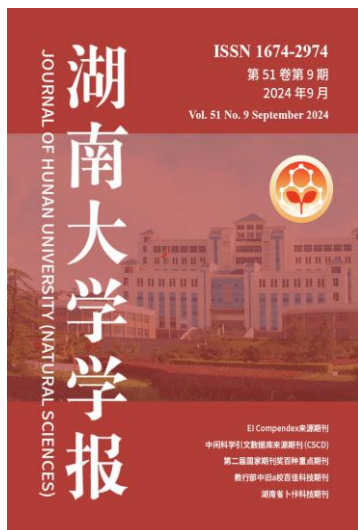




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Development of MCA-Contextual Crossword Media to Enhance Students' Interest and Critical Thinking in Mathematics

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Abstract: This research aims to develop minimum competency assessment (MCA)-contextualized crossword media to improve students' interest in learning and critical thinking skills, which are valid, practical, and effective in mathematics learning. This study was an R&D research project that used the ADDIE model. Questionnaires were used to collect data on the validity and practicality of the media and student learning interest. Pre- and posttest exams were used as tools for data collection. The media validity test yielded an average score of 3.24, the material validity test yielded an average score of 3.35, the practicality percentage was 88.1%, and the N-gain pre- and posttest showed that students' interest in learning and critical thinking skills improved. This research highlights that MCA-contextualized crossword media improve students' interest in learning and critical thinking skills. Therefore, MCA-contextualized crossword media can be used at various educational levels, such as elementary, secondary, and higher education. This can provide deeper insights into how this media works across different stages of cognitive development.

Keywords: crossword; critical thinking; learning interest; minimum competency assessment



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开发MCA语境填字游戏媒体以提高学生对数学的兴趣和批判性思维

摘要：本研究旨在开发最低能力评估 (MCA) 情境化填字游戏媒体，以提高学生的学习兴趣 and 批判性思维能力，这些媒体在数学学习中是有效、实用和有效的。本研究是一个使用ADDIE模型的研发研究项目。问卷用于收集有关媒体的有效性和实用性以及学生学习兴趣的数据。前测和后测考试被用作数据收集工具。媒体效度测试的平均得分为3.24，材料效度测试的平均得分为3.35，实用性百分比为88.1%，N增益前测和后测显示学生的学习兴趣 and 批判性思维能力有所提高。本研究强调，MCA情境化填字游戏媒体提高了学生的学习兴趣 and 批判性思维能力。因此，MCA情境化填字游戏媒体可用于各种教育水平，例如小学、中学和高等教育。这可以更深入地了解这种媒体如何在认知发展的不同阶段发挥作用。

关键词：填字游戏；批判性思维；学习兴趣；最低能力评估

1. Introduction

The use of media in mathematics teaching is essential to enhance instruction, foster understanding, and increase student engagement and interest in learning. Learning media serve as supportive tools that educators use to convey messages, concepts, or materials to students, thereby facilitating their comprehension [1]. In mathematics education, media not only deliver lesson content but also engage students, aid in knowledge retention, and motivate them. Additionally, they assist in conceptualizing abstract mathematical ideas, making learning more meaningful and suited to students' cognitive development [2].

In addition to the use of learning media, assessing students' mathematical competencies is crucial, with assessments providing insights into their learning progress [3]. The minimum competency assessment (MCA) focuses on literacy and numeracy, identifying students' computational skills and highlighting their strengths and weaknesses across various mathematical domains [4]. MCA-based assessments enhance students' mathematical abilities and literacy by incorporating high-order thinking skills (HOTS) and fostering critical thinking [5].

However, the use of media in mathematics teaching has remained limited. This reduces student interest and hampers the development of critical thinking skills [6]. Additionally, MCA-contextual questions are still not widely incorporated into teaching practice. Observations and interviews with the eighth-grade students at SMP Muhammadiyah 1 Malang revealed that teachers did not integrate media containing MCA questions and relied solely on government-provided textbooks. This led to suboptimal students' interest in learning and insufficient development of mathematical critical thinking skills.

Interest in learning mathematics is crucial for the success of the learning process, which involves curiosity and enthusiasm [7]. Research has shown a positive correlation between interest in learning mathematics, students' understanding, and academic

achievement [8]. One effective way to increase students' interest in learning is through the use of learning media [9]. Furthermore, critical thinking skills are essential for understanding and solving mathematical problems [10]. There are various methods to enhance students' critical thinking skills, and studies have demonstrated that critical thinking skills can be improved through the use of learning media [11].

