Development of Geoladder Polygon Board Game Learning Media to Enhance Critical Thingking Skills of 4th Grade Students

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Abstract

This study aims to develop and evaluate the effectiveness of the GeoLadder Polygon Board Game as an innovative learning medium to enhance the critical thinking skills of fourth-grade elementary students, specifically in polygon geometry. Using a Research and Development (R&D) approach based on the ADDIE model (analysis, design, development, implementation, and evaluation), the board game was systematically created and tested for educational use. The GeoLadder Polygon Board Game combines mathematical content with critical thinking exercises in a collaborative, interactive format, offering a hands-on and engaging alternative to traditional lectures. Validation by subject matter experts and media specialists yielded high feasibility scores: 88.3% for content accuracy and 96.6% for media quality, confirming the product's suitability for classroom use. Field implementation at SD Negeri 02 Jampiroso with a purposive sample of students showed significant improvement in critical thinking skills, supported by a paired t-test ($p < 0.05$) and an N-Gain score of 0.83, indicating high learning effectiveness. Qualitative data from classroom observations and student questionnaires also indicated increased motivation, engagement, and collaboration. These results suggest that board games can effectively address challenges in understanding abstract mathematical concepts while fostering higher-order cognitive skills. The study recommends broader use of the GeoLadder Polygon Board Game in elementary mathematics curricula and encourages further innovation, including digital integration, to enhance accessibility and adaptability in diverse learning environments.

Keywords: Geoladder Board Game; Learning Media; Students' Critical Thinking Ability

Introduction

Education is a crucial investment in civilization because it can enhance the quality of knowledge and the orderliness of human life. The educational process is a learning journey from ignorance to understanding that helps individuals recognize their potential and guide them to live according to their passions. Basic education, particularly at the elementary school level, serves as the primary foundation in Indonesia's education system since at this stage children are introduced to essential basic knowledge and skills for daily life as well as character and moral development (Lismaya, 2019). Basic education functions to instill values of faith, noble character, nationalism, and provide fundamental intellectual abilities such as reading, writing, and arithmetic. The role of basic education is also strategically important to prepare students to face future challenges, including higher-order thinking skills such as critical thinking (Lismaya, 2019). Critical thinking is a cognitive process involving comprehension, analysis, synthesis, and evaluation of information to make appropriate decisions (Lismaya, 2019). However, various studies indicate that the critical thinking skills of elementary school students remain low. Wahyuni et al. (2022) reported that 73.72% of students at SD Dwijendra Denpasar were unable to optimally develop critical thinking skills. Setyawan and Kristanti (2021) also

found that 50.8% of students exhibited critical thinking skills categorized as low. Data from the Programme for International Student Assessment (PISA) in 2012 and 2018 also indicated that Indonesian students' critical thinking skills were still at a low level compared to other countries (OECD, 2018 in Lismaya, 2019).

Critical thinking is an essential cognitive ability that enables individuals to logically and rationally evaluate information for appropriate decision-making. Etymologically, the word "thinking" in the Indonesian Dictionary (Kamus Besar Bahasa Indonesia) means using reasoning to consider and make decisions and is part of the learning process involving the collection and processing of knowledge (Sujanto, 2016; Slameto, 2015). Thinking is not merely a simple mental activity but encompasses complex mental operations such as induction, deduction, classification, and critical and analytical reasoning. The concept of "critical" in thinking is described as the ability to express opinions supported by logical reasons and strong evidence (Egok, 2016). Johnson emphasizes that critical thinking is an organized process involving the evaluation of evidence, assumptions, and logic within an argument (Sari et al., 2017). Ennis (in Sani, 2019) divides critical thinking skills into five aspects, ranging from providing simple explanations, building basic skills, making inferences, offering detailed explanations, to arranging strategies and techniques for rational decision-making. According to Fister (in Susanto, 2016) and Tuanakotta (in Suprijono, 2016), critical thinking involves the ability to ask questions, analyze, synthesize, and evaluate information obtained from experience and observation. This is further reinforced by Norris and Ennis (in Lismaya, 2019), who define critical thinking as logical and reflective thought focused on decision-making based on rational evidence. Critical thinking skills are vital in basic education because they encourage students to be open to multiple solutions, gather facts, and draw accurate conclusions (Santrock, 2011; Fisher, 2009; Woolfolk, 2016). Paul (2006) adds that the main aspects of critical thinking include interpretation, analysis, inference, evaluation, explanation, and self-regulation, which form logical and rational decision-making.

