

Development of Comic-Based Media for Financial Mathematics Content to Support High School Students' Mathematical Problem-Solving Skills

Dita Susi Evrihatin¹, A'yunnisa Tsani¹, Sunismi^{1*}, Any Herawati², Retno Trisniwati²

¹Universitas Islam Malang, Mayjen Haryono St. No. 193, Malang, East Java, 65144, Indonesia

²Sekolah Menengah Atas Negeri 3 Malang, Sultan Agung Utara St. No. 7, Malang, East Java, 65111, Indonesia

*Corresponding author, email: sunismi@unisma.ac.id

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Abstract

This study aims to develop a mathematics comic as a teaching medium for financial mathematics to support high school students' mathematical problem-solving skills. This study was motivated by students' still-low ability to understand the concept of compound interest and solve contextual mathematical problems related to daily life. This study employed the Research and Development (R&D) method using the ADDIE model, which consists of the analysis, design, development, implementation, and evaluation stages. The research subjects included 36 11th-grade high school students, two subject matter experts, two media experts, and one mathematics teacher. The product developed was a context-based mathematical comic that presents the concept of compound interest through visual storytelling, engaging illustrations, and real-life financial scenarios, thereby helping students understand the concept in a more concrete and communicative way. Data collection techniques included observation, interviews, expert validation sheets, a practicality questionnaire, and pretest and posttest instruments. The validation results showed that the developed media met the criteria for high validity, with an average percentage of 81.7%. The results of the teacher practicality test yielded a percentage of 71.9%, and the student response rate was 86%, thus confirming that the media is practical and suitable for use in learning. Based on the pretest and posttest results, it can be concluded that the use of digital comic learning media has a positive impact on students' problem-solving skills. This is evidenced by an increase in the average score from 56.05 on the pretest to 90.83 on the posttest, accompanied by an increase in the lowest score from 11 to 85 and the highest score from 85 to 100. These results indicate that comic-based learning media can help improve students' understanding of the material being studied and are suitable for use as learning media in the classroom learning process.

1. Introduction

Mathematics plays a crucial role in developing the logical, critical, analytical, and systematic thinking skills that students need to face the challenges of the 21st century. Mathematics education in the 21st century is not only oriented toward conceptual mastery but also emphasizes students' ability to solve contextual problems related to daily life (Suparatulorn et al., 2023). Strong mathematical skills also help students develop reasoning and reflective thinking in problem-solving (Kholid et al., 2024). In this context, mathematical problem-solving skills are among the key competencies that need to be developed, as they involve understanding the problem, formulating strategies, implementing solutions, and evaluating results (Risnawati et al., 2023; Rochim et al., 2023). However, students still often struggle to understand the information in problems, determine solution strategies, and connect mathematical concepts to real-world situations (Fardah & Kusumah, 2024; Rocha et al., 2024). Recent research also confirms that real-world contexts are crucial in mathematics problem-solving instruction because they help students become more engaged and understand problems in a meaningful way.

From a pedagogical perspective, this situation highlights the need for instructional media that are not only visually engaging but also capable of facilitating conceptual understanding and problem-solving in a step-by-step manner. Mathematics instruction, which remains dominated by conventional approaches, tends to lead students to memorize formulas rather than gain meaningful learning experiences (Ngu & Phan, 2024; Putra et al., 2024). Therefore, innovative learning approaches are needed to help students understand concepts in a more concrete and communicative way. Innovative learning media are considered capable of creating more meaningful learning experiences, helping to visualize abstract concepts, and increasing student engagement in

the learning process (Putra et al., 2021). In several recent studies, mathematics comics were developed using the ADDIE model and demonstrated valid, practical results that support conceptual understanding and student engagement. Furthermore, these comics can be produced in PDF format and then printed as physical teaching materials, making them relevant for the development of printed comic booklets.

Previous studies indicate that math comics have the potential to support learning because they combine images, stories, and dialogue that help students understand the material (Putra et al., 2021). Research by Umam et al. (2024) shows that Problem-Based Learning-based math comics using Pixton can meet the criteria of being valid, practical, and sufficiently effective in improving students' mathematical problem-solving skills. Putri et al. (2025) also demonstrated that digital math comics based on Realistic Mathematics Education using the ADDIE model are capable of integrating real-world contexts, visual narratives, and interactive learning activities, and were thus deemed highly valid, practical, and effective. Pramesti and Wahyudi (2025) found that culture-based interactive comics using the ADDIE model also fall into the categories of highly valid and highly practical. These findings indicate that math comics consistently serve as a promising medium to help students learn through contextual stories, engaging visuals, and more active learning activities.

Nevertheless, there remains a significant research gap that needs to be addressed. Most previous studies have focused on digital comics, middle school or elementary school content, and outcomes such as motivation, literacy, or learning outcomes, while the development of print comics or booklets on compound interest for high school students specifically designed to support mathematical problem-solving skills remains limited (Ngu & Phan, 2024; Putra et al., 2021; Umam et al., 2024; Putri et al., 2025; Pramesti & Wahyudi, 2025). Furthermore, there has been little research that systematically presents compound interest material in the form of printed comic stories that are closely aligned with students' learning experiences and simultaneously designed using the ADDIE model with AI assistance. Thus, the novelty of this study lies in the development of AI-assisted printed mathematical comic media on compound interest to support high school students' mathematical problem-solving skills. Based on the above description, this study aims to develop a mathematics comic medium on the topic of compound interest using the AI-assisted ADDIE model to support high school students' mathematical problem-solving skills. This objective aligns with the need for contextual and visual mathematics learning that helps students understand concepts and solve problems more systematically.

2. Method

This study employed the Research and Development (R&D) method using the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model was chosen because it provides a systematic yet flexible development process, making it suitable for the development of instructional media that requires a gradual refinement process from needs analysis to product evaluation. In the context of education, this model is widely used because it helps researchers tailor products to students' characteristics, learning needs, and field implementation conditions (Mutya et al., 2025; Umam et al., 2024; Yuniawati et al., 2024). This study focuses on the development of printed/booklet-format mathematics comic materials on the topic of compound interest to support high school students' mathematical problem-solving skills.