From the above discussion, it is evident that learning media that can make learning more interesting and engaging is needed, as it can positively impact students' interest in learning and critical thinking skills. To address these issues, innovative learning media such as crossword puzzles are needed. Studies indicate that crossword puzzles make learning more active, stimulate thinking, and enhance student concentration and problem-solving skills [12], [13]. Previous research on developing mathematical crossword media has demonstrated positive outcomes regarding student responses [13], [14], [15].

This study aimed to develop and implement MCA-contextual crossword media in mathematics learning to enhance students' interest and critical thinking skills. Unlike traditional media, these crosswords integrate MCA-type questions that are specifically designed to stimulate critical thinking. This approach aims to engage students more deeply in the learning process while fostering essential cognitive skills. It is anticipated that the implementation of MCA-contextual crossword media will provide positive outcomes, address current educational gaps, and improve overall student performance in mathematics. Based on the above explanation and supported by previous relevant research, the objective of this study is to develop MCA-contextual crossword media that are valid, practical, and effective for enhancing students' interest in learning and critical thinking skills in mathematics.

2. Literature Review

2.1. Crossword Media

The use of crossword puzzles in education can make learning more active, stimulate students' thinking, and increase interactivity in the classroom [16]. Crosswords, as educational games, have characteristics that make them effective for enhancing students' understanding and knowledge. The characteristics of crosswords that support learning activities and are relevant to this research include:

(1) *Interactive and active learning*: Crosswords allow students to engage directly with the learning content. This interactivity makes learning dynamic and encourages student participation.

(2) *Strengthening concept understanding*: By requiring students to find answers based on definitions or given clues, crosswords help students apply their knowledge of concepts. This process reinforces their understanding of the subject matter.

(3) *Enhancing critical thinking skills*: Solving crosswords involves problem-solving and high-level thinking. Students must use their reasoning abilities to determine the correct answers, thereby improving their critical thinking capabilities [17]. Crossword puzzles, as pedagogical tools, offer a multifaceted approach to learning that not only engages students but also enhances their conceptual understanding and critical thinking skills.

These attributes make crosswords valuable resources in educational settings, promoting deeper and more interactive learning experiences.

2.2. MCA

The MCA is designed to measure the cognitive and basic skills of students according to their educational level. Its aim is to equip students with essential 21st-century skills, often referred to as the 4Cs: critical thinking and problem-solving, creativity, communication skills, and the ability to work collaboratively [18]. In terms of cognitive levels, MCA questions are categorized into three levels:

(1) *Knowing*: This level involves basic cognitive skills such as recall, identification, classification, counting, retrieving, and measuring information. It focuses on students' ability to remember and recognize information.

(2) *Applying*: At this level, students are expected to apply their knowledge to practical situations. This includes skills such as determining, creating, and implementing solutions based on the information they have learned.

(3) *Reasoning*: The highest cognitive level involves HOTS such as analyzing, synthesizing, evaluating, drawing conclusions, and providing arguments. It emphasizes the ability to think logically and critically about complex problems [19].

The MCA framework is integral to developing students' competencies in line with the demands of the 21st century. This ensures that students are not only knowledgeable but also capable of applying their knowledge in real-world situations and thinking critically about the information they encounter.

2.3. Learning Interest

Interest in learning is a key factor in achieving educational objectives as it significantly influences students' academic success [20]. In the learning process, students with high interest in learning are more active and tend to pay more attention during lessons [21]. Various factors influence students' learning interest:

Internal factors:

(1) *Study techniques*: Effective study techniques tailored to individual learning styles can enhance students' interest and engagement.

(2) *Academic self-concept*: Students' beliefs about their academic abilities affect their motivation and interest in learning.

(3) *Study habits*: Consistent and productive study habits contribute to sustained interest and better learning outcomes.

External factors:

(1) *Family support*: Encouragement and support from family members can boost students' confidence and interest in learning.

(2) *Student learning facilities*: Access to adequate learning resources and facilities creates a conducive environment for learning.

(3) *Learning atmosphere*: A positive and stimulating classroom environment fosters greater student engagement and interest [22].

Research indicates that these factors collectively play a crucial role in shaping students' interest in learning natural sciences. Understanding and addressing both internal and external factors can help educators develop strategies to enhance student motivation and engagement in the learning process.

