000

In Table 14. obtained that the value of Asymp.sig. (2-tailed) is smaller than 0.05. So H_0 is rejected, and H_1 is accepted. These findings indicate that the use of digital mathematics comic media is more effective than conventional learning in enhancing students' mathematical resilience.

DISCUSSION

The data analysis findings indicate that the use of digital comics effectively enhances students' representation abilities and mathematical resilience, as evidenced by an average N-Gain score in the medium range. The N-Gain value for the experimental group for mathematical representation capacity was 0.49, whereas the control group recorded a value of 0.38. In terms of mathematical resilience, the experimental class exhibited an N-Gain value of 0.44 (in the middle category), while the control class demonstrated a mere 0.01 (in the low category). This indicates that the utilization of digital comics markedly improves students' representational abilities and mathematical resilience in contrast to traditional training that excludes this medium. However, the test results indicate no statistically significant variation between the pretest and posttest scores (retaining H_0) regarding representational capacity. The statistical examination of the ability data reveals an asymptotic

tendency. A significance (2-tailed) value of 0.000 leads to the acceptance of H_1 and the rejection of H_0, as 0.000 is less than 0.05. This condition indicates that although there is a considerable increase in scores, the growth is neither substantial nor consistent enough to be considered statistically significant. The insignificance may stem from several reasons, such as the very small sample size, considerable variability in student performance, and limited duration of media exposure. Nevertheless, because the experimental group attained superior N-Gain scores compared to the control group, suggesting that digital comics possess significant promise as an instructional medium for improving students' representational skills and mathematical resilience. Therefore, it is prudent to perform further testing with larger sample sizes and more stringent experimental controls to strengthen the empirical data validating the efficacy of the developed medium. The findings of this study are pertinent to the research by Kustantina, Nuryadi, and Marhaeni, which indicates that interactive mathematics comics are beneficial in enhancing students' numeracy literacy skills and their excitement for learning. The findings from the data analysis, as indicated by the Independent Samples T-Test, reveal that the significance (2-tailed) is less than the alpha level ($0.004 < 0.05$) for numeracy literacy ability and less than the alpha level ($0.000 < 0.05$) for learning motivation. This suggests that the implementation of interactive math comics was more effective than traditional classes utilizing school worksheets. Moreover, the mean difference analysis indicated that the average enhancement in the experimental group surpassed that of the control group ($23 > 16$). The rationale resides in the design of mathematics comics, which employ engaging narrative concepts and participatory forms of quotidian discourse to invigorate students' passion for studying. The questions presented in math comics enhance students' numeracy literacy by familiarizing them with numerical data, symbols, and other mathematical concepts (Kustantina, Nuryadi, & Marhaeni, 2022).

These findings also align with a study by Hayati (2017), which indicated that the average score of students' mathematical representation ability was 83%, which is categorized as high. The results indicate that the developed comic media can enhance students' mathematical representation skills.

With regard to mathematical resilience, the present finding that digital comic media produced a notably larger improvement in the experimental group than in the control group is consistent with the study of Kusmaryono and Maharani (2025). They found that digital comic media play a meaningful role in shaping students' emotional reactions and motivation toward mathematics learning, with students exposed to digital comics displaying more positive affective responses than those taught through conventional approaches. This similarity suggests that the narrative and visual elements of digital comics do not merely make mathematics content easier to follow, but also help students manage negative emotional responses to difficulty, such as anxiety and the tendency to give up, which is precisely what mathematical resilience is intended to capture. The relatively modest improvement observed in the control group in the present study, compared with the substantial gain in the experimental group, reinforces the view that conventional learning media alone may be insufficient to foster the affective and persistence-related aspects of mathematical resilience without the support of a more engaging instructional medium.

CONCLUSION

The implementation of digital mathematics comic media for instructing seventh-grade students at *SMPN* 33 Bandar Lampung demonstrates greater efficacy than conventional techniques in enhancing students' mathematical representation and resilience. The N gain for students' mathematical representation skills in the experimental class is 0.49, (medium category), surpassing the control class's average of 0.38, also in the medium category. The results also demonstrate that the average N-Gain of students' mathematical resilience in the experimental group was 0.44, medium category, whereas the control group had a lower average of 0.01 (low category). Overall the findings demonstrate that the utilization of digital mathematics comics substantially enhances students' representation skills and mathematical resilience. However, while the increase in mathematical

representation capacity was visible but not fully robust across all test, there was a highly significant and distinct improvement in students' mathematical resilience.

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