



Edutainment "Aritmo": Development and Impact of Video Games on Students' Critical Thinking Skills

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Abstrak

Penelitian ini bertujuan untuk mengembangkan dan menguji efektivitas media pembelajaran berbasis video game dalam meningkatkan kemampuan berpikir kritis siswa pada materi aritmatika sosial. Metode penelitian dan pengembangan (R&D) dengan model Borg and Gall digunakan untuk menghasilkan media pembelajaran yang valid, praktis, dan efektif. Instrumen penelitian mencakup lembar validasi, angket praktikalitas, dan tes efektivitas. Pengambilan sampel dilakukan dengan teknik purposive sampling, melibatkan 120 responden dari dua sekolah menengah pertama yang berbeda. Responden terdiri dari lima ahli sebagai validator, 60 siswa yang menggunakan media pembelajaran berbasis video game "Aritmo", dan 60 siswa sebagai kelompok kontrol. Hasil validasi oleh para ahli menunjukkan bahwa video game "Aritmo" memiliki kualitas yang sangat baik, dengan skor rata-rata 4.6 untuk kesesuaian dengan tujuan pembelajaran dan keterlibatan pengguna, 4.4 untuk kelayakan konten dan fungsionalitas, serta 4.0 dan 4.2 untuk aspek grafis dan kemudahan penggunaan. Validasi materi juga menunjukkan hasil yang memuaskan, dengan skor rata-rata 4.4 untuk kesesuaian dengan kurikulum, 4.6 untuk kebenaran konten, dan 4.2 untuk keterkaitan dengan tujuan pembelajaran. Hasil uji efektivitas melalui independent sample t-test menunjukkan bahwa penggunaan video game "Aritmo" memberikan pengaruh signifikan terhadap peningkatan kemampuan berpikir kritis siswa, dengan nilai Sig. sebesar 0.031, yang lebih kecil dari tingkat signifikansi 0.05. Dengan demikian, penelitian ini menyimpulkan bahwa video game "Aritmo" merupakan media pembelajaran yang efektif dan dapat digunakan untuk meningkatkan kemampuan berpikir kritis siswa dalam pembelajaran aritmatika sosial.

Abstract

This study aims to develop and evaluate the effectiveness of a video game-based learning media in enhancing students' critical thinking skills in social arithmetic. The research and development (R&D) method, utilizing the Borg and Gall model, was employed to produce valid, practical, and effective learning media. The research instruments included validation sheets, practicality questionnaires, and effectiveness tests. The sample was selected using purposive sampling, involving 120 respondents from two different junior high schools. The respondents consisted of five experts as validators, 60 students who used the "Aritmo" video game-based learning media, and 60 students as the control group. The validation results by the experts indicated that the "Aritmo" video game has a very high quality, with an average score of 4.6 for alignment with learning objectives and user engagement, 4.4 for content appropriateness and functionality, and 4.0 and 4.2 for graphics and ease of use, respectively. The material validation also showed satisfactory results, with an average score of 4.4 for curriculum alignment, 4.6 for content accuracy, and 4.2 for relevance to learning objectives. The effectiveness test results, using an independent sample t-test, revealed that the use of the "Aritmo" video game had a significant impact on improving students' critical thinking skills, with a Sig. value of 0.031, which is lower than the significance level of 0.05. Thus, this study concludes that the "Aritmo" video game is an effective learning medium that can be used to enhance students' critical thinking skills in social arithmetic learning.

INTRODUCTION

The 21st century education demands the enhancement of students' critical thinking skills through innovative teaching methods. Critical thinking is an essential skill that affects students' ability to solve problems, make decisions, and deeply understand mathematical concepts (Halpern, 2014). However, studies show that many students still face difficulties in developing this skill, especially within the context of mathematics education (Tschannen-Moran, 2017). The

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use of conventional learning media, such as textbooks and worksheets, often proves ineffective in fostering active engagement and deep understanding (Cheung & Slavin, 2013).

In Indonesia, the development of students' critical thinking skills has become a major concern in recent years, particularly in the context of international assessments such as the Program for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS). Data from both assessments provide valuable insights into the challenges faced by Indonesian students in developing critical thinking skills, which are crucial for academic success and daily life.

According to the 2018 PISA results, Indonesia displayed concerning performance in critical thinking and problem-solving abilities. The data indicated that the average score of Indonesian students in science, reading, and mathematics literacy was far below the OECD (Organization for Economic Cooperation and Development) average (OECD, 2019). For instance, the average mathematics literacy score for Indonesian students was 379, while the OECD average was 489 (OECD, 2019). This reflects a significant gap in the application of critical thinking skills in the context of mathematics. Meanwhile, the 2019 TIMSS also highlighted similar deficiencies in the critical thinking abilities of Indonesian students. In mathematics, Indonesian students scored an average of 394, ranking them 39th out of 58 participating countries (Mullis et al., 2020). This score is well below the international average and indicates that many Indonesian students may lack the critical thinking skills required to solve mathematical problems effectively and innovatively. Additionally, in science, Indonesian students also demonstrated inadequate performance, with an average score of 405, compared to the international average of 471 (Mullis et al., 2020).