2.4. Critical Thinking Skills

Mathematical critical thinking skills are essential abilities that involve problem-solving, argumentation, interpreting functions, and developing problem-solving strategies. As highlighted in research on cognitive flexibility and critical thinking, they are crucial for students and can be developed through effective teaching practices and student engagement [23]. In the learning process, critical thinking helps students to understand and analyze information, form their own opinions, and make informed decisions. Students are encouraged to answer questions critically, not just by providing answers but also by considering the concepts and principles involved, such as "what," "how," and "why" [24]. Critical thinking in mathematics can be broken down into several key indicators: (1)

interpretation: understanding and explaining the meaning of information or an event; (2) analysis: examining ideas and identifying arguments; (3) evaluation: assessing the credibility and logical strength of evidence and arguments; (4) inference: drawing conclusions based on evidence and reasoning [25]. These indicators serve as a framework for developing and assessing students' critical thinking skills, which are vital to their academic and personal growth.

3. Method

This study adopts a development research methodology utilizing the research and development (R&D) approach with the ADDIE model, as shown in Figure 1. The ADDIE model, comprising five stages (analysis, design, development, implementation, and evaluation), is widely recognized for its effectiveness in developing educational materials, ensuring that resources and tools are tailored to learners' specific needs, thereby promoting effective learning outcomes and skill development [26], [27]. The following are the stages of media development in this study using the ADDIE model.

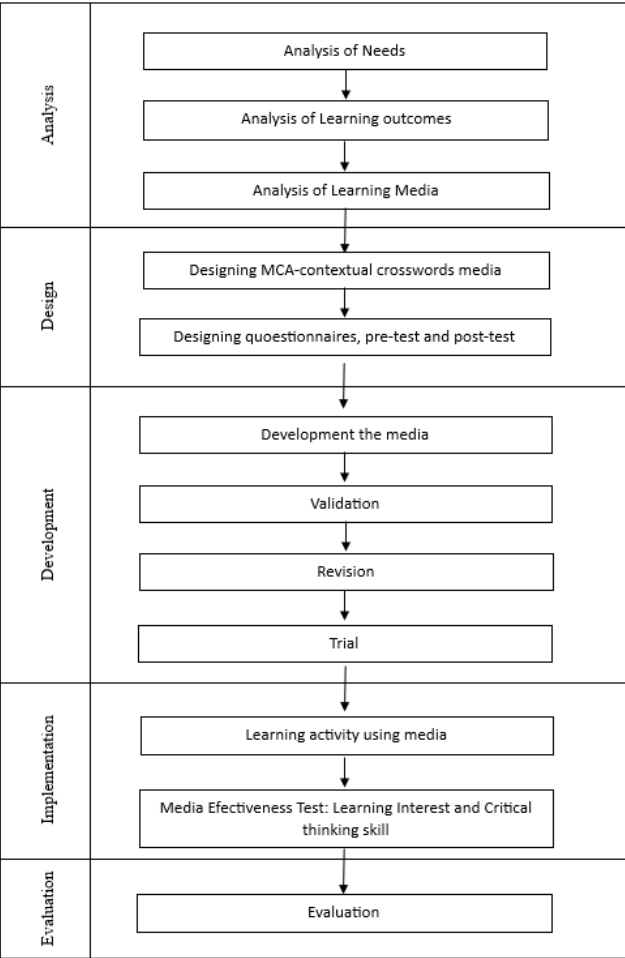


Figure 1. Stages of media development using the ADDIE model (The authors’ elaboration)

The study was conducted with the eighth-grade

students at SMP Muhammadiyah 1 Malang, focusing on flat-sided geometric shapes. The selection of research subjects was based on the consideration that the subjects had better learning adaptation than those in the lower class who were new to the school and those in the higher class who had a busier schedule. Additionally, the selection of these subjects was based on recommendations from teachers at the school.

The application of the ADDIE stages in this research is detailed as follows:

- (1) *Analysis*: This initial phase involved identifying and determining the specific needs for mathematics learning, including analyzing the materials, media, and tools required to address these needs effectively.
- (2) *Design*: Based on the analysis, this phase involved preparing materials and tools and designing learning media. It also included the development of data collection instruments such as questionnaires, pretests, and posttests.
- (3) *Development*: The learning media were developed to a semi-finished state and validated by media and material experts. This expert validation ensured the quality and relevance of the developed media.
- (4) *Implementation*: Post-validation, the media underwent student testing divided into practicality and effectiveness tests. Student response questionnaires were used to gather data on media practicality. Additionally, questionnaires on learning interest and tests measuring students' critical mathematical thinking skills were administered before and after the implementation to assess media effectiveness.
- (5) *Evaluation*: This stage involves evaluation of the entire development phase.

