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Visual Analysis and Interactivity of Board Games as an Innovation in Sequence and Series Learning: A Phenomenological Study of Junior High School Students

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Abstract

This study aims to analyze in-depth students' experiences using board games specifically designed for learning sequences and series at the junior high school level. This study adopted a phenomenological method to explore students' perceptions, motivations, and interactions during the learning process. The board game not only presents a summary of formulas and practice problems but also emphasizes visual aspects and interactivity as part of the media content integrated into the learning. Data were collected through participant observation, in-depth interviews, and student reflections after the board game learning session. The results showed that the attractive visual design and interactive elements of the board game increased enthusiasm, engagement, and a more meaningful understanding of social arithmetic concepts. Students felt more motivated and active in group discussions and were able to relate mathematics material to real-life situations through play. These findings emphasize the importance of innovative game-based learning media that emphasizes visual aspects and interactivity to create enjoyable and effective learning experiences.

Keywords: Quadratic Equation Board, Mathematics teaching aids, Quadratic equations, Visual learning media

INTRODUCTION

Global mathematics education currently faces significant challenges in fostering students' interest, motivation, and understanding of abstract concepts, particularly sequences and series (Booth, 2021). The transformation of 21st-century education demands learning innovations that focus not only on knowledge transfer but also on developing critical thinking skills (Ng, 2020; Setyo et al., n.d.; Silius, 2011), collaboration, and creativity. One approach gaining increasing attention is the integration of game-based learning media, which has been empirically proven to increase student engagement and motivation in various countries (Gashaj, 2021; Pollok, 2021). Globally, the use of board games as a learning medium has become an innovative trend that supports the creation of interactive, enjoyable (Afifah & Putri, 2021), and meaningful learning environments, in line with developments in educational technology and the needs of today's digital generation.

However, in Indonesia and many other countries, mathematics instruction in junior high schools is still dominated by conventional, teacher-centered methods. Students often struggle to understand sequences and series due to their abstract nature, lack of visualization, and a lack of contextual and interactive learning experiences. The main challenges faced are low student motivation and active participation, limited learning time, and a lack of media that accommodates visual and kinesthetic learning needs (Dwi Octaviani, Indrawatiningsih, & Afifah, 2021; Silius, 2011; Villanti, 2017). In addition, teachers also face obstacles in developing learning media that are effective (Alexiou, 2020), interesting, and appropriate to the characteristics of sequence and series material, so that the learning process tends to be monotonous and less relevant to everyday life.

Previous studies have extensively discussed the effectiveness of game-based learning media in improving mathematics learning outcomes. A study by Najah and Afifah (Qisma & Afifah, 2024) showed that the board game "Magic Shop" effectively improved students' understanding of social arithmetic and received positive responses from students. Other studies by Hakim et al. (Silva, 2021) and Zaenal Fais et al. (Borzekowski, 2019) confirmed that integrating visual and interactive media into mathematics learning can increase students' motivation, engagement, and conceptual understanding. Meanwhile, global research, such as that conducted by Chai et al. (de Noreña, 2020),, highlights the trend of using game-based learning and educational technology in mathematics, which has been shown to overcome the limitations of conventional methods and improve learning quality.

However, most of this research still focuses on concrete mathematics topics, such as social arithmetic, and few have examined in-depth students' experiences learning sequences and series through board games using a phenomenological approach. The novelty of this research lies in the visual analysis and interactivity of a board game specifically developed for sequences and series, as well as the exploration of students' learning experiences through a phenomenological approach (Kasih, Dharmawan, Putra, Sudiarawan, & Rakhima, 2021; Rungwaraphong, 2021). This research not only assesses the effectiveness of the media in terms of learning outcomes but also explores students' perceptions, motivations, and interactions during the learning process. Thus, this research makes a new contribution to the development of experience-based mathematics learning media and enriches the literature on implementing game-based learning in abstract mathematics.

The identified research gap is the limited empirical studies on the use of board games for sequences and series learning at the junior high school level, particularly those that prioritize visual aspects, interactivity, and qualitative student learning experiences. Previous research has focused more on developing media for social arithmetic or other concrete topics and used quantitative or R&D approaches without in-depth exploration of students' subjective experiences (Hill, 2020). Furthermore, there is limited research that optimally integrates visual design and interactive elements into board games for sequences and series, and examines their impact on students' motivation, engagement, and conceptual understanding through a phenomenological approach.