The study was conducted with 11th-grade students at a public high school during the second semester of the 2025–2026 academic year. The study population consisted of 11th-grade students studying financial mathematics. The research participants included two subject matter experts, two media experts, one mathematics teacher serving as a practitioner validator, and 10 11th-grade high school students as participants in a limited pilot test. The students were between the ages of 15 and 17, with the class comprising 24 male students and 12 female students. The selection of 10 students for the pilot study was based on the recommendation by Borg and Gall (1989), who stated that an initial field trial can be conducted with 10–30 respondents. Additionally, Dick, Carey, and Carey (2005) also recommend small-group evaluations with 8–20 students to assess the product's effectiveness before conducting a broader test.

Participants were selected using purposive sampling, which involves selecting subjects based on the alignment of their characteristics with the research objectives and product development needs. This technique was chosen because development research is not oriented toward statistical generalization but rather toward the depth of information, the relevance of participants, and the suitability of the context for implementing the learning media (Dahal et al., 2024; Ramírez et al., 2025).

The research instruments included an observation sheet, an expert validation sheet, a student response questionnaire, and a mathematical problem-solving test. Observations were used during the analysis phase to gather information about learning conditions, media use, and student characteristics. The validation sheet was used to assess aspects of the content, the media's presentation, and the product's suitability for use, while the student response questionnaire was used to measure the media's practicality. The research flow chart is illustrated in the Figure 1.

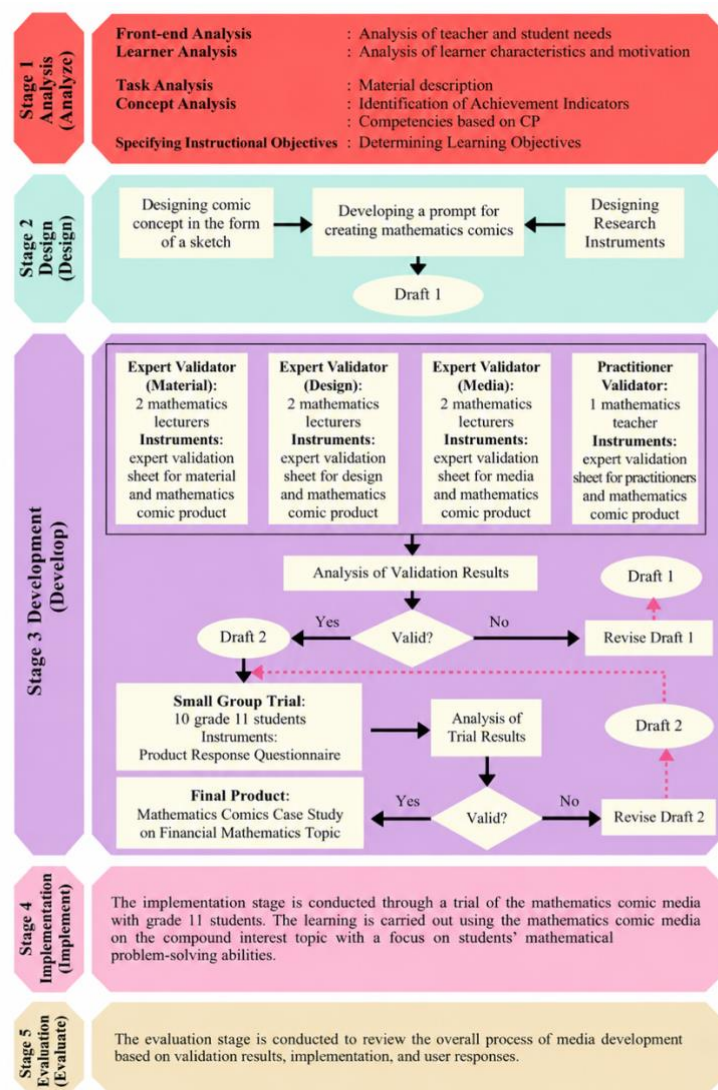


Figure 1. Research Flow Chart

The mathematical problem-solving ability test was designed based on Polya's indicators: understanding the problem, planning the solution, executing the solution, and checking the results. An example of a test item is a contextual problem on compound interest that requires students to determine the final value of an investment in an everyday financial situation. All instruments underwent an expert judgment process by validator faculty members before being used in the study. Expert validation and general response questionnaires are commonly used in development research to ensure that the product meets the criteria of validity, practicality, and educational feasibility (Santos-Trigo et al., 2024; Liu et al., 2025).

The research procedure followed the stages of the ADDIE model. The analysis stage included an analysis of learning needs, student characteristics, and compound interest material. The design stage involved creating comic sketches, developing contextual storylines, and designing research instruments. The development stage was carried out through the creation of teaching media, expert validation, and product revisions based on validators' suggestions. The implementation phase involved a pilot test with 11th-grade high school students using the comic-based learning material. The evaluation phase was based on validation results, student feedback, and a mathematical problem-solving test to refine the developed product (Umam et al., 2024; Yuniawati et al., 2024).

The data were analyzed using quantitative and qualitative descriptive analysis. Observational data were analyzed qualitatively to describe learning needs. Expert validation data and student response questionnaires were analyzed using percentage calculations: Score obtained

$$P = \frac{\text{obtained score}}{\text{maximum score}} \times 100\% \quad (1)$$

The results of the calculations were then interpreted in terms of the media's validity and practicality. Meanwhile, data on mathematical problem-solving ability tests were analyzed based on Polya's indicators to describe students' abilities after using the math comic media. This analytical approach is widely used in educational development research because it provides a clear picture of product quality, feasibility of implementation, and the achievement of learning objectives (Vázquez-Parra et al., 2024; Soriano-Alcantara et al., 2025; Santos-Trigo et al., 2024).

3. Results and Discussion

The results of this study are presented based on the stages of the ADDIE model, which include Analysis, Design, Development, Implementation, and Evaluation. Each stage describes the process of developing a mathematics comic as a teaching aid on the topic of compound interest to support high school students' mathematical problem-solving skills.

3.1. Results

3.1.1. Analysis

The analysis phase was conducted to identify the needs for developing instructional media on financial mathematics topics. The analysis process was based on (1) the results of the initial diagnostic test on compound interest, (2) classroom observations and an analysis of student needs based on learning styles, and (3) an analysis of learning outcomes and objectives for financial mathematics. Through the initial diagnostic test on compound interest, it was found that students' initial proficiency was still suboptimal. The analysis results showed that 22.2% of students fell into the high category, 52.8% into the moderate category, and 25% into the low category. This indicates that the majority of students do not yet fully understand the concept of compound interest and its application in solving contextual problems.