4. Results and Discussion

4.1. Analysis

To conduct the analysis, the researchers first interviewed the teachers regarding their students' critical thinking abilities. The interviews revealed that very few students could proficiently analyze mathematical problems. Educators suggested that this low proficiency was due to various factors, including lack of problem-solving experience. This issue highlights that students' critical thinking skills had not yet reached their optimum potential, resulting in a weakness in their ability to think critically. Furthermore, the teachers noted that students demonstrated insufficient attention during mathematics lessons, indicating a diminished interest in acquiring knowledge of the subject. It was also observed that the instructional resources used were limited to textbooks and PowerPoint presentations provided by the school. Teachers recommended diversifying instructional media to optimize skill development as such media can enhance students' critical thinking abilities and learning

interests.

4.2. Design

The process of media design began with a detailed outline of the problems faced by students in learning mathematics, which were identified during the analysis stage. This outline ensured that the developed teaching media contained relevant mathematical content and was designed to challenge students to think critically and to solve problems related to their learning interests.

Following problem identification, the design phase included creating several contents for the learning media, such as learning objectives in a flat-sided space and practice questions contextualized within the MCA framework. These MCA-related challenges were selected to help students develop their critical thinking abilities because MCA can stimulate their critical thinking skills [24]. Subsequently, icons were created to display white boxes for answers, and images were added for the background.

In addition to creating learning materials, the researchers also developed pretests, posttests, and practicality, interest, and validation questionnaires. The practicality questionnaire aimed to determine the suitability and feasibility of the materials, whereas the validation questionnaire assessed the authenticity of the materials. The interest questionnaire, pretest, and posttest were designed to evaluate students' interest in learning and their critical thinking capacity before and after using MCA-contextualized crossword media.

4.3. Development

After the design stage, the media prototype was made accessible on liveworksheets.com. Upon accessing the link, students were presented with learning objectives and outcomes for flat-sided shapes, followed by MCA-contextualized questions with white boxes for answers. Instructions for usage were also provided. Once the students completed the tasks, they could click the "finish" button to display their scores.

Following the development phase, the media underwent a validation stage conducted by subject matter and media experts. This validation aimed to determine the validity of the designed media before it was introduced to students. Validation is crucial to ensure the media's appropriateness, effectiveness, and accuracy and to gather feedback for improvement [28]. Validators included two lecturers from a mathematics education program and two mathematics teachers.

Table 1. Media validation (The authors' elaboration)

No.	Validator	Score	Category
1	Validator 1	3.1	Valid
2	Validator 2	3.4	Valid
Average		3.24	Valid

The average score for the media validation results was 3.24, indicating a valid interpretation. This result suggests that the visual appearance of the designed media is valid, with a clear layout, legible sentences, and a design that does not confuse students. Despite receiving a valid category with an average of 3.24, several notes from the validators highlighted areas for improvement in layout and readability.

Table 2. Material validation (The authors' elaboration)

No.	Validator	Score	Category
1	Validator 1	3.3	Valid
2	Validator 2	3.4	Valid
Average		3.35	Valid

The average score for the material validation results was 3.35, indicating validity. This suggests that the validated materials, which are context-based MCA materials, are likely to enhance or train students' critical thinking skills. Despite receiving a valid category, the validators had some notes and suggestions about trying out different types of questions, thus allowing for a diversity of other question types.

4.4. Implementation

The implementation of the MCA-contextualized crossword media was divided into two stages: a small-scale trial to assess the practicality of the media and a large-scale trial to evaluate its effectiveness. This phase was conducted in an eighth-grade mathematics class with 26 students.

4.4.1. Practicality

Practicality data were collected through student response questionnaires, with the objective of assessing students' reactions to MCA-contextualized crossword media. The results of the student response questionnaires are summarized in Table 3.

Table 3. Practicality analysis (The authors' elaboration)

No.	Aspect	Score
1	Usefulness	3.5
2	Ease of Use	3.6
3	Appearance	3.6
4	Attractiveness	3.5
Total Average Score		3.6
Percentage		88.1
Category		Very Practical

Based on the data presented in Table 3, the practicality analysis of the MCA-contextualized crossword media reveals the following insights:

(1) *Usefulness*: The media received a score of 3.5, indicating that students found it beneficial for their

learning process.

(2) *Ease of use*: With a score of 3.6, the media were deemed easy for students to use and operate, facilitating a smooth learning experience.

(3) *Appearance*: The visual appeal of the media scored 3.6, demonstrating that its design was attractive and engaging for students.

