



Development of Gen-M Media Based on Active Learning Approach to Enhance Critical Thinking and Mutual Cooperation Characters in Mathematics Learning for Fifth-Grade Elementary Students

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Abstract: This study aims to develop Gen-M Media (Dragon Mathematics Educational Game), based on an active learning approach, that is valid, practical, and effective in enhancing students' critical thinking skills and fostering cooperative character in mathematics learning among fifth-grade elementary school students. The study employed a Research and Development (R&D) method using the ADDIE model, which consists of five stages: analysis, design, development, implementation, and evaluation. The instruments used included validation sheets, questionnaires, observation sheets, and critical thinking tests. Validation sheets were administered to media experts, material experts, and practitioners to assess the validity and feasibility of the Gen-M media. Questionnaires were distributed to teachers and students to evaluate practicality. Observation sheets were used to assess the development of students' cooperative character. In addition, pretests and posttests were used to measure critical thinking skills. The data were analyzed using both qualitative and quantitative techniques. The results indicated that: (1) expert and practitioner validation categorized the media as "highly appropriate"; (2) practicality tests yielded scores of 95% from teachers and 91.17% from students, classified as "very practical"; and (3) quantitative analysis confirmed that the Gen-M media significantly improved students' critical thinking skills by [insert value]% and fostered cooperative character development. In conclusion, the Gen-M media integrated with an active learning approach is a valid, practical, and effective instructional tool that positively influences both the cognitive and social competencies of elementary school students in mathematics education.

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Introduction

Education plays a crucial role in daily life, particularly mathematics education, which is a compulsory subject in formal education and has adequate learning facilities so that teaching and learning activities can proceed in accordance with the expected basic competencies (Supriyadi, 2021). Mathematics is a subject taught from elementary school to university. This demonstrates that mathematics must be studied. Students can also use it to solve everyday problems and other disciplines (Anggoro, 2015). Because mathematics is a fundamental science, its learning at all levels of formal education must be prioritized (Sagala, 2019).

Mathematics is crucial for students because it helps them understand the concept of arithmetic, aids them in learning other subjects, and understands its application in everyday



life. In both technology and everyday life, we constantly interact with numbers and mathematics. Mathematical concepts in everyday life are essential for problem-solving. In this regard, numerous issues remain to be resolved to improve the quality of mathematics learning. Mathematics learning, which tends to use conventional methods, is often ineffective in actively engaging students. Lectures or one-way delivery methods quickly make students bored and unmotivated. This results in poor critical thinking and minimal social interaction in the learning process. Therefore, learning innovations that are engaging, interactive, and capable of utilizing technology are needed.

The rapid and rapid advancement of technology in today's life is unavoidable. We can feel this progress in various fields, one of which is education, which is experiencing significant changes. Today, teachers are no longer the sole source of knowledge for students. The emergence of the internet and easily accessible electronic media allows students to learn anywhere and anytime without the need for teacher supervision (Riswandi, 2019). This technological advancement can be utilized in elementary school learning, for example, by utilizing it as a learning medium to deliver learning materials in the classroom.

Elementary school education plays a crucial role in developing students' cognitive, affective, and social skills. Mathematics, as a core subject, is often challenging for students because it is perceived as difficult and uninteresting. As a result, student achievement in mathematics is often suboptimal. Furthermore, student character traits, such as mutual cooperation, also need to be developed to create a generation capable of working together and possessing a strong social spirit. One relevant solution is the application of Gen-M Media (Mathematical Dragon Educational Game) with an active learning approach. Gen-M Media (Mathematical Dragon Educational Game), as an educational game, can help students learn in a fun way and actively involve them in the learning process. Based on the results of research conducted by (Ferryka, 2017), this media can be used as an interesting medium for students because it is presented in the form of a game so that it can be an interesting medium for students. Then, research by (Indriasih, 2015) found that the snakes and ladders game media can help students understand the material, build independence, and apply character education through games. In this game, students are given the opportunity to work together in groups, so that it not only improves the understanding of mathematical concepts, but also builds the character of mutual cooperation.