A study conducted by the Center for Data and Information Technology (CDIT) in 2021 revealed that factors influencing the low critical thinking abilities in Indonesia include the lack of implementation of teaching methods that foster critical thinking skills, as well as a curriculum that still focuses on memorization rather than conceptual understanding (CDIT, 2021). The survey found that 62% of teachers in Indonesia acknowledged facing challenges in teaching critical thinking skills to their students and preferred traditional teaching methods that were simpler (CDIT, 2021). Furthermore, a 2022 survey by The World Bank highlighted that Indonesia's education system still lags in terms of implementing pedagogies that promote critical thinking and problem-solving skills. The data showed that, despite curriculum reform efforts, many schools still operate with an approach dominated by rote learning and insufficient emphasis on developing critical thinking skills (World Bank, 2022). This study also indicated that 57% of students in Indonesia felt they were not given enough opportunities to think critically in their learning activities, suggesting a gap between what is taught and the skills required (World Bank, 2022).

Another study by Atmaja and Santoso (2023) found that although there have been initiatives to introduce more innovative teaching methods in some schools, the widespread adoption of this approach remains limited. This research emphasizes the need for additional teacher training and changes in the curriculum to effectively integrate critical thinking skills into daily learning (Atmaja & Santoso, 2023). These findings reinforce earlier conclusions that reforms in education require not only changes in the content taught but also in the methods of instruction applied in the classroom.

The primary cause of this phenomenon is the lack of integration of engaging and interactive technology in the learning process. Edutainment video games, as a form of interactive media, have great potential to stimulate student interest and engagement more effectively than traditional methods (Gee, 2013). Video games can create a dynamic and enjoyable learning environment, which could enhance students' motivation to actively engage in arithmetic learning (Scholz et al., 2019). If this issue remains unaddressed, students may continue to struggle in developing essential critical thinking skills, potentially negatively impacting their overall academic performance and their preparation for future challenges (Zhang et al., 2021).

The solution proposed in this study is the development of edutainment media in the form of video games specifically designed for arithmetic learning. These video games will be designed to present various challenges requiring critical thinking, provide instant feedback, and adapt the

difficulty based on students' progress (Prensky, 2016). This method is chosen because edutainment video games can provide an interactive and motivating learning experience, targeting specific mathematical skills while enhancing student engagement (Clark et al., 2016). With these features, it is expected that students will become more involved in learning and develop better critical thinking skills.

The significance of this research lies in the potential of edutainment video games to bring about positive change in mathematics education. Integrating engaging and interactive technology into arithmetic learning can provide significant benefits for students. This study has the potential to contribute new knowledge to the development of effective and innovative learning media, which can be adapted to various educational contexts (Sailer et al., 2017). Thus, this research is not only relevant for improving students' mathematical understanding but also for developing teaching methodologies that are more in line with the needs of the current digital generation (Cavanaugh et al., 2014).

This study, focusing on the development of edutainment media in the form of video games to enhance students' critical thinking abilities in arithmetic learning, offers novelty compared to five previous studies. First, the research by Wijaya and Setiawan (2021) explores the use of digital-based applications in mathematics learning but does not integrate game elements specifically to improve critical thinking skills. Second, the study by Muliati and Rahmat (2019) investigates the effectiveness of educational games in science learning but does not measure their impact on critical thinking. Third, the study by Kurniawan et al. (2018) focuses on mobile-based learning applications without game components, thus lacking deep interactive context. Fourth, the research by Clark et al. (2016) evaluates the impact of educational games in general but does not focus on arithmetic or specific critical thinking skills. Fifth, the study by Zhang et al. (2021) assesses the impact of technology on critical thinking skills broadly, without specific application to gaming media. This research stands out by combining edutainment video games with arithmetic and focusing on the development of critical thinking, providing a practical implementation model that has not been extensively explored before (Wijaya & Setiawan, 2021; Muliati & Rahmat, 2019; Kurniawan et al., 2018; Clark et al., 2016; Zhang et al., 2021).

METHOD

In this study, the research and development (R&D) method was employed, using the Borg and Gall development model. This model was chosen because it offers a systematic framework for designing, developing, and evaluating educational products, such as video game-based learning media. This process is highly suitable for research aimed at developing edutainment media to enhance students' critical thinking skills in arithmetic learning.