Preliminary studies at SD Negeri in the Jampiroso cluster revealed several challenges, including difficulty in understanding material concepts, low critical thinking skills, lack of interactive learning activities, and limited use of learning media by teachers. Based on these findings, there is a need for learning media that can increase students' enthusiasm in the learning process. The media should also serve as an alternative learning source enabling students to learn independently (Sandra & Kusuma, 2024). Interviews with fourth-grade teachers also revealed that flat geometry material was considered abstract and difficult for students to comprehend, while limited teaching time posed challenges in implementing varied instructional methods.

Learning media as instructional aids represent one solution to present abstract concepts concretely and facilitate cognitive development in students (Shoimah, 2020). According to Piaget's theory, at the concrete operational stage (ages 7–11), children begin to think logically with the assistance of real objects as learning media (Piaget in Azizah, Sulianto, & Cintang, 2018). The use of lecturing methods without creative and enjoyable media results in students tending to lack confidence to express their opinions or ask questions about unclear matters, thus hindering their habit of thinking critically, creatively, and analytically when faced with problems. This occurs because students' curiosity remains low and they are not accustomed to organizing their knowledge independently (Iswara & Kusuma, 2022). Therefore, developing concrete and interactive learning media is highly appropriate to support the enhancement of critical thinking skills in fourth-grade elementary students.

Learning media are tools or means used to deliver instructional material to achieve educational goals (Briggs in Mudlofir & Rusydiyah, 2019). Learning media function as

message intermediaries that can enhance learning motivation and facilitate the reception of material by students (Mudlofir & Rusydiyah, 2019). The selection of learning media must meet criteria such as accommodation of student stimuli and responses, feedback, alignment with objectives, ease of use by teachers, and technical quality in visual and audio aspects (Arsyad, 2019; Nana Sudjana in Marlina et al., 2021). Appropriate media can stimulate students' thoughts and feelings and increase learning effectiveness.

Board games as learning media are a type of interactive, engaging, and multiplayer board-based game (Ismi Yunita, 2017). The game of snakes and ladders, a variant of board games, is very popular and effective for learning because it is already familiar to students and can increase learning motivation (Pramita & Agustini, 2016). Wati (2021) showed that the use of snakes and ladders games improved student learning outcomes to the point where 100% of students achieved scores above the Minimum Competency Criteria. Other studies by Auliyawati and Nugroho (2023) and Ardi and Desstya (2023) also confirmed the effectiveness of snakes and ladders media in enhancing student motivation and understanding, particularly in mathematics subjects.

Board games are educational and recreational tabletop games that can improve students' soft skills and critical thinking abilities (Mufida & Abidin, 2021; Maulana & Asmarani, 2021). Board games involve strategy, luck, or a combination thereof, with goals to be achieved by players (Rogerson et al., 2015; Scorviano, 2010). The use of board games in learning can stimulate concentration, social interaction, communication, and provide a fun and contextual learning experience (Ratih & Ningsih, 2017; Limantara, 2016). Key characteristics of board games include strong social interaction, negotiation, competition, and cooperation, all contributing to the development of students' critical thinking and social skills. The Geo Ladder Polygon Board Game is a learning media development based on the snakes and ladders game with flat geometry content designed for fourth-grade students. This media combines visual and interactive elements that allow students to learn while playing, collaborate, and engage in healthy competition to understand mathematical concepts concretely (Prastiwi, 2014).