Gen-M (Mathematical Dragon Educational Game) media, with its active learning approach, supports interactive learning, enabling students to collaborate, think critically, and solve problems together. By integrating snakes and ladders media into active learning, teachers can create a more lively and engaging atmosphere for students. In addition to increasing interest in learning, this method can also develop important social values in students, such as cooperation and solidarity. This aligns with research conducted by (Hajar, 2018), which states that snakes and ladders media can increase teacher motivation to teach and improve student attitudes and skills. Furthermore, research by (Pramono, 2023) indicates that the use of active learning methods can improve academic achievement.

Gen-M media, with its active learning approach, can create a fun learning process for students. Using Gen-M media with an active learning approach can encourage students to spend more time playing and learning. The role of Gen-M media, with its active learning approach, can improve student concentration, foster sportsmanship, and problem-solving skills, as the game presents challenges that must be resolved quickly and accurately (Setiani, 2022).

Based on interviews with the fifth-grade teacher at SD Negeri Jomblang 03, mathematics learning has implemented the Merdeka Curriculum; however, classroom



practices still rely heavily on conventional lecture and discussion methods with limited and less innovative learning media (Syutharidho and Rakhmawati, 2015). This condition has contributed to low student engagement and difficulties in understanding mathematical concepts, particularly plane geometry material that requires analytical and critical thinking skills. Although the curriculum emphasizes active and student-centered learning, the instructional process in reality has not fully supported the development of higher-order thinking skills.

The findings indicate that low critical thinking skills constitute a significant pedagogical issue. Many students experience difficulties in independently analyzing and solving mathematical problems, resulting in low academic achievement and the need for remedial learning. In addition, a considerable number of students failed to meet the Minimum Completeness Criteria (KKTP), reflecting a gap between curriculum expectations and actual classroom outcomes. This issue is not solely caused by students' lack of attention during lessons, but also by the limited use of engaging learning media, the dominance of teacher-centered instruction, and the insufficient opportunities for students to actively practice problem-solving and critical reasoning in mathematics learning. To address these challenges, teachers, as learning facilitators, need to develop innovative learning media aimed at improving the quality of instruction, facilitating students' understanding of learning materials, and increasing their motivation to learn both inside and outside the classroom. One alternative that can be developed is educational game-based learning media, namely Gen-M media, which integrates an active learning approach. Starting from these problems, this study aims to develop Gen-M Media (Dragon Mathematics Educational Game) based on an active learning approach for fifth-grade elementary students that is valid, practical, and effective in enhancing students' critical thinking skills and fostering mutual cooperation character in mathematics learning for fifth-grade elementary students.

Research Method

This study employed a Research and Development (R&D) method with the ADDIE model, which consists of five stages: analysis, design, development, implementation, and evaluation (Sugiyono, 2022). Before the Gen-M (Mathematical Dragon Educational Game) media with an active learning approach was field-tested, revisions were made based on the assessments, suggestions, and input from experts and practitioners. Therefore, the ADDIE model is highly suitable for use in research focused on the development of learning media and teaching materials.

This study was conducted in a public elementary school in Semarang City, Indonesia, involving 28 fifth-grade students as research subjects. The study population consisted of all fifth-grade students, while the sample was selected using a purposive sampling technique based on characteristics relevant to the research objectives. The selected sample included students who participated in the implementation of the Gen-M learning media. Data collection techniques in this study included observation, interviews, questionnaires, and tests. Observations and interviews were conducted during the preliminary study to identify problems in mathematics learning. Questionnaires were used for expert validation, practitioner validation, teacher responses, and student responses. Tests (pretests and posttests) were administered to measure student learning achievement before and after using Gen-M media with an active learning approach.

The instruments used in this study consisted of: (1) expert and practitioner validation sheets covering media, materials, and language aspects; (2) observation sheets to assess

student activity; (3) questionnaires to measure teacher and student responses and the practicality of the media; and (4) test instruments to measure student learning outcomes. These instruments were developed based on research indicators and validated before use. Data analysis techniques included qualitative and quantitative approaches. Qualitative data from observations, interviews, and suggestions from experts and practitioners were analyzed descriptively to develop the product. Validity analysis was conducted by calculating the average score from the expert and practitioner validation questionnaires for each aspect, converting them to percentages, and classifying them into validity categories according to predetermined criteria. Comments and suggestions from experts and practitioners were analyzed qualitatively to inform module revisions. Practicality analysis involved calculating the percentage of teacher and student responses for each Likert scale category and interpreting them into appropriate practicality levels.