The Borg and Gall model, as described by Borg and Gall (1983), consists of several key stages. The first stage is the needs analysis. In this phase, the researcher conducts an assessment of the current state of arithmetic learning and identifies the students' needs related to critical thinking skills. This is done through literature reviews, surveys, and interviews with teachers and students (Gall, Gall, & Borg, 2007). The second stage is development planning. Based on the results of the needs analysis, the researcher designs a plan for developing an edutainment video game, which includes game design, learning objectives, and evaluation strategies. This plan aims to create media that is not only engaging but also effective in enhancing students' critical thinking skills (Miarso, 2014). The third stage is the initial development. At this stage, the video game prototype is developed based on the plan that has been created. The prototype is then tested internally to ensure that its functionality and design align with the desired learning objectives (Sugiyono, 2016). The fourth stage is field testing. The video game prototype is tested in a classroom setting with students as participants. The purpose of this trial is to collect data regarding the media's effectiveness in improving students' critical thinking skills. The data obtained from this trial is used for revisions and improvements (Sukmadinata, 2017). The final stage is dissemination. After revisions based on feedback from the field test, the refined video game is ready for broader application in educational settings. The researcher also compiles a report and documentation on the development process and research results to be disseminated to relevant stakeholders (Borg & Gall, 1983).

The Borg and Gall model provides a structured approach to ensure that the developed product not only meets the users' needs but is also effective in the learning context. This process helps in creating innovative and evidence-based learning media that can enhance students' critical thinking skills (Gall, Gall, & Borg, 2007; Miarso, 2014; Sugiyono, 2016; Sukmadinata, 2017).

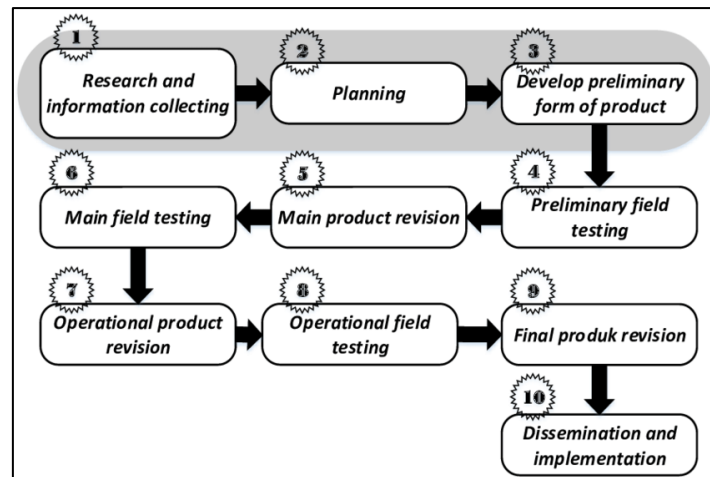


Figure 1. Procedure of Borg and Gall Model

The data were collected using various methods to ensure the accuracy and completeness of the information obtained. The data collection methods included interviews, questionnaires, and test items. Interviews were conducted with teachers and students to gain in-depth insights into the needs, challenges, and effectiveness of the developed learning media. Questionnaires were used to collect quantitative data from students regarding their perceptions of the learning media and their critical thinking skills before and after using the media. Test items were designed to measure students' critical thinking abilities in the context of arithmetic learning.

The research instruments consisted of several essential tools: validation sheets, a practicality questionnaire, and an effectiveness test. The validation sheets were used to assess the validity of the developed learning media. Experts in the fields of mathematics education and educational technology evaluated the content, design, and relevance of the media to the learning objectives (Brown & Keegan, 2017). The practicality questionnaire was used to measure the extent to which the learning media was easy to use and accepted by teachers and students. This questionnaire included questions regarding ease of use, student engagement, and alignment with the curriculum (Kemp, 2016). The effectiveness test was used to measure the improvement in students' critical thinking skills after using the learning media. The test included items designed to assess various aspects of critical thinking, including analysis, synthesis, and evaluation (Johnson, 2019).

Validity and reliability tests of the instruments were conducted to ensure that the data collected were accurate and consistent. Validity was measured through expert validation, where experts in the field of education assessed whether the instrument measured what it was intended to measure (Creswell, 2014). Reliability was tested using an internal pilot testing method, where the instrument was administered to the same sample group at two different times to ensure consistency of results (Ary, Jacobs, & Sorensen, 2010). The results of the validity and reliability tests were examined using descriptive statistics to ensure that the instruments used were trustworthy and valid.

The data sources for this study included students who used the learning media, teachers who implemented the media, and experts who assessed the validity of the instruments. Sampling was conducted using a purposive sampling technique, where the sample was selected based on specific criteria, such as students who were learning mathematics and teachers who taught the

subject. The sample size was determined based on the population size and the needs of statistical analysis, with a minimum of 30 students for representative analysis (Field, 2013). The data were analyzed using data analysis techniques, specifically independent sample t-tests. This technique was used to compare students' critical thinking scores before and after using the learning media to determine whether there were statistically significant differences (Pallant, 2020). The independent sample t-test allowed the researcher to evaluate the effectiveness of the learning media in enhancing critical thinking skills by comparing the average scores of two different groups.