(4) *Attractiveness*: The media's ability to capture and retain student attention scored 3.5, further supporting its effectiveness as an educational tool.

The total average score obtained from the student response questionnaire was 3.6, corresponding to 88.1%, categorizing the media as "very practical." This high practicality score indicates that students found MCA-based crossword media to be highly suitable for their learning needs. The media's practicality encompasses various aspects, including usability, ease of use, appearance, and attractiveness, all of which contribute to a positive and engaging learning experience.

4.4.2. Effectiveness

The effectiveness data on the learning media were obtained through pre- and posttests for critical thinking skills and interest in learning questionnaires after and before using MCA-contextualized crossword media.

4.4.3. Critical Thinking

To measure the improvement in students' critical thinking skills, pretest and posttest methods were utilized. The pretest was conducted before the students used the MCA-contextualized crossword media, while the posttest was administered after its use. Comparing the pre- and posttest results provides an overview of the improvement in students' critical thinking skills following the use of the media. Based on the results of these tests, student performance was classified into five categories: "very low," "low," "medium," "high," and "very high." The students' distribution across these categories is shown in Table 4.

Table 4. Distribution of students' critical thinking criteria (The authors' elaboration)

Number of Students	Category
3	Medium
2	High
21	Very High

Based on the data in Table 4, after using the MCA-contextualized crossword media, it was observed that 21 students fell into the "very high" category for critical thinking skills, 2 students fell into the "high" category, and 3 students were categorized as "medium." This distribution indicated that a significant portion of the student population, specifically 21 out of 26 students, demonstrated strong critical thinking abilities. Meanwhile, a smaller percentage of students

exhibited medium to high critical thinking skills.

Below are the results of a task performed by a student who received a "medium" rating for critical thinking skills. The students' tasks were typed in English, without changing the content.

Figure 2 illustrates the work of a student who exhibits a "medium" level of critical thinking. The analysis indicates that the student had not yet fully met several critical thinking indicators, specifically interpretation, analysis, evaluation, and inference [29].

$$\begin{aligned}
 1. \text{ Volume of the cabinet} &= 120\text{cm} \times 80\text{cm} \times 200\text{cm} \\
 &= 9600\text{cm} \times 200\text{cm} \\
 &= 1.920.000\text{cm} \\
 \text{Volume of the gold} &= 20\text{cm} \times 10\text{cm} \times 5\text{cm} \\
 &= 200\text{cm} \times 5\text{cm} \\
 &= 1.000\text{cm} \\
 2. (24 \times 24) + 4 \left(\frac{1}{2} + 24 + 15 \right) \\
 &= 576 + 4 \times 180 = 72 + 576 = 648
 \end{aligned}$$

(a) Pretest

$$\begin{aligned}
 1. \text{ Volume of the cabinet} &= 120\text{cm} \times 80\text{cm} \times 200\text{cm} \\
 &= 9600\text{cm} \times 200\text{cm} \\
 &= 1.920.000\text{cm} \\
 \text{Volume of the gold} &= 20\text{cm} \times 10\text{cm} \times 5\text{cm} \\
 &= 200\text{cm} \times 5\text{cm} \\
 &= 1.000\text{cm} \\
 &= \frac{1.920.000}{1.000} = 1.920 \\
 2. a^2 + b^2 &= c^2 \\
 12^2 + 9^2 &= c^2 \\
 144 + 81 &= c^2 \\
 225 &= c^2 \\
 (24 \times 24) + 4 \left(\frac{1}{2} + 24 + 15 \right) \\
 &= 576 + 4 \times 180 = 72 + 576 = 648
 \end{aligned}$$

(b) Posttest

Figure 2. Results on a task performed by a student who received a "medium" rating (The authors' elaboration)

Interpretation: In the pre- and posttest, the student failed to adequately articulate or express what is known and what is being asked. Documenting what is known and the questions posed are crucial for understanding the given information and problem requirements, enabling the determination of the appropriate formula or concept for problem-solving.

Analysis: The student did not document the concept or formula applied in the pre- and posttest. This omission affects the accuracy of their work. Clearly

writing down relevant concepts or formulas is essential for solving mathematical problems correctly.

Evaluation: During the pretest, the student endeavored to solve the problem utilizing an understood formula or concept but committed errors, resulting in inaccurate outcomes. Although the student performed the calculations without explicitly stating the formula or concept, mistakes in the calculations affected the final solution. In the posttest, there was some improvement in the calculations, but the results remained incorrect, highlighting persistent issues in the evaluation process.