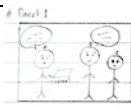
Furthermore, observation results indicate that the learning process is still dominated by conventional methods, which tend to make students passive and less interested in learning financial mathematics. An analysis of students' learning needs based on learning styles also reveals a strong preference for media that present information visually and digitally, incorporating illustrations, stories, and real-life contexts. Therefore, it is necessary to develop AI-based comic media as an effort to help students understand the concept of compound interest through contextual visualization and mathematical problem-solving.

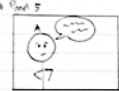
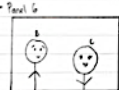
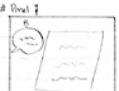
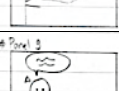
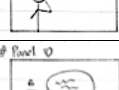
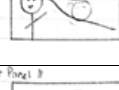
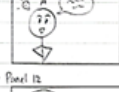
At this stage, an analysis of learning outcomes and learning objectives aligned with Phase F of the Merdeka Curriculum was also conducted. The developed material focuses on students' ability to analyze the impact of compound interest parameters on the final value of investments and loans through both numerical and visual representations.

3.1.2. Design

This phase aims to create a preliminary product design, which includes (1) creating an initial comic design, (2) drafting AI prompts for each comic panel, and (3) creating the comic via the gemini.google.com website. In the preliminary design phase, the comic's structure was adapted to the characteristics of high school students and the learning objectives for financial mathematics. The creation of the preliminary design involves developing the storyline, character designs, settings, and atmosphere, as well as the details of each comic panel's content, which presents contextual situations related to compound interest in everyday life. Each part of the comic is systematically organized around contextual problems that help students understand how compound interest works or the concepts behind its calculation. The results of the preliminary comic design is presented in Table 1.

Table 1. Preliminary Design of the Product

Panel number	Sketch	Description
1		Andi, Alfian, and Ismi are sitting together at a café. Andi stares at his laptop with a confused expression, saying, "This is so confusing! I want to save the prize money from the competition, but I'm not sure which bank to choose." Then Alfian, holding a cup of coffee, replies, "Are these two offers exactly the same?" Meanwhile, Ismi just listens to the two of them.
2		Andi pointed at his laptop and said, "Look! Both are 12% per year. What's the difference? What kind of math is this?" Meanwhile, on Andi's laptop screen it read, "Bank A = 12% per year, annual," and below that, "Bank B = 12% per year, monthly."
3		Alfian, holding a pen in his right hand and his glasses in his left, smiled and explained to Andi, saying, "Hold on a second, Ndi. The percentage is the same, but the amounts can be different. It's a matter of COMPOUNDING FREQUENCY"

Panel number	Sketch	Description
4		Alfian wrote on a piece of paper, while Andi and Ismi watched him write. Alfian wrote, "Bank A: 12% per year. Annually." He said, "Take a look at the fine print. Bank A pays 12% interest per year, paid EVERY YEAR."
5		Alfian folded his arms and put on a look of surprise and disbelief, saying, "So what? The total for the year is still 12%, right? What's the difference between getting paid once a year or in installments?" (An illustration depicting Andi's train of thought may be added.)
6		Ismi replied, "Hahaha, Andi, Andi! This is where the magic of FINANCIAL MATH begins. Have you ever heard of 'compound interest'?" Meanwhile, Alfian listened to Ismi's explanation, his expression seeming to show agreement. (An illustration depicting Ismi's line of thinking may be added)
7		In this panel, only a piece of paper and Alfian's hand are visible as he explains the interest calculations at Bank B. Add an illustration such as a line graph titled "Monthly Compound Interest" showing the steadily increasing monthly interest growth. Alfian says, "For example, with Rp10,000,000.00, let's look at the 'interest on interest' effect at Bank B."
8		Alfian then compares this to Bank A's calculation using a laptop, whose screen displays "Initial amount: Rp10,000,000.00," followed by "Final interest (12%): Rp1,200,000.00," and below that, "Total: Rp11,200,000.00." Alfian said, "Bank A: Rp10,000,000.00 grows to Rp11,200,000.00 by the end of the year."
9		Andi tried to understand Alfian's explanation with a pensive expression, his left hand resting on his chin. He said, "Okay, Rp11,200,000.00. That makes sense. So why is Bank B different?" (An illustration depicting Andi's thought process may be added)
10		Alfian explained enthusiastically, saying, "Bank B: 12% interest per year divided by 12 months = 1% per month. But the interest for the second month is calculated based on Rp10,000,000.00 plus the interest from the first month." The background for this panel could feature an illustration of a snowball rolling downhill, showing that the compound interest system works like a snowball effect.
11		Andi, with a look of surprise, finally understood Alfian's explanation and said, "WOW! Look! At the end of the year, my money at Bank B becomes Rp11,268,250! That's a difference of Rp68,250.00 compared to Bank A." An illustration such as a lightbulb (idea) near Andi's head could be added.
12		Andi finally smiled, scratching his head, and said, "Hahaha! Turns out financial math is fun! Now I know: Choose Bank B because its interest frequency is more profitable!" Alfian and Ismi smiled as they looked at Andi.

The initial design of the developed product is presented in Figure 1.



Figure 2. Initial Product Design

3.1.3. Development

The development phase produced the final product after revisions were made based on suggestions and evaluations from subject matter experts and media experts. The product’s practicality was then tested with teachers by having them fill out a questionnaire, and we look forward to seeing this product taught to students.

The first activity in the development phase was the validation of the comic-based media. The validators consisted of two faculty members qualified in the field of mathematics. The validation of the comic-based media was conducted by administering an assessment instrument. The validation process comprised two components: media expert validation and content expert validation. The results of the content expert and media expert validations are presented in Table 2.

Table 2. Media Validation Results

Aspect	Validator 1	Validator 2
Media Use	7	8
Integration	13	16
Balance	12	15
Appearance and Design	15	19
Language	10	12
Total	47	70
Maximum Total	72	72
Percentage	65.28%	97.22
Validity Level	Valid	Highly Valid

Based on Table 2, the average of Validator 1 and Validator 2 yielded a percentage of 81.25%, which means that this comic medium is deemed Highly Valid in terms of validity. Based on Table 3, the average of Validator 1 and Validator 2 yielded a percentage of 82.14%, which means that this comic medium is deemed Highly Valid in terms of content validity. Based on the assessment results from the content expert validation and media expert validation, the final average percentage was 81.7%, which falls within the 81%–100% range. It is concluded that the developed product is categorized as “Highly Valid” and can be used in learning. Description of the revision suggestions provided by Validator 1 and Validator 2 is presented in Table 4.