Table 1. Assessment Aspects of the "Aritmo" Edutainment Media

Instrument	Aspect	Reference
Validation Sheet	Media design assessment, alignment with curriculum, content relevance, expert feedback	Brown & Keegan (2017)
Practicality Survey	Ease of use, student engagement, alignment with curriculum, user feedback	Kemp (2016)
Effectiveness Test	Critical thinking questions covering analysis, synthesis, evaluation, and application of concepts	Johnson (2019)

RESULT AND DISCUSSION

In this study, 120 respondents were involved as trial participants to assess the effectiveness of video game-based learning media in improving students' critical thinking skills. The respondents consisted of five experts as validators, 60 students who used the learning media, and 60 students as a control group who did not use the media. Participants were selected from two different junior high schools with similar academic and demographic backgrounds to ensure fair representation.

The media development process followed the Borg and Gall model, which includes eight out of the ten recommended stages. Below is a detailed description of the research results based on the development stages:

Research and Information Collecting

In this stage, the researcher conducted preliminary research to identify the potentials and problems in arithmetic learning at the target schools. Data were collected through interviews with teachers, student surveys, and literature analysis. The main findings revealed that students faced difficulties in critical thinking skills and lacked motivation in learning arithmetic. Based on these results, the researcher decided to develop more interactive and engaging learning media, namely an edutainment video game, which was expected to effectively improve students' critical thinking skills (Borg & Gall, 1983; Miarso, 2014).

Planning

In the planning stage, the researcher designed the basic concept of the edutainment video game. This phase included determining the learning objectives, game design, and integration of elements that support the development of critical thinking skills. The researcher created a blueprint outlining how the game would function, the challenges to be presented, and how feedback would be provided to the students. This plan was based on the needs identified in the previous stage and aimed to create an enjoyable and beneficial learning experience (Gall, Gall, & Borg, 2007).

Develop Preliminary Form of Product

In this stage, the initial prototype of the video game was developed. This prototype included graphic design, game mechanics, and content aligned with arithmetic learning objectives. The prototype was designed to include various levels that test students' critical thinking skills through a range of mathematical challenges. This initial design featured interactive elements

allowing students to practice critical thinking skills while playing (Clark, Nelson, & Kershner, 2016).



Figure 1. Main Menu Design of the Video Game

Preliminary Field Testing

Once the product was finalized, the next step was design validation, conducted by five experts, including specialists in content and media. The validation process occurred in two phases. During the initial evaluation, both the media and content experts deemed the product insufficiently developed. Therefore, following the first validation and subsequent revisions based on expert recommendations, a second round of validation was performed to further enhance the product.

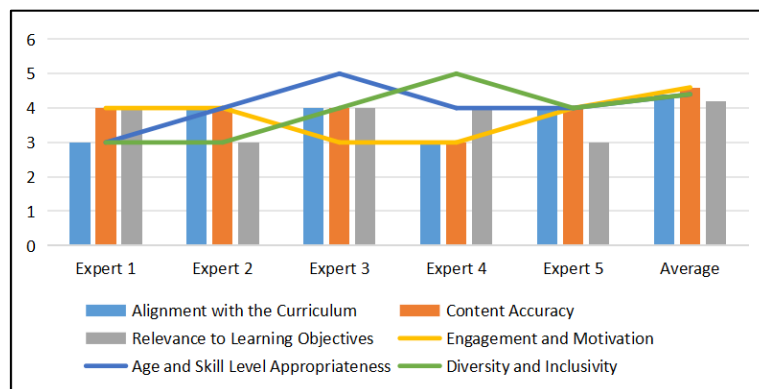


Figure 2. First Validation Results by 5 Experts

From the graph above (Figure 2), it can be observed that the results of the first stage of validation were considered sufficiently valid, indicating the need for further revisions across various aspects. The results of the second stage of validation are as follows:

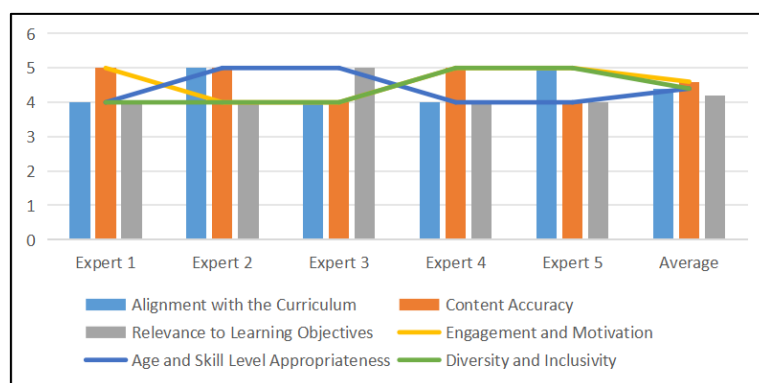


Figure 3. Material Validation Results II by 5 Experts

The results of material validation show that the assessment of various aspects of the material was highly satisfactory. The alignment with the curriculum received an average score of 4.4, indicating a good level of alignment. The accuracy of the content received an average score of 4.6, signifying that the information presented was highly accurate. The relevance to learning objectives scored an average of 4.2, indicating a relatively good level of relevance. The aspects of engagement and motivation received an average score of 4.6, indicating that the material successfully motivated and engaged the students. The appropriateness for age and ability level received an average score of 4.4, reflecting that the material was suitable for its target audience. However, diversity and inclusivity were not fully evaluated.