Effectiveness was examined by comparing pretest and posttest scores. Data obtained from the research subjects, namely 28 fifth-grade students, were then analyzed using a Paired Sample t-Test with the help of SPSS 25. Then, the data obtained were analyzed using a gain score by comparing the pretest and posttest scores for each student. The gain value will indicate the effectiveness of the treatment given to the experimental group.

Results and Discussion

Analysis

Research on the development of Gen-M Media (Mathematical Dragon Educational Game) using an active learning approach at Jomblang 01 Public Elementary School shows that students need visual, interactive, and digital-based learning media to better understand abstract mathematical concepts. Students more easily understand material presented through images, animations, and game simulations, which supports the opinion of (Arsyad, 2019) that visual media can improve information retention and make concepts more concrete. Interviews with teachers also revealed that students tend to have visual and kinesthetic learning styles, where they learn more effectively through direct involvement, games, and group discussions. This finding is in line with (Aziz, 2018), who states that audiovisual and hands-on learning activities are more effective than conventional methods.

The implementation of Gen-M Media was found to increase students' learning motivation because educational games create a fun and challenging learning environment. This supports (Prensky, 2021), who explains that game-based learning enhances students' intrinsic motivation through interactive experiences. In addition, the feedback feature in Gen-M Media helps students improve their understanding and problem-solving skills, which aligns with (Hattie, 2017), emphasizing that feedback is an important factor in developing critical thinking. Group-based game activities also encourage collaboration, discussion, and mutual support among students, supporting (Johnson, 2019), which states that cooperative learning can improve social skills and cooperative attitudes. Therefore, Gen-M Media focuses not only on critical thinking but also on developing students' social character.

The study also found that limited use of digital media in classrooms remains a challenge, even though facilities such as projectors are available. This finding supports, (Fitri, 2023) which states that technology facilities alone are insufficient without appropriate learning media. Furthermore, the classroom social environment at Jomblang 01 Public Elementary School supports collaborative learning because students feel more comfortable learning in groups, consistent with (Rachamdyanti, 2019) who highlights the importance of social interaction in learning. Overall, the findings indicate that Gen-M Media with an active learning approach is an effective solution for improving students' critical mathematical

thinking, motivation, and collaborative character, making it suitable for wider implementation in elementary mathematics learning.

Design

The design stage of Gen-M Media (Mathematical Dragon Educational Game) is an important foundation to ensure the media aligns with learning objectives, student characteristics, and elementary school mathematics needs. The design includes interfaces, gameplay, question types, visual illustrations, and interactive features that support active student involvement. This is consistent with (Sadiman, 2022) who states that the design stage is the main basis for creating effective learning media according to student needs.

Gen-M Media was designed as an interactive digital educational game that integrates text, images, animation, and feedback into one platform, creating a more engaging learning experience. This finding is supported by (Riyanto, 2020) who explains that interactive digital media can improve students' interest and understanding through multimedia elements. The media structure includes an opening page, game instructions, levels, math problems, and feedback features, all arranged systematically to provide a clear learning flow. The interface was also designed to be simple, attractive, and suitable for elementary school students.

The questions in Gen-M Media are arranged gradually from simple to complex and connected to students' daily life contexts to help them better understand mathematical concepts. Interactive features such as direct feedback, scoring systems, and group challenges support active and collaborative learning. This supports (Rahmawati, 2021), who found that interactive digital features increase student engagement and understanding. In addition, group game activities encourage cooperation, discussion, and mutual support among students, which aligns with (Johnson, 2019) regarding the benefits of cooperative learning for improving social and collaborative skills. Overall, the design of Gen-M Media combines pedagogical and aesthetic considerations through attractive colors, communicative icons, and simple navigation, making it user-friendly and effective for elementary school mathematics learning.

Development

The expert and practitioner validation phase showed that Gen-M Media (Math Dragon Educational Game) with an active learning approach has a very high level of feasibility in terms of content, presentation, language, and interactivity. This validation process is an essential stage in research and development to ensure that the media meets quality standards and is suitable for learning. The media was evaluated by material experts, language experts, and media experts to assess the appropriateness of the content, presentation, and media components for elementary school students and learning objectives. This aligns with (Borg, 2023), which emphasizes that products must undergo an expert evaluation stage before being tested with users.