Table 3. Results of Content Validation

Aspect	Validator 1	Validator 2
Content Suitability	38	45
Language	25	30
Total	63	75
Maximum Total	84	84
Percentage	75%	89.29%
Validity Level	Valid	Highly Valid

Table 4. Revision Process for the Comic Based on Validators’ Comments

No.	Before	After	Revision Details
1.			Change the character’s outfit to a school uniform with a library background. Prompt: Change the character’s outfit to a gray-and-white uniform, without altering the dialogue or the character’s individual details.

No.	Before	After	Revision Details
2.			Number each panel Prompt: Number each panel, starting with number 1 in the top-left corner, then continuing to the right with number 2 and so on, followed by the bottom-left panel and so on.

Final Result			
			

Next is the practicality test, which was conducted by teachers in mathematics classes. The results of the teachers' practicality test calculations can be seen in Table 5.

Table 5. Teacher Usability Results

Aspect	Teacher Practitioner
Use of Media	5
Integration	13
Balance	11
Appearance and Design	26
Language	20
Content	27
Total	102
Maximum total	142
Percentage	71.9%
Validity Level	Practical

Based on Table 5, the results of the practicality test yielded a percentage of 71.9%, which means that this comic medium can be considered practical. Therefore, it can be concluded that the developed product falls into the "Practical" category and can be used in learning.

Based on the results of the student response questionnaire, the math comic medium received a score of 86%, placing it in the "practical" category (see Table 6). These results indicate that the math comic medium is practical to use and supports engaging, easy-to-understand learning that enhances student engagement.

Table 6. Student Practicality Results

Aspect	Total Respondent Score
Ease of Use	96
Relevance of Content and Materials	89
Conceptual Understanding/Cognitive	92
Media Presentation and Appeal	42
Engagement & Learning Experience	95
Motivation and Interest in Learning	147
Total	561
Maximum Total	650
Percentage	86%
Practicality Level	Practical

3.1.4. Implementation

The implementation phase of this study began with the use of AI-based digital comic learning media with 36 11th-grade high school students. Before instruction using this medium began, all students took a pretest to assess their initial ability to solve problems involving compound interest. After the entire learning sequence was completed, the students then took a posttest aimed at determining changes in their problem-solving abilities following the use of the developed medium. A comparison between the pretest and posttest results served as the basis for evaluating the AI-based digital comic learning medium in supporting students' mathematical problem-solving abilities.

The pretest results showed that the students' initial problem-solving skills were still relatively low. The lowest score obtained by a student was 11, while the highest reached 85, with an average score of 56.05. These results indicate that most students did not yet possess optimal problem-solving skills before participating in the learning activities using the digital comic medium. This situation indicates that students still struggled to understand the information provided in the problems, determine the appropriate solution strategies, and connect the necessary concepts to arrive at the correct solutions.

After the AI-based digital comic-based learning was implemented, there was a significant improvement in problem-solving skills. The posttest results showed that the lowest score increased to 85, while the highest score reached 100, with a class average of 90.83. Compared to the pretest results, the students' average score increased by 34.78 points. This improvement was evident not only in the class average but also in the rise of the minimum score, which increased from 11 to 85. These findings indicate that nearly all students demonstrated improved ability in solving mathematical problems after participating in the AI-based digital comic-based learning.

This improvement in problem-solving skills demonstrates that the developed medium is effective in helping students by presenting material in a more easily understandable way. Visual illustrations, contextual storylines, and the step-by-step presentation of concepts provide students with the opportunity to understand the problem before determining a solution strategy. Consequently, students do not merely focus on applying formulas but also learn to analyze information, select appropriate solution steps, and justify their answers. This process makes learning more meaningful, as students are actively engaged in constructing their understanding while solving mathematical problems.

Overall, the results of this study indicate that AI-based digital comic learning media have significant potential to enhance students' mathematical problem-solving skills. In addition to being practical for use during the learning process, this medium creates a more engaging learning experience, encouraging students to actively explore concepts and solve the problems presented. These findings reinforce the idea that the use of contextually designed digital media can serve as an alternative learning approach to support the development of problem-solving skills in mathematics education.

3.1.5. Evaluation

The evaluation phase was conducted at the end of the development process to review all the stages that had been carried out, ranging from validation by experts and implementation in the classroom to the feedback

provided by teachers and students regarding the developed teaching materials. This evaluation process aimed to ensure that the teaching materials not only met the established criteria but could also be used optimally in learning activities. Based on the evaluation results, the math comic was found to meet the criteria for validity and practicality, making it suitable for use as a learning resource. Overall, the developed resource is effective in helping students improve their financial math problem-solving skills through the presentation of material in a visual format and contextual problems closely related to their daily experiences.

3.2. Discussion

The development of this mathematics comic was carried out using the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation), in which each stage is interrelated and generates data that serves as the basis for decision-making in the next stage. In the analysis stage, students' initial abilities were divided into three categories: high (22.2%), moderate (52.8%), and low (25%). These results indicate that most students still require assistance in understanding the concept of compound interest, particularly in its contextual application to daily life. Observation results also show that instruction tends to be conventional, thus failing to meet the learning styles of high school students who prefer learning through visual and contextual media. Studies show that the use of visual media can help students strengthen the connection between abstract concepts and concrete visual representations, so that the information acquired will remain in students' memories for longer (Amalia & Sofiyan, 2018; Meganingtyas, 2021; Nurhayati et al., 2020). For this reason, math comics developed with the help of AI were chosen as a relevant and targeted solution.

The math comic is designed to consist of 12 panels with a contextual storyline, in which three characters discuss a comparison of two banking products with different compound interest rates. The storytelling approach used is based on real-world problems. This approach can encourage students to analyze, predict, reason, evaluate, and reflect on prior knowledge when facing problems in new situations which is the core of problem-solving skills (Siswanto & Meiliasari, 2024). Additionally, the comic's storyline is structured to integrate Polya's (1973) stages of problem-solving: understanding the problem (panels 1–3), formulating a plan (panels 4–6), implementing the plan (panels 7–11), and reviewing the results (panel 12). The use of AI (Gemini) in the illustration process aims to maintain visual consistency across panels while accelerating design iterations based on validator feedback.