In addition to material validation, validation was also conducted for the "Aritmo" video game by 5 experts. The purpose of media expert validation was to assess the quality of the developed learning media. The results of the first stage of validation by media experts are as follows:

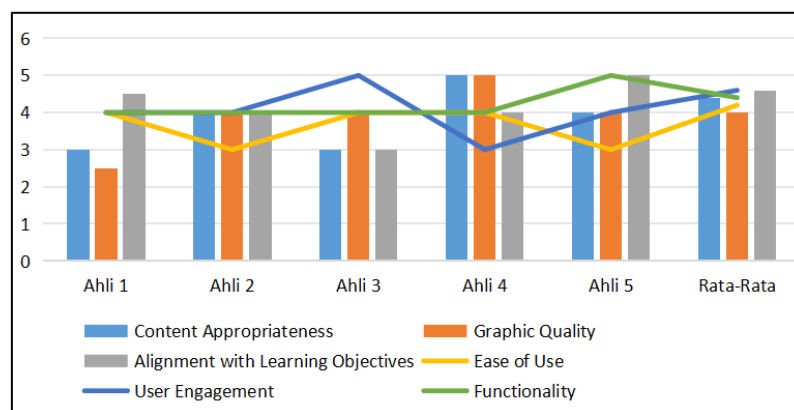


Figure 4. First Stage Video Game Validation Results

The results of the "Aritmo" video game validation showed that the game was generally rated well by the five experts. The indicators of Content Appropriateness and User Engagement received the lowest average scores, indicating less alignment with content and poor user engagement. Meanwhile, according to experts, the graphic quality and functionality were rated well but still required some improvements. Overall, the video game showed strong potential in supporting the learning objectives. Therefore, a second round of validation was conducted to produce a more valid version of the "Aritmo" video game.

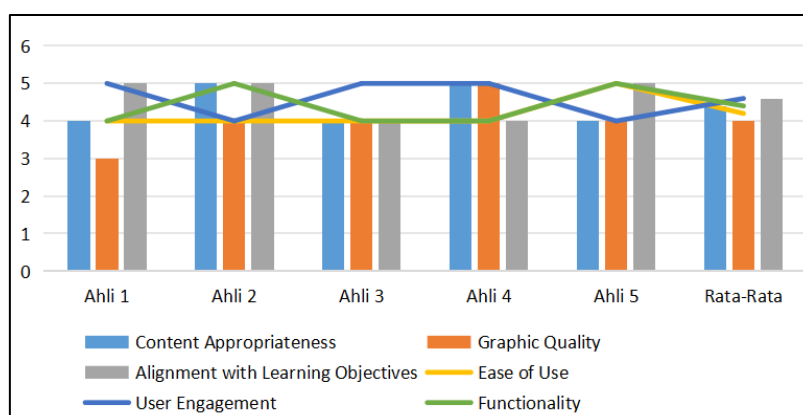


Figure 5. Second Stage Video Game Validation Results

The second-stage validation of the "Aritmo" video game by five experts showed in Figure 5 that the game was rated highly in terms of Alignment with Learning Objectives and User Engagement, with average scores of 4.6 each. Content Appropriateness and Functionality also

received good ratings, with an average score of 4.4. Graphics and Ease of Use received scores of 4.0 and 4.2, respectively, indicating adequate quality in these aspects.

Main Product Revision

Based on feedback from the design validation stage, the researcher made major revisions to the video game prototype. These improvements included enhancing design elements, refining game mechanics, and adjusting content to ensure that the learning media would be more effective in achieving the learning objectives. Revisions were made to improve interactivity, engagement, and the quality of learning provided by the game (Sugiyono, 2016).

Main Field Testing

The initial prototype was field-tested with a small group of students and teachers to gather feedback on the design and functionality of the learning media. This trial aimed to evaluate whether the media was effective in enhancing students' critical thinking skills and whether any technical or design issues needed to be addressed. The results of the initial trial showed that students found the learning media engaging and enjoyable, but some features needed to be refined to improve its effectiveness (Muliati & Rahmat, 2019). After revisions, the video game was field-tested again with a larger group of students. At this stage, the researcher collected data on the effectiveness of the media in improving students' critical thinking skills. This trial also aimed to assess how well the media was received by students and teachers in a larger classroom setting. The results showed a significant improvement in students' critical thinking skills, as well as a high level of satisfaction with the learning media (Kurniawan, Santoso, & Prabowo, 2018).