The validation results indicated that Gen-M Media achieved the "very feasible" category in all major aspects. The average score for media design, material, and language aspects reached 96.5, while the material aspect obtained 91.66 and the language aspect 91.58, all categorized as very appropriate. These results show that the visual structure, layout, language clarity, and suitability of the material with learning outcomes meet elementary school learning needs. This finding supports (Ramdhani, 2019), who states that digital teaching materials become more effective after expert validation because it improves pedagogical and technical quality.

Validation by practitioners, particularly school principals, further strengthened the results, with scores ranging from 90–97%, indicating that the media is highly suitable for classroom use. Practitioners considered Gen-M Media visually attractive, relevant to real



learning conditions, and appropriate for students' learning styles. This is consistent with (Supriyadi, 2021), who explains that practitioner validation is important because teachers understand students' concrete classroom needs. The validation and revision process ensured that Gen-M Media met feasibility standards in content, appearance, and technology use before being introduced to teachers and fifth-grade students at Jomblang 01 Elementary School in Semarang City. This trial stage supports (Tessmer, 2023) who emphasizes that field trials are essential to ensure products can be used effectively and provide optimal learning experiences.

Implementation

This trial phase was the stage where the Gen-M (math dragon educational game) media, using an active learning approach, was introduced to users, namely teachers and fifth-grade students in Jomblang 01 State Elementary School, Semarang City. There were limitations to this trial phase due to time and cost constraints. Therefore, the trial of the Gen-M (math dragon educational game) media, using an active learning approach, was conducted only with mathematics teachers. The trial phase of the Gen-M (math dragon educational game) media, using an active learning approach, was conducted to gauge teacher and student responses to the Gen-M (math dragon educational game) media, using an active learning approach in the learning process. The trial began with the introduction of the Gen-M (math dragon educational game) media, using an active learning approach, to 23 students. The use of the Gen-M (math dragon educational game) media, using an active learning approach, is expected to improve student competency while fostering critical thinking and collaborative skills in the learning process.

The teacher assessment results showed that this digital textbook received a total score of 43 out of a maximum of 45, with a percentage of 95%, categorized as very practical. Teachers assessed that the Gen-M (math dragon educational game) media, with its active learning approach, was easy to use, easy to understand, and effective in supporting the mathematics learning process. This high level of practicality indicates that the media's design and features align with teachers' needs in managing learning. Research by (Putra, 2021) shows that digital learning media designed with a simple structure, clear navigation, and interactive content tend to provide a high level of practicality because they facilitate teachers' teaching. After determining teachers' responses to the practicality of the Gen-M (math dragon educational game) media with the active learning approach developed, a student response questionnaire was administered to 23 students at Jomblang 01 State Elementary School, Semarang City.

The results of the questionnaire from the student perspective showed a practicality percentage of 91.17%, which is also categorized as very practical. Students considered the media easy to understand, engaging, and helped them practice observing the circumference of plane figures. This data indicates that the visual features, illustrations, and systematic presentation of the material significantly support the learning needs of elementary school students. This finding is consistent with research by (Lestari, 2022), which stated that students grasp material more quickly when learning media combine visual elements and competencies relevant to their lives.

The practicality of the Gen-M (math dragon educational game) media is also influenced by the active learning approach. This approach allows students to more easily understand the learning material, thus motivating them to learn. (Gay, 2022) explains that active learning not only improves understanding but also fosters critical thinking and collaborative skills, as well as student self-confidence, as students experience ease and enthusiasm in the learning process. The results of the practicality test of the Gen-M (math

dragon educational game) media using the active learning approach for the circumference of plane figures are presented in Figure 1.