The validation process included media expert validation and content expert validation, conducted by two faculty members qualified in the field of mathematics. Media expert validation yielded an average percentage of 81.25%, which falls into the "Highly Valid" category. There was a fairly significant difference in ratings between Validator 1 (65.28%) and Validator 2 (97.22%). This difference is considered reasonable, given that each validator has different points of focus regarding media aspects. Validator 1 provided critical feedback, particularly regarding the use of media and the integration of visual elements, which subsequently served as the basis for revising the costumes and panel numbering. Meanwhile, Validator 2 assessed that the product already met the standards for visual learning media very well. The appearance and design aspects received the highest scores from both validators, indicating that the math comic possesses high-quality visual illustrations. This supports the argument that the use of AI in creating math comics has significant potential to efficiently produce high-quality illustrations (Surya, 2026). Meanwhile, the subject matter expert validation yielded a result of 82.14%, meaning this comic medium was deemed "Highly Valid" in terms of content. During the development phase, the final product underwent two rounds of revisions based on feedback from the two expert validators. The first revision involved changing the characters' costumes to grayish-white with a library setting, as well as adding numbers to each panel to clarify the reading order of the comic. The second revision involved increasing the number of panels in the comic to ensure the material presented was more comprehensive. Both of these revisions were substantive because they affected readability and contextual appropriateness, rather than being merely aesthetic improvements. Additionally, the practicality assessment by teachers yielded a score of 71.9%, falling into the "Practical" category. Teachers assessed that the math comic could be easily integrated into math instruction. The highest scores in the practicality test were in the areas of content and design, indicating that, from the teachers' perspective, this comic is pedagogically relevant and does not require complex adaptations for implementation in classroom instruction.

The implementation phase was conducted in the 11th-grade class at one of public senior high school, involving 36 students as test subjects. The comic was used to teach the topic of compound interest, and students were asked to complete a response questionnaire as well as take pre- and post-tests. The results of the student response questionnaire yielded a percentage of 86%, indicating that the math comic falls into the "Practical" category. The aspects of motivation and interest in learning achieved the highest score (147), followed by ease of use (96), and engagement in the learning experience (95). These response results indicate that the math comic successfully supported an increase in students' interest and intrinsic motivation toward financial mathematics material. The implementation proceeded as planned, with students demonstrating active engagement while reading and discussing the comic's content. This confirms that the comic format is capable of creating a more interactive learning environment compared to conventional textual approaches. The results of the posttest also showed a significant improvement compared to the pretest. Students' average scores increased from 56.06 on the pretest to 90.83 on the posttest, with an improvement of 34.77 points. Subsequently, a comprehensive

evaluation was conducted by integrating data from the previous stages. The evaluation results showed that the comic medium met the criteria for validity and practicality, making it suitable for use as a mathematics learning medium. This evaluation also served as feedback for improvements should the medium be further developed on a larger scale.

The findings of this study indicate that the mathematics comic medium on the topic of compound interest falls into the category of highly suitable and practical for use in learning. Pedagogically, this achievement demonstrates that comics designed with a narrative flow, illustrations, and real-world financial contexts meet the requirements of a learning resource that is relevant to learning objectives and easy to integrate into the classroom. This aligns with the view that curriculum resources in mathematics need to be contextual, easy to use, and aligned with specific learning objectives (Rezat, 2024), as well as the notion that the quality of mathematics learning is largely determined by the appropriateness of the context, topic, and the way learning resources are presented to students (Brunner & Star, 2024). These findings also align with studies on visual and interactive media in mathematics, which show that well-designed media can help students build connections between concepts and maintain engagement in learning (Debrenti, 2024).

The practicality evident in the assessments by teachers and students indicates that these comics are not only content-rich but also convenient for classroom instruction. Such positive feedback is crucial because effective mathematics learning resources must not only be engaging but also feel familiar, be easily accessible, and help students grasp the material more comfortably (Hwang et al., 2025; Jatileni et al., 2024). In studies on the use of digital tools and digitization in mathematics education, media that can make abstract concepts more visual and interactive tend to receive more positive reception from users, while the need for visual-digital competencies in mathematics is also becoming increasingly prominent (Dinçer, 2025; Jatileni et al., 2024). Furthermore, recent RME studies indicate that topics such as problem solving, learning tools, and model development remain at the forefront of research, reinforcing the relevance of contextual media such as comics for school mathematics education (Fajri et al., 2025).

The increase in scores from the pretest to the posttest and the significant test results suggest that this comic helps students move beyond simply reading information toward developing a more structured problem-solving process. These findings align with a review of PBL in K-12 mathematics, which shows that integrated approaches tend to support students' cognitive, affective, social, and metacognitive achievements (Ayari et al., 2025). Furthermore, research on problem-posing emphasizes that textbooks or learning resources that provide students with the space to transform situations into mathematical questions and solutions can drive instructional changes and enhance learning outcomes (Hwang et al., 2025). A scoping survey on ChatGPT in mathematics education also emphasizes the importance of learning resources that aid conceptual understanding, personalized learning, and critical thinking which is fundamentally aligned with the role of comics as guides for students' thinking, rather than merely passive reading material (Pepin et al., 2025). Thus, the improvement in learning outcomes in this study is a positive result of presenting concrete material, storylines that support reasoning, and tasks that encourage students to take an active role in the learning process.

In practice, teachers can use math comics as a supplementary medium for teaching compound interest, especially when students need assistance that bridges the gap between abstract concepts and real-life financial contexts. However, one limitation of this medium is that the pilot study was still confined to a single school context, involving a small number of students. Therefore, future research should expand the sample and test other financial mathematics topics to strengthen its contribution to mathematics learning (Rezat, 2024; Dinçer, 2025; Ayari et al., 2025). Furthermore, the contexts used in the comics need to be adapted to the real-world environments that students or specific schools frequently encounter, so that the material can be more easily understood. More broadly, these findings suggest that the development of context-based visual media is not only technically feasible but also pedagogically relevant for helping students understand and solve mathematical problems in a more meaningful way.