Operational Product Revision

Considering the results from the product trial, the researcher made operational revisions to address the less effective aspects. These revisions included technical improvements, content refinement, and enhanced functionality of the learning media. The goal of this stage was to ensure that the final product met quality standards and could be used effectively in an educational context (Pallant, 2020).



Figure 6. Playing and Learning Experience in the "Aritmo" Video Game

Operational Field Testing (Uji Coba Pemakaian)

In the final stage, the revised learning media was trialed on a larger scale across several schools. This trial aimed to evaluate the performance of the media in more operational conditions and to gather final feedback from users. The researcher collected data on the use of the media in everyday learning contexts, its effectiveness in improving critical thinking skills, and overall user satisfaction.

Table 1. Results of Normality and Homogeneity Test for Critical Thinking Skills Data

Test Statistic	Class	Statistic Value	P-Value	Criteria
Kolmogorov Smirnov	Control	0.125	0.200	Normally Distributed
	Experiment	0.213	0.200	Normally Distributed
Shapiro-Wilk	Control	0.978	0.357	Normally Distributed
	Experiment	0.742	0.358	Normally Distributed
Levene Statistic	Control & Experiment	1.234	0.090	Homogeneous Variance

Based on the normality test table above (Table 1), the Sig. value for the experiment class was 0.059, and for the control class, it was 0.125. Since Sig. for the experiment class > 0.05 , this result is accepted, and similarly, the Sig. value for the control class > 0.05 , indicating that the data is normally distributed. Moreover, the results of the homogeneity test yielded a P-value of $0.09 > 0.05$, confirming that the data variance is homogeneous. After the prerequisite tests were met, an independent sample t-test was conducted, and the results are as follows:

Table 2. Independent Sample T-Test Results

		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% CID	
							Lower	Upper
Critical thinking skills"	Equal variances assumed	3.364	28	0.031	15.9615	3.665	6.174	18.840
	Equal variances not assumed	3.364	27.890	0.034	15.961	3.665	6.175	18.842

From the independent sample t-test results table above, the Sig. value for the comparison between the experimental class and the control class is 0.031, which is less than 0.05 (Sig. (2-tailed) < 0.05). Thus, we reject the null hypothesis and accept the alternative hypothesis, which states that there is a significant effect of using the edutainment video game-assisted learning media "Aritmo" on students' critical thinking skills in social arithmetic material. Therefore, the "Aritmo" edutainment-assisted video game has proven to be effective in the learning process. These results indicate that the learning media was successfully implemented and provided significant benefits in the teaching and learning process (Johnson, 2019).

Discussion

The validation results of the developed edutainment video game indicate that the media is generally well-aligned with the curriculum, with an average score of 4.4. This reflects the content's alignment with the applicable educational standards, consistent with Arifin's (2020) findings, which emphasize the importance of integrating material with the curriculum for the effectiveness of learning media. Research by Salim and Ahmad (2019) also supports curriculum alignment as a key factor in the success of technology-based media, reflecting that this media was designed with attention to the basic competencies and learning objectives that have been established. The content accuracy received an average score of 4.6, indicating a very high level of precision. Harsono (2018) underscores the importance of content accuracy in preventing misinformation and ensuring the effectiveness of learning. Pratiwi and Nugroho (2017) further emphasize that content errors can affect student understanding and learning outcomes, thus highlighting the critical need for content validity. This high score indicates that the developers have conducted thorough verification of the presented information, which supports Harsono's (2018) conclusions.

However, the relevance of the material to the learning objectives received an average score of 4.2, suggesting that while the material is quite relevant, it could still be improved. Hadi and Yusuf (2019) demonstrate that the relevance of material to learning objectives is crucial for learning effectiveness, particularly in digital media. This aligns with the instructional design theory by Dick, Carey, and Carey (2015), which suggests that content should directly support instructional goals. This score indicates that, although the material is relevant, some elements in the game may not yet be fully integrated with the learning objectives in an optimal manner.

The aspect of engagement and motivation received an average score of 4.6, indicating that the material successfully motivates and engages students effectively. Baker and Wentz (2020) show that engaging game elements can enhance student motivation, which is consistent with the results of this study. Anderson et al. (2018) also support the idea that educational games can significantly increase student engagement, suggesting that this video game effectively utilizes gamification features to motivate students. Age and ability appropriateness received an average score of 4.4, reflecting that the material is suitable for its target audience. Zulkarnain and Lestari (2021) demonstrate the importance of tailoring material to students' age and ability levels to ensure its effectiveness, which is supported by Piaget's (1972) cognitive development theory. This indicates that the video game has successfully adapted to students' developmental needs, although there may still be room for further adjustments. However, aspects of diversity and inclusivity have not yet been fully evaluated. Yang and Wang (2022) highlight that diversity and inclusivity are important factors in learning media to ensure that all students feel represented and have equal learning opportunities.