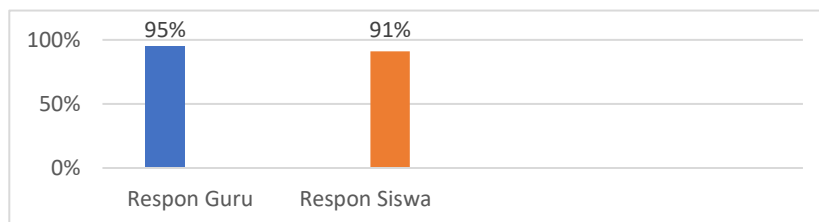


Figure 1. Practicality Test Results

Based on the results of the questionnaire calculating student responses to the Gen-M (math dragon educational game) media using an active learning approach, a total score of 946 was obtained from 23 students, with an average score of 41 and a practicality percentage of 91.17%. This percentage indicates that the developed media falls into the very practical category. This finding is supported by the diagram showing that teacher responses reached 95%, while student responses reached 91%, both falling into the very practical category. Therefore, it can be concluded that the Gen-M (math dragon educational game) media using an active learning approach is feasible and easy to apply in mathematics teaching on the perimeter of plane figures.

The pretest analysis results showed that students' initial abilities were in the moderate category with an average score of 55.56. Frequency distribution data also showed that half of the students were in the highest score interval of 49–62, but the others were still in the low score range, namely 20–34. This finding reflects that before the treatment, students' abilities were still uneven and required more structured and contextual learning interventions. This condition is also in line with (Rahayu, 2020) research which found that elementary school students often experience difficulty in finding the perimeter of flat shapes due to limited media, a lack of examples, and a lack of interesting and relevant learning media. The results of the frequency distribution of Gen-M media (math dragon educational game) with an active learning approach can be seen in the following diagram:

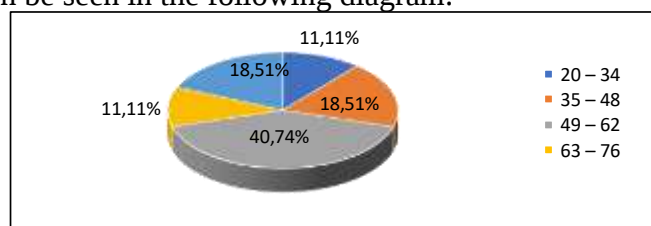


Figure 2. Pretest Perceptions of Gen-M Media

Based on Figure 2, it can be seen that the perceptions of 27 respondents regarding Gen-M media (math dragon educational game) with an active learning approach, with the highest score in the 49-62 class range, at 11 respondents (40.74%). This finding aligns with (Rahayu, 2020) research, which found that elementary school students often experience difficulty in finding the perimeter of flat shapes due to limited media, a lack of examples, and a lack of engaging and relevant learning media. This posttest was conducted by distributing questionnaires and questions on the perimeter of flat shapes for mathematics learning using Gen-M media (math dragon educational game) with an active learning approach in fifth grade at Jomblang 01 State Elementary School, Semarang City. After completing the questionnaires and questions, the posttest on the perimeter of flat shapes was analyzed.

After using the Gen-M media (math dragon educational game) with an active learning approach, the posttest results showed a significant increase. The average posttest score increased to 82.59, which means an increase of 27.03 points from the pretest results. In

addition, the distribution of scores also shifted where most students were in the higher score intervals, namely 71–80 and 91–100. This shows that the Gen-M media (math dragon educational game) with the active learning approach used was able to substantially improve students' understanding and critical thinking. The results of the frequency distribution of the Gen-M media (math dragon educational game) with an active learning approach can be seen in the following diagram:

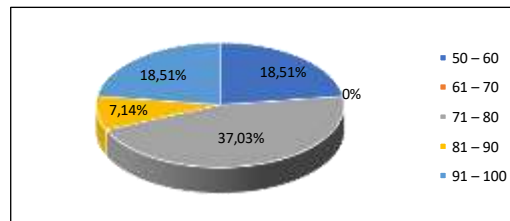


Figure 3. Post-Test Perceptions of Gen-M Media

Based on the data in Figure 3, it can be seen that the perceptions of 27 respondents regarding Gen-M media (Math Dragon educational game) with an active learning approach, with the highest scores in the 71-80 range, at 10 respondents (37.03%). This increase aligns with research by (Suyanto, 2021), which states that interactive digital media can increase students' focus and motivation, thus impacting their critical thinking skills. To prove this hypothesis, a t-test was conducted. The experimental class used to measure the significance of the difference in scores before and after the experiment, using the experimental class. The results of the hypothesis test are shown in Table 2, and the results of the paired samples test are shown in Table 3.