The practical feedback from teachers and students indicates that this comic booklet is not only substantively sound but also convenient to use in the classroom. Such positive responses are important because effective mathematics learning resources must not only be engaging but also feel familiar, be easily accessible, and help students grasp the material with greater ease (Hwang et al., 2025; Jatileni et al., 2024). In studies on the use of digital tools and digitization in mathematics education, media that can make abstract concepts more visual and interactive tend to be better received by users, while the need for visual-digital competencies in mathematics is also becoming increasingly prominent (Dinçer, 2025; Jatileni et al., 2024). Furthermore, recent RME studies indicate that topics such as problem solving, learning tools, and model development remain at the forefront of research, reinforcing the relevance of contextual media such as comics for school mathematics learning (Fajri et al., 2025).

The improvement in scores from the pretest to the posttest and the significant test results suggest that this booklet helps students move beyond simply reading information toward constructing more purposeful

problem-solving steps. These findings align with a review of PBL in K-12 mathematics, which shows that integrated approaches tend to support students' cognitive, affective, social, and metacognitive achievements (Ayari et al., 2025). Furthermore, research on problem-posing emphasizes that textbooks or learning resources that provide students with the space to transform situations into mathematical questions and solutions can drive instructional change and enhance learning outcomes (Hwang et al., 2025). A scoping survey on ChatGPT in mathematics education also emphasizes the importance of learning resources that aid conceptual understanding, personalized learning, and critical thinking which fundamentally aligns with the role of comic booklets as guides for student thinking, rather than merely passive reading material (Pepin et al., 2025). Thus, the improvement in learning outcomes observed in this study is a positive result of the use of concrete teaching materials, storylines that facilitate reasoning, and tasks that encourage students to take an active role in the learning process.

In practice, printed math comics can be used by teachers as a supplementary medium for teaching compound interest, especially when students need a bridge from abstract concepts to financial contexts that are closer to their daily lives. However, these results should still be interpreted with caution because the pilot study was limited to a single school context and a small number of students. Therefore, future research should expand the sample, compare printed booklets with digital media, and test other topics in financial mathematics to strengthen their contribution to mathematics learning (Rezat, 2024; Dinçer, 2025; Ayari et al., 2025). More broadly, these findings suggest that the development of context-based visual media is not only technically feasible but also pedagogically relevant for helping students understand and solve mathematical problems in a more meaningful way.

3.3. Implications

The findings of this study have practical, theoretical, and pedagogical implications for the development of mathematics instruction in secondary schools. Practically, printed/booklet-based mathematical comics on compound interest can serve as an alternative instructional medium that supports teachers in presenting financial mathematics concepts in a more contextual, visual, and relatable way to students' daily experiences. The results regarding validity, practicality, and effectiveness indicate that story- and illustration-based media have the potential to help teachers create more engaging learning experiences while supporting the development of students' mathematical problem-solving skills. Thus, comic-based media not only serve as a supplement to instructional materials but can also be utilized as a complementary learning resource to help students understand abstract concepts through visual representations and real-life situations.

Theoretically, this study reinforces research on the use of contextual visual media in mathematics education, particularly in the development of mathematical problem-solving skills. The research results indicate that the integration of narrative, illustrations, and financial mathematics contexts supports students in understanding problems, formulating solution strategies, carrying out procedures, and evaluating results in accordance with the stages of mathematical problem-solving. These findings expand the discourse on mathematics media development research, particularly regarding the use of printed comics or booklets, which remains relatively limited to high school-level financial mathematics material.

Furthermore, this study has broader implications for educational practice. The development of learning media based on real-life contexts can serve as a strategy to address the challenges of 21st-century mathematics education, which demands critical thinking, problem-solving, and decision-making skills grounded in real-world situations. In the context of educational policy, the results of this study can serve as a reference for teachers, schools, and curriculum developers in promoting the use of innovative learning media that are not only oriented toward content delivery but also toward strengthening students' mathematical skills. However, since this study was conducted on a limited pilot scale, further research with a broader range of participants and more diverse school contexts is still needed to strengthen the generalizability of the findings.

3.4. Limitations

This study has several limitations that must be considered when interpreting the results. First, the implementation of the mathematics comic media was conducted on a limited pilot scale involving 36 11th-grade high school students. Although the number of participants was sufficient for the product implementation phase, the results of this study cannot yet be widely generalized because student characteristics, school environments, and learning processes may vary across schools.

Second, the developed medium focused on compound interest within the topic of financial mathematics. Therefore, the results of this study cannot yet illustrate the suitability of using comic-based media for other mathematics topics with different conceptual characteristics. Each topic has varying levels of abstraction and representation needs; thus, the development of visual design, storylines, and learning activities may require adjustments.

Third, this study has not comprehensively tested the effectiveness of the mathematics comic media through an experimental or quasi-experimental research design. The implementation was still aimed at obtaining information regarding the product's feasibility based on aspects of validity, practicality, user response, and an overview of students' problem-solving abilities after using the medium. Therefore, the findings of this study cannot yet serve as a basis for concluding that mathematics comics are more effective than other media or learning models.

Furthermore, this study used the ADDIE development model, which focuses on the systematic processes of analysis, design, development, implementation, and evaluation of a product. Although this model provides a structured development framework, the process of revision through implementation across various school characteristics and learning conditions remains limited. Therefore, future research is recommended to test the effectiveness of the medium using an experimental design involving an experimental class and a control class, so that the impact of using comic-based media on mathematical problem-solving skills can be more strongly demonstrated. Future research could also expand the application of this medium to other mathematics topics, involve a larger number of participants, and compare the use of print and digital comics to provide a more comprehensive picture of their utility in mathematics learning.

4. Conclusion

This study aimed to develop a printed/booklet-based mathematical comic as a learning medium on the topic of compound interest to support high school students' mathematical problem-solving skills using the ADDIE model. The results indicate that the developed medium meets the criteria for validity, practicality, and effectiveness, making it suitable for use as a mathematics learning medium. These findings indicate that the integration of contextual stories, visual illustrations, and real-life mathematical problems has the potential to help students understand financial mathematics concepts while supporting a more meaningful mathematical problem-solving process. This study also confirms that comic-based media not only serve as a visual innovation in learning but can also function as a pedagogical alternative to bridge abstract mathematical concepts with students' more concrete and communicative learning experiences. Therefore, the use of mathematical comic-based media can be considered as one of the learning strategies for contextual mathematics material at the high school level. Future research is recommended to implement this medium with a broader range of participants and school contexts, develop digital or interactive versions, and test its application to other mathematics topics to gain a more comprehensive understanding of the contribution of comic-based media to mathematics learning and students' mathematical problem-solving skills.