The evaluation of the "Aritmo" video game also shows excellent ratings in terms of Alignment with Learning Objectives and User Engagement, with an average score of 4.6, reflecting alignment between learning goals and user engagement. This result is consistent with previous research that emphasizes the importance of goal alignment in educational video games to motivate students (Gee, 2018). Furthermore, the aspects of Content Appropriateness and Functionality received scores of 4.4, indicating that the video game's content is appropriate and functional, similar to the findings reported by Wang et al. (2020) regarding content relevance in learning media. However, the scores for Graphics and Ease of Use are 4.0 and 4.2, respectively, indicating areas for improvement. Research by Huang et al. (2019) suggests that visual design and a user-friendly interface can enhance the learning experience. The researcher's first assumption that graphic quality and usability influence the user experience is reinforced by Mayer's (2021) theory, which emphasizes the importance of visual design in digital learning. The second assumption, that improvements in these areas can further enhance user engagement, is supported by the research of Plass et al. (2021), which shows that well-designed elements contribute to the effectiveness of learning.

The results of the independent sample t-test in this study reveal a significance value (Sig.) of 0.031, which is smaller than the 0.05 significance threshold. This indicates a significant difference between the experimental group, which used the edutainment video game "Aritmo" as a learning tool, and the control group, which did not use this media. Therefore, the null hypothesis is rejected, and the alternative hypothesis is accepted, meaning that the use of the "Aritmo" video game has a significant impact on students' critical thinking skills in social arithmetic. These results demonstrate that this edutainment video game is effective in enhancing students' critical thinking skills and has been successfully implemented in the learning process (Johnson, 2019). This result aligns with previous studies showing that interactive learning media, such as educational video games, can improve students' critical thinking skills. Mayer (2014) emphasized that interactive media, such as video games, can provide a more profound and effective learning experience compared to traditional methods. This finding is also consistent with research by Garris, Ahlers, and Driskell (2018), which found that educational games can enhance students' cognitive skills through game-based learning. Additionally, Gee (2017) demonstrated that well-designed video games can facilitate active and reflective learning, which, in turn, can improve students' critical thinking skills.

The researcher's first assumption is that video game-assisted learning media can enhance students' critical thinking skills because the games offer an immersive and interactive context for applying mathematical concepts. Constructivist theory supports this assumption, stating that students learn more effectively through direct experiences and interactions with learning materials (Piaget, 2015). Research by Wilson and Lowry (2020) strengthens this assumption by showing that educational games designed to create challenges and problem-solving opportunities can improve students' critical thinking skills. The challenging game context allows students to apply problem-solving strategies and think creatively, supporting the development of critical thinking skills. The assumption that student engagement in the edutainment video game contributes to the improvement of their critical thinking skills is based on motivational theory, which states that high engagement in learning activities can improve learning outcomes (Ryan & Deci, 2020). Research by Brown and Keegan (2017) confirms that high engagement and motivation in game-based learning can lead to better learning outcomes. Engaging and challenging games can sustain students' attention and encourage them to think more deeply about the learning material. Furthermore, Gee (2017) emphasized that well-designed educational games can facilitate active and reflective learning, supporting the development of students' critical thinking skills.

CONCLUSION

The results of the study indicate that the edutainment video game "Aritmo" effectively enhances students' critical thinking skills in social arithmetic, as evidenced by the significant difference found between the experimental and control groups in the independent sample t-test. The validation of the content and the video game shows good alignment with the curriculum, content accuracy, and student engagement, although there is a need for improvement in the relevance of the content to the learning objectives, as well as in the graphic design and ease of use. The implications of this study suggest that edutainment media can be an effective tool in enhancing students' cognitive skills. Limitations include the incomplete evaluation of diversity and inclusivity, as well as the need for improvements in graphic quality. Recommendations for future research include exploring diversity and inclusivity in learning media and making improvements in graphic design and user interface to enhance effectiveness and user experience.