Several studies demonstrate the effectiveness of board games and innovative learning models in improving students' critical thinking abilities. Nizmatullayla and Fauzi (2023) proved increased activity and critical thinking skills using snakes and ladders games with a Problem-Based Learning (PBL) approach. Anggraeni et al. (2023) affirmed that the PBL model significantly develops critical thinking across various subjects. Additionally, collaborative learning (Warsah et al., 2021), inquiry mind maps (Sari et al., 2021), and the integration of technology in learning (Alsaleh, 2020) have also proven to enhance students' critical thinking skills. The use of snakes and ladders games is effective in improving mathematics learning outcomes, students' self-confidence, and motivation (Devantari et al., 2024; Fransisca et al., 2020; Suciati, 2021). STEAM-based hybrid models also yield better results compared to conventional methods in the context of critical thinking ability (Utomo, 2023).

Based on the above, this study aims to develop a learning media in the form of the GeoLadder Polygon Board Game to improve the critical thinking skills of fourth-grade students at SD Negeri 02 Jampiroso, especially on flat geometry material. This media is expected to address the limitations of abstract learning by providing a more concrete, interactive, and enjoyable learning experience for students.

Method

The research method employed in this study is Research and Development (R&D). Research and development is a method used to test, develop, and produce a valid and feasible product. The product developed in this study is the Geo Ladder Polygon

Board Game as a learning media for flat geometry material aimed at fourth-grade elementary school students, with the objective of improving critical thinking skills. The development model used is the ADDIE model, which consists of five main stages: Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model was selected because it provides a systematic framework for the development of learning media. The research procedure follows the structured stages of the ADDIE model. In the analysis stage, learning needs were identified through observations and interviews with teachers and students to understand the challenges in teaching flat geometry material and the characteristics of fourth-grade students. Subsequently, the design stage involved creating the board game learning media based on the results of the needs analysis and relevant literature review. The development stage included the creation of a prototype of the board game and validation by content and media experts to ensure the feasibility of the content and media appearance. Following this, the media was piloted with fourth-grade students as the implementation phase to collect data on its effectiveness and user responses. The evaluation stage was conducted by analyzing the results of pretest and posttest critical thinking skills, observing student engagement, and using questionnaires and interviews with teachers and students as a basis for improving and finalizing the learning media.

The research subjects comprised 30 to 40 fourth-grade elementary school students selected through purposive sampling based on the research criteria. The fourth-grade teacher responsible for instruction was also a subject in this study to provide an assessment of the application of the learning media. The research location was SD Negeri 02 Jampiroso, Temanggung Regency, selected based on the school's readiness and cooperation with the researcher. The variables in this study consist of the independent variable, namely the Geo Ladder Polygon Board Game learning media, and the dependent variable, which is the critical thinking ability of fourth-grade students on flat geometry material. Data were collected using several techniques, including tests of critical thinking skills in the form of pretests and posttests employing validated and reliable essay-question instruments, passive participatory observation to assess student engagement during the use of the board game, response questionnaires to measure acceptance and learning motivation, and interviews with teachers to obtain qualitative data regarding the effectiveness of the learning media. The test instruments were validated through content expert validation and Pearson correlation statistical testing using SPSS, where the validation results showed that 13 out of 15 questions were declared valid according to the validity criteria. Furthermore, reliability tests using Cronbach's Alpha yielded values of 0.984 for the pretest and 0.956 for the posttest, indicating that the test instruments possessed very high reliability. Quantitative data from the study were analyzed using the Kolmogorov-Smirnov normality test and Levene's homogeneity test to ensure that the assumptions for analysis were met. Subsequently, a t-test was conducted to determine the significant difference in students' critical thinking skills before and after the use of the learning media. Observational data were analyzed descriptively in quantitative terms by calculating the percentage of student engagement, while qualitative data from questionnaires and interviews were analyzed descriptively to support the quantitative findings.