Author Contributions

Dita Susi Evrihatin: Conceptualization of the research idea, development of the research methodology, conduct of the research, data collection and management, data analysis, data visualization/products, drafting of the initial article, and review and editing of the manuscript. A'yunnisa Tsani: Conceptualization of the research idea, development of the research methodology, conduct of the research, data collection and management, data analysis, data visualization/products, drafting of the initial article, and review and editing of the manuscript. Sunismi: Research supervision/guidance, development of the methodology, validation, research project administration, and manuscript review and editing. Any Herawati: Provision of research resources/support, validation, involvement in research implementation, and manuscript review and editing. Retno Trisniwati: Provision of research resources/support, validation, involvement in research implementation, and manuscript review and editing.

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Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethics and Consent Declarations

This study was conducted in accordance with the principles of educational research ethics. Formal ethical approval from an institutional ethics committee was not required because the study involved educational activities with minimal risk, specifically the implementation of learning media in a school setting in accordance with applicable institutional guidelines. Research permission was obtained from the school. Participant involvement was voluntary, and participants were informed of the research objectives and their right to withdraw at any time without consequences. Participant confidentiality and privacy were safeguarded through anonymization procedures. No personally identifiable information was included in the data, analysis, or research publication. All data were used solely for research purposes.

Data Availability

Datasets generated and/or analyzed during this study are available from the corresponding author upon reasonable request. Shareable data include anonymized expert validation data, student survey responses, and learning analysis results used in this study. To protect participants' privacy and confidentiality, all personally identifiable information has been removed from the datasets.

Declaration on AI Use

The authors declare that artificial intelligence (AI) technology or AI-based tools were used to support the development of educational comic media and to assist with language refinement, readability, and manuscript formatting under the authors' full supervision. AI tools were used solely as supporting instruments in the creation of the media and the refinement of the writing. All research concepts, research design, data collection, analysis, interpretation of results, and final conclusions were developed, critically reviewed, verified, and approved by the authors. AI was not used to independently generate scientific claims, research findings, interpretations, recommendations, or conclusions, and is not listed as an author.

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References

- Amalia, R., & Sofiyan, S. (2018). Virtual manipulatives pada pembelajaran matematika. *Jurnal Dimensi Matematika*, 1(2), 6–18. Retrieved from <https://ejurnalunsam.id/index.php/JDM/article/view/1068>
- Ayari, M. A. S., Sellami, A. S. A., Santhosh, M. E. M., Naji, K. K., Al-Ali, A. A., & Al-Hazbi, S. M. (2025). From problems to performance: A systematic review of problem-based learning in K–12 mathematics. *Frontiers in Education*, 10, 1731307. <https://doi.org/10.3389/feduc.2025.1731307>
- Borg, W. R., & Gall, M. D. (1989). *Educational research: An introduction* (5th ed.). New York, NY: Longman.
- Brunner, E., & Star, J. R. (2024). The quality of mathematics teaching from a mathematics educational perspective: What do we actually know and which questions are still open? *ZDM–Mathematics Education*, 56, 775–787. <https://doi.org/10.1007/s11858-024-01600-z>
- Dahal, N., Neupane, B. P., Pant, B. P., Dhakal, R. K., Giri, D. R., Ghimire, P. R., & Bhandari, L. P. (2024). Participant selection procedures in qualitative research: Experiences and some points for consideration. *Frontiers in Research Metrics and Analytics*, 9, 1512747. <https://doi.org/10.3389/frma.2024.1512747>
- Debrenti, E. (2024). Game-based learning experiences in primary mathematics education. *Frontiers in Education*, 9, 1331312. <https://doi.org/10.3389/feduc.2024.1331312>
- Dick, W., Carey, L., & Carey, J. O. (2005). *The systematic design of instruction* (6th ed.). Boston, MA: Pearson.
- Dinçer, B. D. (2025). Digitalization in mathematics education: How distance and online learning shape pre-service teachers' career perceptions. *Frontiers in Education*, 10, 1639893. <https://doi.org/10.3389/feduc.2025.1639893>
- Fajri, H. M., Marini, A., & Suyono. (2025). Trends and patterns in realistic mathematics education research in elementary schools: A bibliometric approach. *Social Sciences & Humanities Open*, 12, 101730. <https://doi.org/10.1016/j.ssaho.2025.101730>
- Fardah, D. K., & Kusumah, Y. S. (2024). Students' and teacher's difficulties in dealing with real-context problems: A case study. *Journal of Honai Math*, 8(2), 147–165. <https://doi.org/10.30862/jhm.v8i2.828>
- Hwang, S., Han, J., Muirhead, F., Brown, A., Melville, M., & Cai, J. (2025). Textbooks as a resource for teaching mathematics. *ZDM–Mathematics Education*. Advance online publication. <https://doi.org/10.1007/s11858-025-01694-z>
- Jatileni, C. N. C., Havu-Nuutinen, S., Pöntinen, S., & Kukkonen, J. (2024). Learning mathematics with personal mobile devices in school: A multigroup invariance analysis of acceptance among students and teachers. *Frontiers in Education*, 9, 1425779. <https://doi.org/10.3389/feduc.2024.1425779>
- Kholid, M. N., Santosa, Y. T., Toh, T. L., Wijaya, A. P., Sujadi, I., & Hendriana, H. (2024). Defragmenting students' reflective thinking levels for mathematical problem solving: Does it work? *Reflective Practice*, 25(3), 319–351. <https://doi.org/10.1080/14623943.2024.2320140>
- Liu, J., Keane, T., Sun, D., Yang, Y., & Yang, Y. (2025). Design and evaluation of ChatGPT-MWPS: An AI-enhanced learning system for improving primary students' mathematical word problem solving. *Smart Learning Environments*, 12, 68. <https://doi.org/10.1186/s40561-025-00419-9>
- Meganingtyas, D. E. W. (2021). Pemanfaatan software Cabri, GeoGebra, dan SketchUp sebagai media visualisasi konsep Matematika pada materi geometri ruang. *Jurnal Riset Pendidikan Matematika Jakarta*, 3(1), 67–75. <https://doi.org/10.21009/jrpmj.v3i1.20122>