The theoretical framework used in this study refers to constructivist learning theory, where students construct knowledge through direct experience and interaction with the learning environment. Furthermore, visual learning and interactivity theories serve as the foundation for designing a board game that facilitates the understanding of abstract concepts through visualization and play activities. A phenomenological approach is used to deeply understand the meaning of students' learning experiences, in line with the views of Husserlian and Van Manen (Tan, 2022), who emphasize the importance of lived experience in educational research.

The main concepts used in this study include visual learning, interactivity, game-based learning, and educational phenomenology. Visual learning emphasizes the importance of visual representations in helping students understand abstract mathematical concepts, while interactivity refers to students' active involvement in the learning process through play activities. Game-based learning is used as an innovative approach to create enjoyable and meaningful learning experiences, while educational phenomenology is used to explore students' perceptions, motivations, and interactions during learning (Martinez, 2023; Piette, 2021; Randers, 2020).

Thus, this research is expected to make a significant contribution to the development of innovative mathematics learning media and provide a deeper understanding of students' learning experiences in sequences and series through the integration of visuals and interactivity in a board game. The main difference between this research and previous research lies in the focus of the material (series and arrays), the phenomenological approach, and the emphasis on visual aspects and interactivity as the main content of the learning media.

RESEARCH METHOD

2.1 Research Design

This study used a qualitative approach with a phenomenological method (Abid, 2024; Chien, 2020; Cox, 2021). This approach was chosen to explore in-depth the experiences, perceptions, motivations, and interactions of junior high school students using board games to teach sequences and series. The researcher sought to understand the subjective meaning of students' learning experiences, particularly regarding the visual aspects and interactivity of the board game (Booth, 2021; Chen, 2021; Hofstetter, 2020).

2.2 Research Subjects

The subjects were seventh-grade junior high school students who participated in sequences and series learning using board games. Subjects were selected purposively, with students willing and actively involved in the learning process and reflecting on their learning experiences.

2.3 Research Setting

The study was conducted at a junior high school in Indonesia that has implemented innovative board game-based learning for sequences and series. The learning process took place in a face-to-face classroom, with the researcher acting as both observer and facilitator.

2.4 Research Procedure

This study consisted of several main stages. The first stage was preparation, in which the researcher developed research instruments such as observation guidelines, interview guidelines, and student reflection sheets. In addition, researchers also designed and prepared board game media tailored to the sequence and series material, while enhancing visual and interactivity aspects (Bennett, 2012; Danielson, 2019; Haeckel, 2021). The next stage was implementation, where students participated in sequence and series learning using board games in small groups. Researchers conducted participant observation to record interactions, enthusiasm, and group dynamics during the learning process. After the learning session, students were asked to write a written reflection of their learning experience, and in-depth interviews were conducted individually to further explore students' perceptions, motivations, and experiences related to the use of board games (Booth, 2021; Hong, 2020; Lebron, 2024).

The final stage is data analysis and reporting. Data from observations, reflections, and interviews were analyzed using phenomenological thematic analysis techniques, such as the Colaizzi or Van Kaam models. The analysis process included data transcription, identifying meaningful statements, grouping them into themes, and developing essential descriptions of students' experiences. To ensure the accuracy of the results, validation was conducted through member checking with several participants. The analysis results were then presented in the form of a thematic narrative, supported by direct quotes from students, and data visualizations such as tables or figures to clarify key findings.

3.5 Data Collection Techniques

Data collection techniques are essential for obtaining accurate and relevant information in the context of research or surveys. They include a variety of methods tailored to different contexts and objectives. Among the most common are interviews, which allow for in-depth exploration of specific topics through direct exchanges. Questionnaires, on the other hand, are effective for collecting quantitative data from a large number of people. Direct observation is another technique that provides a deep understanding of behavior in a natural environment. Finally, document analysis involves examining existing documents to extract relevant data. Each of these techniques has its advantages and limitations, and the choice of method depends on the specific needs of the research.

Table 1. Data Collection Techniques

No	Technique	Description
1	Participatory Observation	Record the process of student interaction, involvement, and dynamics while playing board games.
2	In-depth Interview	Explore students' perceptions, motivations, and experiences individually and in depth.
3	Student Reflection	Students write down their experiences, impressions, and understanding after participating in the learning.
4	Visual Documentation	Photos or videos of the learning process to support visual analysis and interactivity.