Inference: The student did not meet the inference indicator in the pre- and posttest due to errors in earlier steps. Accurate inference requires correct interpretation, analysis, and evaluation, which were not fully achieved.

Based on these observations, the student falls into the "medium" category, indicating that they have not yet met all critical thinking indicators. Despite this, the student demonstrated the ability to analyze what was known and what was being asked in the questions, attempting to solve the problems, even though errors were present in the process. These findings underscore the importance of reinforcing critical thinking skills through targeted educational interventions aimed at improving interpretation, analysis, evaluation, and inference capabilities. Further research is recommended to explore effective strategies to enhance these critical thinking dimensions in students.

Below are the results of a task performed by a student who received a "very high" rating for critical thinking skills. The students' tasks were typed in English, without changing the content.

Figure 3 illustrates the work of a student who attained a "very high" level of critical thinking. Initially, in the pretest, the student did not fully meet the critical thinking indicators despite answering the questions correctly. Specific shortcomings were observed in the following areas:

Interpretation: The student failed to document what was known and what was being asked in the problem, a crucial step for understanding and addressing the problem requirements.

Analysis: The student did not specify the formula used to solve the problem, which impacted the clarity and accuracy of their solutions.

Inference: The student was unable to draw conclusions from their work, indicating a gap in their ability to synthesize and interpret their findings. In contrast, the posttest results showed substantial improvement. The student met all critical thinking indicators by (1) accurately documenting what was known and what was being asked, (2) correctly identifying and applying the appropriate formula, and (3) drawing clear and accurate conclusions for each question. These improvements led to the student achieving a "very high" criterion in critical thinking

skills.

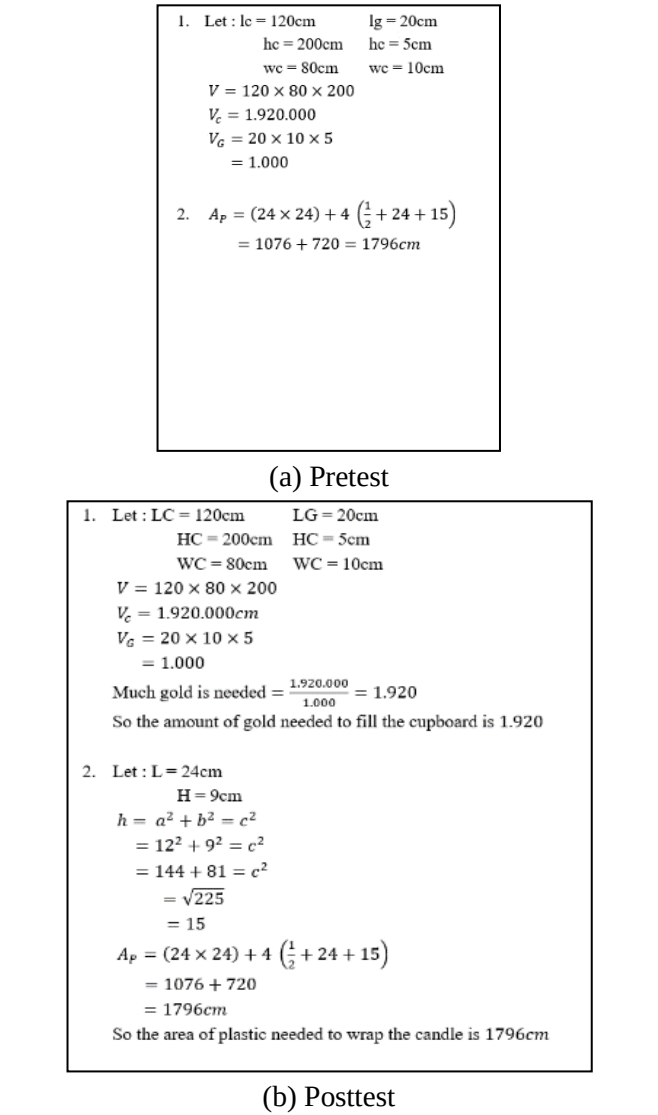


Figure 3. Results on a task performed by a student who received a "very high" rating (The authors' elaboration)

To quantify the effectiveness of MCA-contextualized crossword media, an N-gain test was conducted. The results are presented in Table 5.

