

Enhancing Mathematical Disposition in Geometry Instruction : The Role of E-Comics in Realistic Mathematics Education

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Abstract: Success in learning mathematics can be measured through five aspects called the five strands of mathematical proficiency. These five aspects need to be taught fairly, resulting in a change in students' mathematical attitudes where this aspect is still minimally looked at and researched. Therefore, the research aims to analyze changes in students' mathematical dispositions by reviewing the role of e-comics in Realistic Mathematics Education (RME). This context-based mathematics learning approach is assumed to provide meaningful learning for students. This mixed-methods research with a sequential explanatory research design was carried out on 30 elementary school students by combining quantitative data collection and analysis techniques with qualitative data support. The research showed that using e-comics in RME learning significantly improved students' mathematical dispositions with a large effect size (Cohen's effect size = 0,98). In a qualitative review involving data triangulation, evidence was found that using e-comics in RME learning has a role in facilitating the development of each student indicator, as evidenced in the high students' enthusiasm or response in learning both in observations, questionnaires, and documentation studies. In this way, it is hoped that this innovation can be researched and developed further on a more diverse scale and content. In addition, this research provides further opportunities for research and teacher training related to developing RME learning designs and e-comics in learning.

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INTRODUCTION

Mathematics is one of the subjects that needs to be studied as a provision for carrying out daily activities and is the basis for various fields such as technology, science, business and other fields (Kilpatrick et al., 2001; Sunzuma et al., 2013). Success in learning mathematics is not just seen from the ability to calculate and a series of procedures such as the mechanistic view of mathematics. Rather, there are five aspects or skills that indicate that someone is successful in learning mathematics. The five aspects referred to are called the five strands of mathematical proficiency which include 1) conceptual understanding, 2) procedural fluency, 3) strategic competence, 4) adaptive reasoning, and 5) productive disposition (Kilpatrick et al., 2001; Nugraha & Prabawanto, 2021a).

These five aspects are interrelated with each other, where students are said to be successful in learning mathematics if they have these five skills. If one skill is not mastered, it will affect other skills, such as if students have an incorrect understanding of the concept of spatial shapes, then they will also make mistakes in carrying out procedures (Nugraha & Prabawanto, 2021a), especially looking at mathematics as something meaningful or what is called a productive disposition which is the origin of mathematics learning. Therefore, based on the five mathematics learning skills, it appears that not only cognitive and psychomotor aspects are in the spotlight in mathematics learning, but there are other aspects that also have an impact on mathematics learning, namely the affective aspect which is called a productive disposition (Nugraha, 2017).

In order to achieve this productive disposition, mathematics learning must be supported by several things so that it can be successful. Students must be given the opportunity to gain experience in

mathematical processes because mathematics is also a human activity (Freudenthal, 1968). Basically, mathematics learning in elementary schools has a scope of material: 1) numbers and their operations, 2) geometry and measurement, and 3) data analysis and probability (NCTM, 2000; Van de Walle et al., 2013). One of the topics that is difficult to teach is building space as part of the topic of geometry and measurement which is difficult to teach in class VI where this difficulty is caused by the topic taught not being too close to the context of students' lives (Nugraha & Prabawanto, 2021b; Samsudin & Nugraha, 2024). Apart from that, the large amount of material required by the curriculum causes teachers to be overwhelmed in teaching it to students, so this results in basic concepts that are not really understood by students and they focus too much on achieving the material rather than understanding, skills and productive dispositions.

Based on these problems, the assumption emerged that an instruction was needed that could be used in learning the meaning of spatial shapes, especially at the elementary school level. It is hoped that the instructions in question can help teachers and guide learning activities step by step so that students can understand the concept of building space. Thus, this research seeks to answer the research question in the form of the impact of using e-comic teaching materials in realistic mathematics education on the productive disposition of elementary school students.

The teaching materials designed are in the form of learning designs as guidelines for learning preparation and Student Worksheets (LKPD) designed in several e-comics using the Canva and Bitmoji applications as guidelines for implementing direct learning that students and teachers use during learning. The reason for using interactive e-comic teaching materials in mathematics learning is that it is assumed to be a method that has many advantages in solving mathematics problems for elementary school age children (Dewi et al., 2018). Learning is designed using the Realistic Mathematics Education (RME) approach which is based on RME principles which support and are appropriate to mathematics learning. The RME approach has also been extensively researched and proven successful in improving the five strands of mathematical proficiency, especially productive disposition (Chua, 2021; Haji et al., 2019; Nuraida et al., 2019). Apart from that, the use of RME also increases students' learning activities more compared to other approaches (Arsaythamby & Zubainur, 2014; Irdawati et al., 2019). Thus, the results of this research are in the form of teaching materials containing instructions for developing basic spatial concepts based on local instruction theory and are expected to contribute to solving existing problems in the field, especially increasing productive dispositions.