Table 2. Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pretest	55.56	27	18.467	3.554
	Posttest	82.59	27	14.031	2,700

Table 3. Paired Samples Test

		Paired Differences					T	Df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pretest Posttest	27.037	20.721	3.988	35.234	18.840	6.780	26	.000

The findings of this study indicate that the Gen-M media (Math Dragon Educational Game) integrated with an active learning approach has a significant effect on improving students' critical thinking skills in mathematics learning, particularly on the topic of the perimeter of plane figures (Tauraningsih, 2022). This improvement can be seen from the increase in students' average scores from the pretest (55.56) to the posttest (82.59), with a difference of 27.03 points. Furthermore, the paired sample t-test showed a significance value of 0.000, which indicates a statistically significant difference between students' abilities before and after using the Gen-M media. These results demonstrate that interactive digital media combined with active learning strategies can support students in understanding mathematical concepts more effectively and encourage higher engagement during the learning process. However, the claim that Gen-M media improves critical thinking and collaborative learning in this study was only qualitatively observed during classroom activities, where students appeared more active in discussions and group interactions when using Gen-M media. To strengthen this claim, further research is recommended to include a

structured observation sheet or character questionnaire administered before and after implementation so that the improvement in collaborative learning can be measured empirically and statistically.

In addition, the findings emphasize that the effectiveness of the Gen-M media is closely related to the implementation of the active learning approach. Through active participation, students were encouraged to solve problems, discuss mathematical concepts, and interact with peers during learning activities (Septiarini, 2023). This condition created a more student-centered learning environment compared to conventional lecture-based instruction. As a result, students not only improved their mathematical understanding but also developed confidence and motivation in learning mathematics. Therefore, the integration of interactive educational games and active learning approaches can serve as an innovative strategy to improve mathematics learning quality in elementary schools.

Conclusion

This study concludes that the development of the Gen-M (Mathematical Dragon Educational Game) learning media using an active learning approach successfully achieved the intended research objectives. This media has been empirically proven to be highly valid, demonstrating that it meets the required standards in terms of design, materials, and language, and is therefore suitable for use in elementary mathematics learning. Furthermore, the Gen-M media is highly practical to use, as evidenced by the results of practicality tests conducted on teachers (95%) and students (91.17%), thereby enhancing students' critical thinking and mutual cooperation traits during the learning process. Furthermore, the implementation of the Gen-M media significantly improved students' critical thinking and mutual cooperation traits, as evidenced by the pretest and posttest results, which showed an increase of 27.03. Therefore, the Gen-M media (Mathematical Dragon Educational Game) with an active learning approach is proven effective and has a positive influence on critical thinking and mutual cooperation traits in fifth-grade students at Jomblang 01 Elementary School, Semarang City. The results of this study confirm that the use of contextual digital media can improve the ability to develop ideas, choose methods, and develop strategies in a more structured manner.

Recommendation

Based on the results of this study, teachers are expected to conduct continuous evaluations of the use of Gen-M media (Math Dragon Educational Game) integrated with an active learning approach in order to adjust learning strategies to students' needs and learning styles. Teachers are also encouraged to utilize the media in blended learning formats, both inside and outside the classroom, so that students can continue practicing independently through interactive game features. In addition, the automatic feedback feature available in the game can be used as an instant formative assessment tool to identify students' difficulties in understanding the perimeter of plane shapes and to provide immediate reinforcement or remedial instruction.

Students are expected to actively use Gen-M media not only for playing educational games but also for practicing problem solving, analyzing mathematical situations, and improving critical thinking skills through the interactive exercises provided. The game features can encourage students to learn independently, collaborate with peers, and develop confidence in solving mathematics problems related to plane geometry. Future researchers are expected to develop Gen-M media on a broader scale, including different grade levels, mathematics topics, or other subjects. Researchers may also integrate more adaptive and

collaborative digital features, such as progress tracking, multiplayer problem-solving activities, or online learning integration, so that the active learning approach can be implemented more comprehensively and effectively in improving students' critical thinking and numeracy competencies.

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