Table 5. N-gain for critical thinking skills (The authors' elaboration)

Score		N-Gain	Criteria
Pre	Post		
76.5	89.8	0.58	Medium

Table 5 shows that the average pretest score was 76.5, and the average posttest score was 89.8, with an average N-gain score of 0.58, falling into the "medium" improvement category. This indicates that the media had a positive impact, with room for further enhancement. Nonetheless, the results suggest that MCA-contextualized crossword learning media can be considered effective for improving students' mathematical critical thinking skills.

The results of this study are consistent with previous research showing that critical thinking skills improve when learning through media [30]. This underscores the importance of using appropriate media during the learning process to enhance students' critical thinking skills.

4.4.4. Learning Interest

The results of the student learning interest questionnaire before and after using the MCA-contextualized crossword media in mathematics learning are presented in Table 6.

Table 6. Learning interest questionnaire results before and after using the media (The authors' elaboration)

Students	Pre	Post
Student 1	2.71	2.94
Student 2	3.18	3.35
Student 3	2.12	2.94
Student 4	3.18	3.88
Student 5	2.29	3.00
Student 6	3.24	3.00
Student 7	2.24	3.88
Student 8	2.88	2.17
Student 9	3.00	3.12
Student 10	2.59	3.53
Student 11	2.35	3.12
Student 12	3.47	2.65
Student 13	2.24	3.35
Student 14	3.12	3.00
Student 15	3.06	3.53
Student 16	3.12	2.88
Student 17	3.24	2.94
Student 18	2.59	3.00
Student 19	2.88	3.35
Student 20	2.29	2.29
Student 21	3.12	3.12
Student 22	3.06	3.06
Student 23	3.12	3.12
Student 24	3.06	3.06
Student 25	3.06	3.18
Student 26	3.12	3.12
Average	2.85	3.12

Based on the analysis of the data, it can be concluded that the use of MCA-contextualized crossword learning media increases students' learning interest. Initially, the average student learning interest was 2.85, which increased to 3.12 after using the media. These figures suggest that integrating learning media into the educational process effectively captures students' attention and motivates them to engage more in learning activities. Furthermore, based on these calculated results, students' learning interest can be classified into "high," "medium," and "low." This classification is presented in Table 7.

Table 7. Distriburion of students' learning interest criteria (The authors' elaboration)

Number of Students	Category
11	Low
11	Medium
4	High

After using the MCA-contextualized crossword media, 11 students were categorized as having low interest, 11 as medium interest, and four as high interest. This distribution indicates that 15.3% of the students were in the high category, 42.3% in the medium category, and 42.3% in the low category. Although there is an increase in interest in learning, it did not reach a significant level.

To determine the increase in students' learning interest, an N-gain test was conducted. Below are the results of the N-gain test for students' learning interest in mathematics using MCA-contextualized crosswords.

Table 8. N-gain for learning interest (The authors' elaboration)

Score		N-Gain	Criteria
Pre	Post		
2.85	3.12	0.23	Low

The N-gain test results showed that the average learning interest before using the media was 2.85, and after using the media, it increased to 3.12, with an average N-gain score of 0.23, categorized as a low improvement. Despite this increase, the impact remains in the low category, indicating the need for further enhancement to significantly boost learning interest.

The results of this study are consistent with previous research showing that interest in learning can improve when learning through media [31]. However, based on the N-gain calculation results, there is an increase in learning interest before and after the use of the media, but it is still in the weak or low category and thus cannot significantly enhance learning interest. Therefore, although the media can be classified as "effective" in increasing learning interest, its impact still needs to be improved.

4.5. Evaluation

In the evaluation stage, all validation, practicality, and effectiveness test results were evaluated. Based on the validation results of both the material and media, the MCA-contextualized crossword media obtained a "valid" result, meaning that the developed media can be used in learning. In addition to its applicability in learning, the media is assumed to serve as a stimulus to enhance students' interest in learning and critical thinking skills in mathematics. From the practicality test results of the ten students, the average score was found to be 3.6, with a percentage of 88.1%, indicating that the practicality test results of the MCA-

contextualized crossword media fall under the "very practical" category. Following the practicality assessment, the MCA-contextualized crossword media underwent effectiveness evaluation through implementation in the learning process. The effectiveness data on the media were collected from pre- and posttests to observe the media's effectiveness in enhancing students' critical thinking skills and pre-and-post-use interest in learning questionnaires to assess their effectiveness in boosting students' interest in learning. The results of the effectiveness test of the MCA-contextualized crossword media in improving critical thinking skills yielded a score of 0.58 for N-gain, categorized as "medium" and the result for improving learning interest yielded a score of 0.23 for N-gain, categorized as "low."