Based on this, it is hoped that this research can answer several research questions as follows: 1) how much effect size does e-comic assisted on the Realistic Mathematics Education (RME) in enhancing the mathematical disposition of elementary school students?; 2) What is the role of e-comics in elementary school RME geometry learning in enhancing students' mathematical disposition? It is hoped that the implications of this research can be additional learning innovations in elementary schools that can be elaborated and developed better in the future.

METHOD

Mix method research with a sequential explanatory design was carried out to answer the research questions which are the background of this research. This research method was used because of the characteristics of research problems that need to be answered in the process and results aspects which involve combining quantitative and qualitative research. More clearly, this research design was carried out through several stages presented in Figure 1 (Creswell & Creswell, 2018; Ivankova et al., 2006).

The research was carried out in order to collect and analyze quantitative data first which was then followed up by collecting and analyzing qualitative data so that a clear interpretation of both the results and the process of the learning carried out was obtained (Creswell & Creswell, 2018; Ivankova et al., 2006). Meanwhile, obtaining quantitative data was carried out using a pre-experimental design with the one group pretest and posttest (O1 X O2), so that students' mathematical disposition was taken into account through the difference between pretest and posttest scores with reference to the X effect (Cohen et al., 2018).

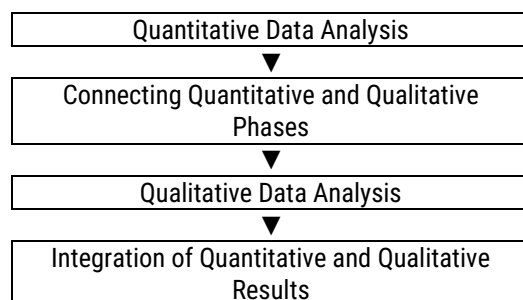


Figure 1. Visual Model for Sequential Explanatory Design Procedures (adapted from Ivankova et al., 2006)

This research involved 30 students in one of the elementary schools in Bandung City. The instrument used to measure this research is a mathematical disposition scale which was developed based on productive disposition indicators (Kilpatrick et al., 2001) and is aimed at obtaining quantitative data. In addition, a student response questionnaire was used to see the role of e-comics and the meaningfulness of RME learning on the productive disposition of elementary school students.

RESULT AND DISCUSSION

This research obtained the results of quantitative analysis which was followed up with qualitative analysis to provide an overview of the role and significance of e-comics in RME learning in elementary schools. The results of descriptive statistical analysis regarding students' mathematical dispositions, both pretest and posttest, are presented in Table 1.

Table 1. The Descriptive Statistics of Students' Mathematical Disposition

Category	Pretest	Posttest
N Statistic	30	30
Mean	79,413	86,213
Std. Deviation	8,322	5,945
Skewness	-0,384	-1,071
Kurtosis	-0,225	2,540

Based on Table 1, it is clear that the average initial and final mathematical disposition scores have increased. However, the description of descriptive statistics is still not sufficient to prove the assumption that there has been a significant increase, so inferential statistical tests that are more significant are needed (Nugraha & Prabawanto, 2021a). Thus, to further confirm these differences, several tests are needed such as the normality test and the average difference test as follows.

Table 2. The Difference of Students' Mathematical Disposition Before and After Learning with E-Comics in Realistic Mathematics Education

Variable	Normality (Shapiro-Wilk)	Mean Difference (T-Test)
Prior of Students' Mathematical Disposition (Pretest)	0,611	0,000
Achievement of Students' Mathematical Disposition (Posttest)	0,053	(Significant Difference)

Based on Table 2 above, it can be seen that the results of the students' mathematical disposition normality test obtained a p-value of 0.611 for the initial value and 0.053 for the final value. This means that the two p-values obtained are $\geq \alpha$, so it can be concluded that the data on the initial and final values of students' mathematical dispositions come from samples with a normal distribution which has an impact on the use of parametric statistical analysis of the t-test (Healey, 2016). Apart from that, the results

of the average difference test obtained a p-value (sig. 2-tailed) of 0.000 which is $< \alpha$, so it can be concluded that the use of E-Comics in Realistic Mathematics Education learning is assumed to be able to significantly improve the mathematical disposition of elementary school students.