Result dan Discussion

This study employs the Research and Development (R&D) method aimed at developing, validating, and assessing the practicality and effectiveness of the GeoLadder Polygon Board Game learning media in enhancing the critical thinking skills of fourth-grade students on flat geometry material. An analysis of student characteristics was

conducted through initial observations and interviews to understand the students' profiles and the learning conditions. The observation results indicated that students exhibited diverse learning styles, with the majority tending to comprehend material more easily through visual approaches and hands-on activities, particularly using interactive media such as educational games. Prior to the implementation of the media, student engagement in learning was still low, characterized by passive attitudes during lecture-based instruction. The main difficulty was found in understanding flat geometry concepts, where students tended to memorize formulas without deeply comprehending the underlying concepts. These findings align with Emzir's (2013) assertion emphasizing the need for interactive learning media to improve conceptual understanding and student engagement. Teachers revealed that conventional learning dominated by lectures and drills failed to motivate students sufficiently, necessitating innovative media that can activate student participation in an enjoyable manner. This perspective is supported by Arsyad (2019), who stated that interactive learning media can enhance motivation and learning outcomes. Therefore, the use of the GeoLadder Polygon Board Game was designed to address this need.

The design phase of the GeoLadder Polygon Board Game media involved determining the title, theme, and compiling learning materials in accordance with the fourth-grade curriculum, focusing on polygon concepts and critical thinking skills. The media takes the form of a board game with key components: game board, question and information cards, pawns, dice, guidebook, answer key book, and score board. This board game was designed with attractive visuals and an easy-to-understand layout, containing challenges and questions progressing from basic comprehension to critical thinking levels. The design refers to the principles of active and collaborative learning advocated by Brookfield (2012) and Fisher (2009) to develop critical thinking skills through enjoyable and meaningful learning activities.

Validation was conducted by content experts and media experts using assessment questionnaires. The content validation by Yohana Setiawan, S.Pd., M.Pd yielded a score of 88.3%, categorized as very good (interval 81–100%). Media validation by Dr. Herry Sanoto, M.Pd resulted in a score of 96.6%, also categorized as very good. Both validation results confirm that the GeoLadder Polygon Board Game media is feasible and effective for use as mathematics learning media, particularly in developing students' critical thinking skills (Arsyad, 2019). The final design of the board game card box was created to be visually appealing and functional for classroom use.

Figure 1. Final Design of the Card Box

The implementation of the media was conducted in the classroom by dividing students into groups and facilitating the use of the board game. Observations during the implementation phase showed an increase in students' enthusiasm and engagement in group discussions, as well as their ability to provide reasoning for their answers, in accordance with critical thinking indicators. Teachers reported that this media was able to enhance students' learning motivation and help them understand flat geometry concepts more deeply and applicably. Students also expressed that learning through the board game was more enjoyable and challenging compared to conventional methods. Evaluation was carried out using statistical tests on the pretest and posttest results of students' critical thinking abilities. The Shapiro-Wilk Normality test indicated that the data were normally distributed ($p > 0.05$) in both the pretest and posttest groups. Levene's Test for Homogeneity showed homogeneous data variance ($p > 0.05$). The Independent t-test revealed a significance value of $0.04 < 0.05$, indicating a significant difference between the pretest and posttest results. The average posttest score increased by 4.04 points from the pretest (from 79.82 to 83.86). These results demonstrate the effectiveness of the GeoLadder Polygon Board Game media in improving the critical thinking skills of fourth-grade students (Hake, 1999; Sugiyono, 2016). The average N-Gain score was 0.83, classified as high (very effective learning), which indicates a significant improvement in students' critical thinking abilities after using this media. This reinforces findings that game-based learning positively impacts student motivation and understanding (Anggraeni et al., 2023; Utomo et al., 2023).

This study developed the GeoLadder Polygon board game as an innovation in mathematics learning, specifically on flat polygon geometry for fourth-grade students. The results showed that the development of this board game met the criteria of validity, effectiveness, and practicality as a learning media, significantly enhancing students' critical thinking skills and mathematical literacy. During the development stage, validation by content and media experts resulted in very high scores of 88.3% and 96.6%, respectively. These findings are consistent with previous research by Pratiwi et al. (2021) and Sari & Dewi (2020), who also reported that board game media were valid and feasible for use as mathematics learning media on flat geometry topics. This rigorous validation ensures that the GeoLadder Polygon board game is aligned with learning needs and educational media design principles (Arsyad, 2019; Mudlofir & Rusydiyah, 2019)1.