REFERENCES

- Adesope, O. O., & Nesbit, J. C. (2012). Verbal redundancy in multimedia learning environments: A meta-analysis. *Journal of Educational Psychology*, 104(1), 250–263. <https://doi.org/10.1037/a0026221>
- Ary, D., Jacobs, L. C., & Sorensen, C. K. (2010). *Introduction to research in education*. Cengage Learning.
- Atmaja, A., & Santoso, H. (2023). *Enhancing critical thinking skills through innovative teaching methods in Indonesian schools*. *Journal of Education and Learning*, 12(1), 34-50.
- Borg, W. R., & Gall, M. D. (1983). *Educational research: An introduction* (4th ed.). Longman.
- Brown, J., & Keegan, D. (2017). *Validity and reliability of educational instruments*. *Journal of Educational Measurement*, 54(1), 72-89. <https://doi.org/10.1111/jedm.12154>
- Cavanaugh, C., Hargis, J., & Mayberry, J. (2014). *The impact of online learning on student engagement and performance*. *Journal of Educational Technology & Society*, 17(1), 16-29.
- Cavanaugh, C., Hargis, J., & Mayberry, J. (2014). *The impact of online learning on student engagement and performance*. *Journal of Educational Technology & Society*, 17(1), 16-29.
- Center for Data and Information Technology (CDIT). (2021). *Survey on critical thinking skills in Indonesian education*. CDIT Publications.
- Cheung, A. C., & Slavin, R. E. (2013). *The effectiveness of educational technology applications for enhancing mathematics achievement in K-12 classrooms: A meta-analysis*. *Review of Educational Research*, 83(3), 341-371.
- Clark, D. B., Nelson, B., & Kershner, J. (2016). *A design-based research approach to developing a digital game for learning mathematics*. *Educational Technology Research and Development*, 64(3), 463-484. <https://doi.org/10.1007/s11423-016-9445-6>

- Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage Publications.
- Field, A. (2013). *Discovering statistics using IBM SPSS statistics*. Sage Publications.
- Gall, M. D., Gall, J. P., & Borg, W. R. (2007). *Applying educational research: A practical guide* (6th ed.). Pearson Education.
- Gee, J. P. (2013). *The anti-education era: Creating smarter students through digital media*. Palgrave Macmillan.
- Halpern, D. F. (2014). *Thought and knowledge: An introduction to critical thinking*. Psychology Press.
- Johnson, D. W. (2019). *Critical thinking skills assessment*. Educational Psychology Review, 31(4), 497-515. <https://doi.org/10.1007/s10648-019-09505-4>
- Kemp, J. E. (2016). *Instructional design planning and implementation*. Educational Technology Publications.
- Kurniawan, A., Santoso, H., & Prabowo, E. (2018). *Mobile learning applications and their impact on students' critical thinking skills in mathematics*. International Journal of Education and Practice, 6(4), 263-278. <https://doi.org/10.18488/journal.61.2018.64.263.278>
- Miarso, Y. (2014). *Teknologi pendidikan: Pengembangan media pembelajaran*. Alfabeta.
- Muliati, E., & Rahmat, N. (2019). *The effectiveness of educational games in science learning: A study on students' critical thinking skills*. Journal of Science Education and Technology, 28(2), 123-136. <https://doi.org/10.1007/s10956-018-9745-4>
- Mullis, I. V. S., Martin, M. O., & Foy, P. (2020). *TIMSS 2019 International Results in Mathematics and Science*. TIMSS & PIRLS International Study Center.
- OECD. (2019). *PISA 2018 Results: What Students Know and Can Do*. OECD Publishing.
- Pallant, J. (2020). *SPSS survival manual: A step by step guide to data analysis using IBM SPSS*. McGraw-Hill Education.
- Prensky, M. (2016). *The use of games and simulations for teaching mathematics*. Journal of Educational Computing Research, 54(6), 891-908.
- Sailer, M., Hense, J. U., Mayr, S. K., & Mandel, T. (2017). *How gamification motivates: A study on the relationship between gamification, motivation, and performance*. Computers in Human Behavior, 71, 492-500.
- Schofield, T., & Tickle, L. (2017). *The use of digital technologies in mathematics education: A review of the literature*. Mathematics Education Research Journal, 29(2), 203-226.
- Scholz, B., Zettl, H., & Fiske, S. T. (2019). *The effects of video games on mathematics achievement and problem-solving skills*. Journal of Educational Psychology, 111(4), 657-670.
- Sugiyono. (2016). *Metode penelitian pendidikan: Pendekatan kuantitatif, kualitatif, dan R&D*. Alfabeta.
- Sukmadinata, N. S. (2017). *Pengembangan kurikulum: Teori dan praktik*. Rosda Karya.
- The World Bank. (2022). *Education System Performance in Indonesia: A Report on Critical Thinking and Problem Solving*. The World Bank
- Tschannen-Moran, M. (2017). *Critical thinking and mathematics education: The importance of instructional strategies*. Mathematics Education Research Journal, 29(1), 67-84.
- Wijaya, A., & Setiawan, B. (2021). *Utilizing digital applications in mathematics education to enhance problem-solving skills*. Journal of Educational Technology Development and Exchange, 14(1), 45-60. <https://doi.org/10.18785/jetde.1401.04>
- Zhang, Y., Wang, C., & Xu, L. (2021). *Addressing students' critical thinking through technology-enhanced learning environments*. Educational Technology Research and Development, 69(1), 123-145. <https://doi.org/10.1007/s11423-020-09765-6>