The level of effectiveness of the role of e-comics in RME learning towards improving mathematical disposition in this research was then reviewed based on measuring the effect size or the influence of learning on enhancing students' mathematical disposition. The Effect Size review was carried out by processing descriptive statistical data through Cohen's Effect Size test analysis (Cohen et al., 2018). The test results obtained the Effect Size value which is presented in Table 3 below.

Table 3. The Effect Size of The Role E-Comics in RME on Enhancing Students' Mathematical Disposition

Cohen Effect Size	P-Value	Interpretation
0,978 (large effect)	0,001 (significant effect)	The role of e-comics in RME learning on enhancing students' mathematical disposition has a large and significant effect size.

Once it is known that the use of E-Comics in Realistic Mathematics Education learning can improve mathematical disposition, the next step is to carry out a correlation test. The correlation test (Pearson's Product Moment) was carried out to determine the correlation or degree of connection, the direction of the relationship, and the significance of the two relationships between the initial score obtained and the final score of students' mathematical disposition in this study (Lestari & Yudhanegara, 2015). The results of the correlation test calculation between the initial and final values of students' mathematical disposition are as follows.

Table 4. The Calculation Results of Students' Mathematical Disposition Correlation Coefficient

SMD Correlation Coefficient	
Pearson Correlation	0,841
Sig. (2-Tailed)	0,000
N	30

Based on Table 4, it can be seen that the correlation value (r) is 0.841. This value can provide information regarding the coefficient of determination, namely $r^2 = (0.841)^2 = 0.7073 = 70.73\%$. The determination coefficient value obtained means that there is a positive relationship between the prior of students' mathematical disposition value and the achievement of student's mathematical disposition value with a determination coefficient of 70.73%. Thus, this shows how much similarity in characteristics or variations there are between the prior and achievement values of students' mathematical dispositions, which can be more clearly concluded that 70.73% of the variation in students' achievement mathematical disposition scores can be influenced by the prior values obtained. Meanwhile, the remaining 29.27% is determined by other variables.

This explanation is strengthened by several qualitative findings in the field, including if studied based on the mathematical disposition indicators examined in this research, for example self-confidence and assessing the application of mathematics to other situations in mathematics learning are assumed to grow when students learn through E-Comics. This confirms that E-Comics media provides space to develop students' motivation in learning mathematics due to the relationship between the application of mathematics in everyday life (Yulaichah & Mariana, 2024). Apart from that, based on the results of field notes, it is known that through group activities passive students are motivated by their friends to be more enthusiastic about learning and their self-confidence arises. Thus, the context presented in RME learning certainly provides a positive correlation to self-confidence, motivation and mathematics learning outcomes, one of which is assessing the application of mathematics to other situations in mathematics and students' daily experiences (Subroto et al., 2020).



Figure 2. E-Comic Based Realistic Mathematics Education

E-comics in RME learning also play a very significant role in improving other mathematical disposition indicators such as curiosity and perseverance as well as flexibility in learning. It is proven that when students are given the opportunity to think through e-comics, students are very happy and diligent in finding solutions to the problems presented in the comics. This is of course in accordance with previous findings that E-Comics Math can increase students' curiosity to read, analyze and provide opportunities for students to enjoy and perceive the context and content presented (Abrori et al., 2023; Yulaichah & Mariana, 2024).

Apart from that, indicators of a reflective attitude or tendency to monitor one's own abilities are also developed through the emergence of problems presented in e-comics. This is in accordance with previous research that the process of giving problems can train students to monitor their own thinking processes and performance (reflective) whether the knowledge they have acquired can be applied in solving new problems (Sunendar, 2016). In this case, the e-comics that are designed are not only conceptual or provide stories of conceptual understanding, but the e-comics which are developed also bridge the gap between presenting the context and presenting the problem, or in other words, the problem is presented indirectly. This is in line with past research that it is better to teach problem solving to elementary school students if it is presented explicitly or indirectly (Glenn & Ellis, 1982), so that students focus more on problems presented in context and activate their unconscious brain rather than being presented directly which might have an impact on fear. to solve the problem.