5. Discussion

Based on these results, the MCA-contextualized crossword media received average ratings of 3.24 and 3.35 for media and content elements, respectively, each indicating a "valid" grade. With high validation scores, these media and material are considered ready for implementation in mathematics learning. This suitability provides confidence that these tools will effectively support the teaching and learning process and help students develop necessary skills. Consequently, the media is deemed suitable for application in the learning environment, consistent with earlier research indicating that learning tools must receive a "valid" categorization during the validation stage to be considered suitable for teaching [32]. The results from the practicality analysis highlight the effectiveness of MCA-contextualized crossword media in providing a practical and engaging learning tool for students. The high scores in usability, ease of use, visual appeal, and attractiveness suggest that the media successfully addresses the key aspects that contribute to a productive learning environment. The overall "very practical" rating underscores the media's potential to enhance the learning experience and support students in developing their critical thinking skills. For the effectiveness to increase students' critical thinking skills, MCA-contextualized crossword media is effective in improving students' critical thinking skills. This underscores the importance of using appropriate media during the learning process to enhance students' critical thinking skills. Furthermore, questions in this media are MCA-contextualized, and previous research has shown that MCA is capable of enhancing students' critical thinking abilities [33]. Although the MCA-contextualized crossword media achieved a "medium" category in the N-gain calculation, this does not apply to the aspect of student interest in learning. The MCA-contextualized crossword media resulted in a "low" category in the N-gain calculation. This "low" category indicates that the MCA-contextualized crossword

media has not been able to significantly increase students' interest in learning. As seen in Table 6, it is evident that some students' interest in learning decreased after using MCA-contextualized crossword media. Furthermore, these results do not align with previous research suggesting that students' interest in learning can be enhanced by using educational media [34]. The inability to increase interest in learning may be influenced by several factors, including lack of attractiveness, less appealing colors or layouts, and students' lack of interest in the media used [29], [34]. Thus, based on these factors, it can be concluded that MCA-contextualized crossword media are effective in significantly improving critical thinking skills. However, when it comes to increasing students' interest in learning, MCA-contextualized crossword media still require further development.

6. Conclusion

The MCA-contextualized crossword media has proven to be effective in enhancing students' critical thinking skills and interest in learning, but the enhancement in students' learning interest is in the low category. The effectiveness of MCA-contextualized crossword media in improving critical thinking skills is evident from the validation results, practicality test results, classroom implementation, and student pre- and posttests. Although it has been validated in terms of media design and content and received a "very practical" result in the practicality test, as well as being able to enhance students' critical thinking skills significantly when they use the MCA-contextualized crossword media, this media has not yet been able to significantly increase students' interest in learning mathematics. Therefore, it is recommended that future researchers pay more attention to the aspects of interactivity and layout so that the media can enhance students' interest in learning mathematics.

Research on MCA-contextualized crossword media has significantly contributed to mathematics education and educational technology by introducing an innovative tool for assessing mathematics competence. This media effectively enhances students' critical thinking skills and interest in learning. Although crossword media are widely used in education, their specific application in mathematics, especially for promoting critical thinking, remains relatively unexplored in the existing literature. This research adds a new dimension to game-based learning in mathematics, offering an alternative approach that moves beyond traditional methods, such as problem-solving exercises, to engage students more effectively in learning.

This study recommends that future research focus on enhancing the interactivity and layout of MCA-contextualized crossword media to further boost students' interest in learning mathematics. By

integrating more engaging features such as gamification elements and adaptive learning pathways, the effectiveness of this tool can be maximized. Additionally, further exploration of the long-term impact of using this medium on students' critical thinking skills and overall mathematics performance is essential. This perspective not only addresses the current limitations but also opens new avenues for innovation in educational technology and pedagogy within mathematics education.

Declarations

Author Contributions

Conceptualization, G.A.R. and M.S.; methodology, G.A.R., M.S., R.D.A.; software, G.A.R.; validation, G.A.R., M.S., R.D.A.; formal analysis, G.A.R. and M.S.; investigation, G.A.R.; resources, G.A.R. and M.S.; data curation, G.A.R.; writing—original draft preparation, all authors contributed equally; writing—review and editing, M.S.; visualization, G.A.R.; supervision, M.S. and R.D.A.; project administration, G.A.R.; funding acquisition, M.S. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement

The data presented in this study are available on request from the corresponding author.

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Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board (or Ethics Committee) of the Universitas of Muhammadiyah Malang.

Conflicts of Interest

The authors declare that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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