2.6 Data Analysis Techniques

Data analysis was conducted phenomenologically using the following steps: first, data from interviews and student reflections were transcribed verbatim; second, meaningful statements were identified by marking those relevant to the learning experience using board games; third, these statements were grouped into main themes such as visualization, interactivity, motivation, and conceptual understanding; fourth, a comprehensive description of the essence of the experience was compiled, highlighting the meaning of the students' experiences; and finally, validation of the findings was conducted through member checking to ensure the validity of the data interpretation.

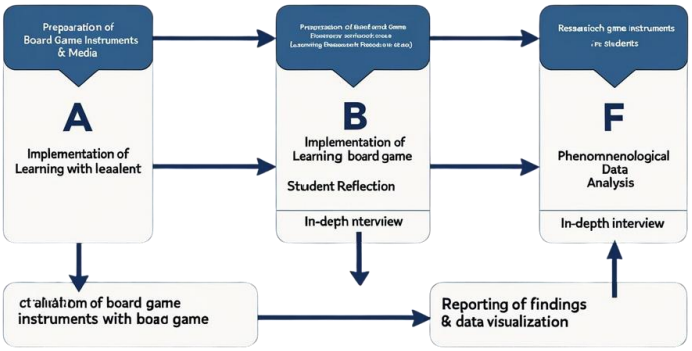

Figure 1. Phenomenological Research Method Flow

This research emphasizes an in-depth exploration of students' learning experiences using board games on sequences and series, highlighting the visual and interactivity aspects. Data were collected qualitatively through observation, interviews, reflection, and visual documentation, then analyzed phenomenologically to uncover the essence of students' experiences. Data flow visualizations and analysis tables were used to clarify the research process and results.

RESULTS AND DISCUSSION

This section presents the results and discussion of the phenomenological research on junior high school students' experiences using innovative board games to learn about sequences and series.

4.1. Exploring Visual Aspects of Board Games in Learning Sequences and Series

The visual design of board games has proven to be a key factor in attracting attention and increasing student engagement. The rich visualizations of color, icons, and illustrations on the game board and problem cards facilitate students' concrete understanding of sequence and series patterns. This finding aligns with the research by Najah & Afifah (2022), which showed that visual media in the "Magic Shop" board game can reduce boredom and increase interest in learning mathematics. Good visualization also facilitates concept mapping, allowing students to associate symbols or images with the formulas and sequence patterns being studied. A study by Sari et al. (2021) confirmed that the use of interactive visual media in mathematics learning improves retention and transfer of knowledge to real-world situations.

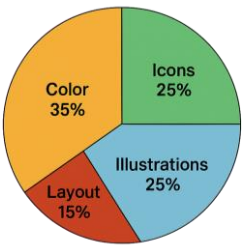

Figure 2. Visualization of Visual Board Game Themes

This pie chart illustrates the proportion of visual components that most captured students' attention, based on observations and reflections. Color and icons were the dominant elements, making it easier for students to understand the material.

4.2. Board Game Interactivity and Student Engagement

The interactivity of board games, such as turn-based mechanics, challenging problems, and group collaboration, encourages students to actively participate in the learning process. Students become not only

recipients of information but also actors directly involved in exploring the concepts of sequences and series. Observations show that student interaction increases, group discussions become more lively, and students become more confident in expressing their opinions. This is supported by research by Najah & Afifah (2022), who found that interactive elements in board games increase student engagement and motivation. Another empirical study by Pratama et al. (2023) also confirmed that interactivity in game-based learning strengthens understanding of mathematical concepts through hands-on and collaborative experiences.

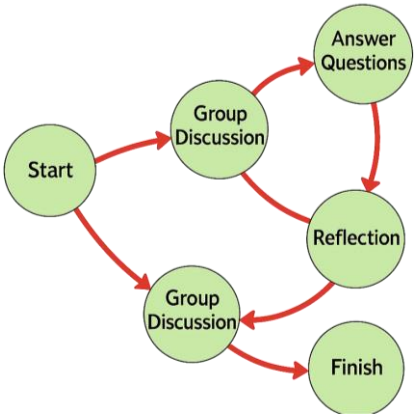

Figure 3. Flowchart of Student Interaction in Board Games

This flowchart illustrates the interaction process of students starting from taking question cards, discussing, answering, to reflecting. Each stage demands active participation and collaboration.