Analysis of pretest and posttest results revealed a significant increase with a two-tailed significance value of $0.001 < 0.05$ and an N-Gain of 0.836 (high category). This confirms the effectiveness of the board game in enhancing students' understanding of polygon concepts and critical thinking skills. These results align with Fauzi's (2023) findings, which emphasized that using board games in mathematics learning can improve mathematical literacy, critical thinking skills, and collaboration. Game-based learning approaches provide an enjoyable learning experience while fostering active student involvement in problem-solving.

Practicality assessments through student and teacher response questionnaires indicated very high percentages of 82.5% and 90%, respectively. This suggests that the GeoLadder Polygon board game is easy to use and well accepted within the context of fourth-grade classroom learning. Media practicality is a crucial factor to ensure that educational innovations can be sustainably implemented and yield positive impacts (Fauzi, 2023; Arsyad, 2019).

The use of the ADDIE model (Analyze, Design, Development, Implementation, Evaluation) in the development of this board game provides a systematic framework guiding each stage in a structured and measurable manner. The needs analysis, design planning, product development, implementation trials, and evaluation ensure that the final

product aligns with learning objectives and student needs (Sugiyono, 2019; Daryanto & Dwi Cahyono, 2014). This model also supports empirical validation so that the resulting product possesses scientifically accountable quality.

The findings of this study strengthen evidence that innovative learning media, particularly game-based media such as board games, play a strategic role in improving the quality of mathematics learning in elementary schools. The GeoLadder Polygon board game functions not only as an introductory medium for the material but also as a tool to train critical thinking, collaboration, and enhance students' learning motivation (Setyawan & Kristanti, 2021; Utomo et al., 2023; Warsash et al., 2021). This aligns with the goals of 21st-century education, which emphasize the development of higher-order thinking skills and active student engagement. Although this study focused on polygon material with a specifically developed board game media, its results support various previous studies demonstrating the effectiveness of board games in mathematics learning (Novita & Sundari, 2020; Pramita & Agustini, 2016; Purnama & Kalkautsar, 2023). The main distinction of this study lies in the explicit integration of critical thinking approaches within the media design and the measurement of its effectiveness through empirically valid statistical tests. Therefore, this media not only enriches alternative teaching methods but also strengthens the literature on the development of effective and practical game-based educational media.

Conclusion

Based on the results of the research and discussion conducted, it can be concluded that the development of the GeoLadder Polygon board game learning media successfully enhanced the critical thinking skills of fourth-grade elementary school students on flat geometry material. This media development encompassed the stages of needs analysis, design planning, prototype development, validation by content and media experts, as well as limited trials involving students and teachers. The media validation yielded excellent scores, with content validity reaching 96.6%, indicating that the media is suitable for use in learning. The effectiveness test results through pre-test and post-test demonstrated a significant improvement in students' critical thinking abilities after using the GeoLadder Polygon media. Furthermore, the practicality test revealed that the media is easy to use, engaging, and capable of enhancing student interaction and cooperation during the learning process. The authors provide several recommendations. First, teachers are advised to use the GeoLadder Polygon media as an alternative in mathematics instruction, particularly for flat geometry material, to increase students' learning motivation as well as their active and enjoyable engagement and critical thinking skills. Second, future researchers are encouraged to expand this study by broadening the target population and learning materials to other grade levels and by integrating interactive digital features to make the learning media more diverse and accessible to a larger number of students. Third, schools are expected to provide support in the form of adequate facilities and time allocation to facilitate the use of innovative learning media such as GeoLadder Polygon in teaching and learning activities. This study has several limitations that need to be addressed in future development. First, the trial sample was limited to fourth-grade students in one school, so the results cannot yet be generalized widely to other levels or schools. Second, the developed media remains a physical form without digital technology integration, thus limiting its accessibility and usage variations. Third, the measurement of critical thinking skills using quantitative pre-test and post-test instruments did not include an in-depth qualitative analysis of aspects related to student motivation and engagement. Therefore, subsequent research is expected to overcome these limitations to produce more effective and applicable learning media.

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