- Mutya, R. C., Tondo Jr, R. C., Aragon, K. M. P., Tablate, D. J. C., & Bonotan, A. M. (2025). Strategic intervention materials-based instruction on disaster literacy for technology students using the ADDIE model. *Frontiers in Education*, 10, 1671079. <https://doi.org/10.3389/feduc.2025.1671079>
- Ngu, B. H., & Phan, H. P. (2024). Instructional approach and acquisition of mathematical proficiency: Theoretical insights from learning by comparison and cognitive load theory. *Journal for the Study of Education and Development*, 3(3), 357–379. <https://doi.org/10.1177/27527263241266765>
- Nurhayati, Y., Zakiah, N. E., & Amam, A. (2020). Integrasi contextual teaching and learning (CTL) dengan GeoGebra: Dapatkah meningkatkan kemampuan koneksi matematis siswa? *Teorema: Teori dan Riset Matematika*, 5(1), 27–34. <https://doi.org/10.25157/teorema.v5i1.3349>
- Pepin, B., Buchholtz, N., & Salinas-Hernández, U. (2025). A scoping survey of ChatGPT in mathematics education. *Digital Experiences in Mathematics Education*, 11, 9–41. <https://doi.org/10.1007/s40751-025-00172-1>
- Polya, G. (1973). How to solve IT. Princeton: Princeton University Press. <https://notendur.hi.is/hei2/teaching/PolyaHowToSolveIt.pdf>
- Pramesti, R. A., & Wahyudi, W. (2025). Development of culture-based interactive comic media to improve mathematical literacy in primary schools. *Electronic Journal of Education, Social Economics and Technology*, 6(1). <https://doi.org/10.33122/ejeset.v6i1.651>
- Putra, F. G., Putra, R. W. Y., Ricardo, S., Widyawati, S., & Juraev, D. A. (2024). Effectiveness of meaningful instructional design in improving students' mathematical skills. *Journal of Philology and Educational Sciences*, 3(2), 58–66. <https://doi.org/10.53898/jpes2024325>
- Putra, Z. H., Dahnilyah, & Aljarrah, A. (2021). A praxeological analysis of pre-service elementary teacher-designed mathematics comics. *Journal on Mathematics Education*, 12(3), 563–580. <https://doi.org/10.22342/jme.12.3.14143.563-580>
- Putri, G. R., Novita, R., & Rahmattullah, R. (2025). Development of digital mathematics comics based on the realistic mathematics education approach. *Indonesian Journal of Science and Mathematics Education*, 8(3), 681–695. <https://doi.org/10.24042/ijsme.v8i3.29156>
- Rezat, S. (2024). Research on curriculum resources in mathematics education: A survey of the field. *ZDM–Mathematics Education*, 56, 223–237. <https://doi.org/10.1007/s11858-024-01559-x>
- Risnawati, Syahwela, M., & MZ, Z. A. (2023). Students' mathematical problem-solving ability based on the level of learning outcomes on sequence and series. *Mosharafa: Jurnal Pendidikan Matematika*, 12(1), 145–154. <https://doi.org/10.31980/mosharafa.v12i1.763>
- Rocha, H., Viseu, F., & Matos, S. (2024). Problem-solving in a real-life context: An approach during the learning of inequalities. *European Journal of Science and Mathematics Education*, 12(1), 21–37. <https://doi.org/10.30935/scimath/13828>
- Rochim, A., Hidayati, W. S., & Masrurroh, F. (2023). Students' profiles with interpersonal and intrapersonal intelligence in solving mathematical problems. *Mosharafa: Jurnal Pendidikan Matematika*, 12(1), 35–46. <https://doi.org/10.31980/mosharafa.v12i1.1948>
- Santos-Trigo, M. (2024). Problem solving in mathematics education: Tracing its foundations and current research-practice trends. *ZDM–Mathematics Education*, 56, 211–222. <https://doi.org/10.1007/s11858-024-01578-8>
- Siswanto, E., & Meiliasari, M. (2024). Kemampuan pemecahan masalah pada pembelajaran matematika: Systematic literature review. *Jurnal Riset Pembelajaran Matematika Sekolah*, 8(1), 45–59. <https://doi.org/10.21009/jrpms.081.06>
- Soriano-Alcantara, J. M., Guillén-Gámez, F. D., & Ruiz-Palmero, J. (2025). Exploring digital competencies: Validation and reliability of an instrument for the educational community and for all educational stages. *Technology, Knowledge and Learning*, 30, 307–326. <https://doi.org/10.1007/s10758-024-09741-6>
- Suparatulorn, R., Jun-On, N., Hong, Y. Y., Intaros, P., & Suwannaut, S. (2023). Exploring problem-solving through the intervention of technology and realistic mathematics education in the calculus content course. *Journal on Mathematics Education*, 14(1), 103–128. <https://doi.org/10.22342/jme.v14i1.pp103-128>
- Surya, D. I. (2026). Analisis pemanfaatan artificial intelligence generatif terhadap efisiensi proses desain grafis digital pada media informasi Polresta Banyumas. *Imajinasi: Jurnal Ilmu Pengetahuan, Seni, dan Teknologi*, 3(2), 10–22. <https://doi.org/10.62383/imajinasi.v3i2.1110>
- Umam, M. A. K., Iriani, D., & Novferma, N. (2024). Development of problem-based learning-based mathematics comic media using Pixton to improve students' mathematical problem-solving skills. *Journal Focus Action of Research Mathematic (Factor M)*, 7(1), 92–109. https://doi.org/10.30762/f_m.v7i1.2623
- Vázquez-Parra, J. C., Henao-Rodríguez, L. C., Lis-Gutiérrez, J. P., Castillo-Martínez, I. M., & Suarez-Brito, P. (2024). eComplexity: Validation of a complex thinking instrument from a structural equation model. *Frontiers in Education*, 9, 1334834. <https://doi.org/10.3389/feduc.2024.1334834>
- Yuniawati, S., Palupi, E. L. W., & Fiangga, S. (2024). Pengembangan e-comic matematika berbasis pendekatan matematika realistik (PMR) pada materi persamaan linear satu variabel. *MATHEdunesa*, 13(2), 576–595. <https://doi.org/10.26740/mathedunesa.v13n2.p576-595>