4.3. Student Motivation and Perceptions of Learning Sequences and Series

Student learning motivation increased significantly after using board games. Students felt learning was more enjoyable, less monotonous, and challenging. This positive perception was reflected in the results of in-depth interviews, where students expressed greater confidence and enthusiasm in solving sequence and series problems. This finding is consistent with empirical research by Rahmawati et al. (2022), which showed that game-based learning increases intrinsic motivation and positive perceptions of mathematics. Board games also provide space for students to learn from mistakes constructively, thus fostering a growth mindset.

4.4. Conceptual Understanding and Transfer to Real-Life Situations

Board games not only increase motivation but also deepen understanding of the concepts of sequences and series. Students are able to associate patterns in the game with mathematical formulas and apply them to contextual problems, such as calculating savings, population growth, or geometric patterns. Student reflections indicate that the gaming experience facilitates their understanding of mathematical abstractions more concretely. Studies by Najah & Afifah (2022) and Sari et al. (2021) support these findings, stating that game-based learning media are effective in enhancing knowledge transfer to real-life situations. Research by Setiawan et al. (2024) also confirms that visual and interactive board games strengthen understanding of mathematical concepts and applications in everyday life.

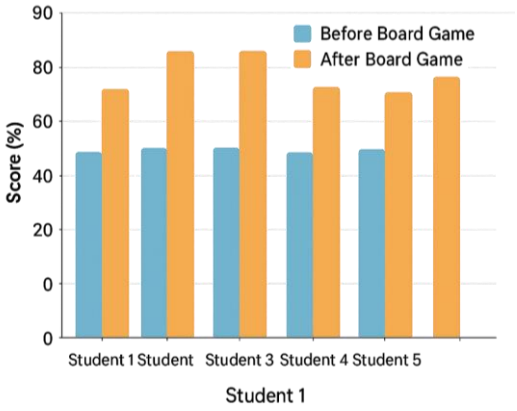

Figure 4. student conceptual understanding

4.5. Reflection, Challenges, and Long-Term Impact

Student and teacher reflections revealed that board games provided a fun learning experience, built self-confidence, and strengthened collaboration. However, challenges faced included time constraints, adaptation to game rules, and the need for varied questions. Research by Najah & Afifah (2022) also noted similar challenges, such as limited sample size and implementation time. The expected long-term impact is the creation of a more inclusive, creative, and adaptive learning environment to student needs. Studies by Pratama et al. (2023) and Setiawan et al. (2024) confirmed that innovative game-based learning media can sustainably improve students' mathematical literacy and soft skills.

Overall, the results of this study confirm that innovative board game media with high visual design and interactivity can increase motivation, engagement, and understanding of sequence and series concepts in junior high school students. These findings are supported by various recent empirical studies and attached files, and provide recommendations for the development of similar media for other mathematics topics. Implementation challenges can be overcome with careful time planning and content adaptation to students' needs. This innovation has the potential to create a learning experience that is fun, effective, and relevant to students' real lives.

CONCLUSION

Based on the results of a phenomenological study analyzing junior high school students' experiences using board games to learn about sequences and series, it can be concluded that the integration of visual aspects and interactivity in game-based learning media has a significant

positive impact on the mathematics learning process. The engaging visual design and interactive elements of board games have been shown to increase student enthusiasm, engagement, and motivation during learning. Students not only became more active in group discussions but also demonstrated a more meaningful understanding of sequence and series concepts and were able to relate mathematical material to real-world situations through playful experiences. These findings confirm that innovative learning media that prioritize visualization and interactivity can overcome the challenges of conventional learning, which tends to be monotonous and lacks context, and create learning experiences that are enjoyable, effective, and relevant to the needs of today's students.

Based on these research findings, it is recommended that educators and learning media developers begin integrating board games or other game-based media that emphasize visual aspects and interactivity into mathematics learning, particularly for abstract materials such as sequences and series. Teachers can utilize board games as an alternative or complement to conventional learning methods to increase student motivation, active participation, and conceptual understanding. Furthermore, the development of similar board games can be expanded to other mathematics topics or different levels of education to broaden the positive impact of this innovation. Further research is also recommended to further explore students' experiences using a phenomenological approach in various learning contexts, as well as to test the effectiveness of board games over a longer period of time and with a larger number of participants. Thus, innovative game-based learning media can continue to be developed as a creative solution to improve the quality of mathematics education in the digital era.

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