Mathematical dispositions which contain indicators for assessing the application of mathematics to other situations in mathematics and everyday experiences are also developed in RME learning assisted by e-comics. This appears more clearly in the context presented in the lesson, that the spatial structure presented is not necessarily directly stated in the name of the spatial structure but is presented in a context related to everyday life. Thus, it is increasingly clear that e-comic media is able to develop student motivation in learning mathematics because students are given examples of the application of mathematics in everyday life (Yulaichah & Mariana, 2024). In addition, the mathematical content studied does not feel foreign to students because the context is taken from students' knowledge and experiences in everyday life (Arliani & Khabibah, 2022). Throughout the learning process, the teacher acts as a facilitator who provokes students' logic to understand the context presented.

Research findings that include an increase in one of the indicators of mathematical disposition, appreciation of the role of mathematics in culture and the value of mathematics as a tool and language also appear in this research. In this case, students' discussions were found about the problems presented, where the context of the spatial structures presented in the comics were some of them presented in ethnomathematics contexts such as tumpeng and others. This is certainly very strong supporting evidence, that culturally valuable contexts need to be presented in mathematics learning because mathematics itself is part of culture and must be civilized (Nugraha et al., 2020).

This curiosity and attitude of flexibility and perseverance are also of course facilitated in the RME

approach which focuses on meaningfulness so that students easily accept and understand the learning process, thereby facilitating students to play an active role in learning and teachers have the role of motivating and encouraging student involvement in learning (Bhoke, 2019; Yulaichah & Mariana, 2024). Thus, it can be concluded that the role of e-comics in realistic mathematical education learning is very closely related, so that when integrated these two concepts will have a big impact on changes in students' behavior, which in this case is called productive disposition or mathematical disposition.

Based on these findings, this research has the implication that RME learning which emphasizes the integration of context learning in mathematics content will produce more meaningfulness if the context presented is packaged in a media or teaching material that is able to increase the meaningfulness of learning for students, one of which is by using e-comics. In this way, students are able to extract the meaningfulness of learning not only in terms of results but also reflected in the learning process. This is certainly what is expected to emerge from learning in elementary schools where the meaningfulness of learning should be an important point, not just emphasizing excitement and ignoring content or vice versa. This research is recognized to have limitations in terms of research scale, research duration, and diversity of learning content. The research was conducted in October-December of the 23/24 academic year, so that the short duration of the program implementation made it possible to influence the depth of development of aspects of mathematical disposition and learning skills. Additionally, this study was limited by its small sample size and potential selection bias. Another possible limitation is that external factors beyond the control of program implementation may influence the results, and its generalizability may be limited due to the specific context of the public elementary school education system in Indonesia.

However, it is hoped that the innovation in this research can be re-developed in the future. Implementing learning programs such as e-comics in mathematics lessons and integrating them into the RME curriculum in elementary school can provide an interesting and interactive learning experience for students. Concentration on the use of modern methods that simulate reality to enhance mathematics learning allows students to actively participate and share their experiences in lessons. Designing a learning environment in mathematics learning in elementary schools that focuses on improving affective aspects can create spaces and activities that are meaningful for students and support their cognitive and psychomotor abilities. Conducting similar research using the proposed e-comic assisted RME program on different samples and content to further validate its effectiveness in developing teaching skills will thus contribute to building strong evidence supporting meaningfulness in education. By implementing these research opportunities and recommendations, educational institutions can leverage the benefits of e-comics-assisted RME to improve teaching skills, create engaging learning environments, and improve the overall educational experience for teachers and students. Apart from that, from a field perspective, it is hoped that this research will become the basis for teacher training in innovation in mathematics learning in elementary schools.

CONCLUSION

The Realistic Mathematics Education learning innovation using e-comic media has been able to improve students' mathematical abilities, one of which is the attitude aspect, namely mathematical disposition. This e-comic is assumed to be effective in learning mathematics because it presents concepts related to everyday life. However, this success cannot be separated from other factors, one of which is the teacher's ability to design learning which has an impact on the efficient use of learning media. Therefore, it is hoped that in the future research or training opportunities will arise for teachers related to increasing the effectiveness of e-comics in RME learning, so that they make a positive contribution to mathematics learning which not only pays attention to cognitive aspects but also affective aspects and skills.

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