



## Development of an Educational Game ‘Petualangan Ryna’ as a Learning Media for Geometric Transformations in Junior High School

Izza Ardiansyah<sup>1,\*</sup>, Sisworo<sup>2</sup>, Purwanto<sup>3</sup>

<sup>1,2,3</sup> Universitas Negeri Malang, Malang

\*Corresponding Authors: izza.ardiansyah.2403118@um.ac.id

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### ABSTRACT

The teaching of geometric transformations in junior high school continues to face several challenges, especially regarding the topics of translation and reflection, which require a strong understanding of visual and spatial concepts. This issue was identified at a junior high school in Pasuruan Regency, where diagnostic tests and classroom observations revealed low student comprehension and a lack of interactive instructional media. In response, this study aimed to develop an educational game titled *Petualangan Ryna di Desa yang Hilang* using the ADDIE (Analysis, Design, Development, Implementation, Evaluation) development model. The goal was to produce a valid, practical, and effective learning tool. The research involved seventh-grade students as participants, with data collected through expert validation, post-tests, and student response questionnaires. The results indicated that the developed game and assessment instruments were valid, the game was practical to use, and it effectively improved students’ understanding of geometric transformations. Therefore, *Petualangan Ryna di Desa yang Hilang* is suitable for classroom use as an innovative learning media that enhances engagement and conceptual understanding through contextual and visual exploration.

Keywords: educational media; educational game; geometric transformations

### INTRODUCTION

In the Merdeka Curriculum, geometric transformation is included as one of the learning objectives within the geometry component of Phase D (Grades VII–IX). Students are expected to perform basic transformations such as translation and reflection on the Cartesian plane and apply them to solve problems (Septian et al., 2022; Swasto et al., 2024). However, this competence demands abstract reasoning and spatial skills, which many students find difficult to master.

Based on interviews with a mathematics teacher at a junior high school in Pasuruan Regency, geometric transformation is one of the most challenging topics for students. A diagnostic test conducted with four seventh-grade classes revealed that while three classes achieved an average score of  $\geq 70$  (meeting the Minimum Mastery Criteria), one class scored an average of only 60. This class was selected as the subject of the study using purposive sampling due to its critical need for instructional intervention.

Further classroom observations found that teaching methods remained conventional, with a predominance of lectures and written exercises (Aziz et al., 2025; Septian & Gustiana, 2022). Despite having technological facilities such as Chromebooks and a computer lab, the school had not yet integrated interactive media—particularly for learning geometric transformations. The available tools lacked support for contextual exercises or visual

explorations. Thus, an alternative learning media was needed to provide a more interactive, visually engaging, and exploratory learning experience.

Instructional media plays a vital role in facilitating the learning process by bridging the gap between teachers and students. Media includes various tools, materials, and delivery channels designed to support effective achievement of learning objectives (Harini & Taufiq, 2021; Rahmi et al., 2023; Septian & Rahayu, 2021). It also helps stimulate student attention, engagement, and makes abstract concepts more (Sarmawati et al., 2024).

One innovative approach in media development is game-based learning. This method integrates game elements such as challenges, missions, and active user roles into the learning process to create an enjoyable and motivating experience. Unlike superficial gamification techniques that only add scores or rewards, well-designed educational games can foster deep engagement and emotional involvement in learning (Kalmpourtzis & Romero, 2022)

Research has consistently shown the effectiveness of game-based media in improving student motivation, engagement, and understanding. Zeng, Parks, and Shang (2020) reported that challenge, feedback, and immersion elements in educational games enhance learning outcomes. Similarly, emphasized the potential of simulation-based games to support collaborative and reflective learning through meaningful problem-solving. A systematic review by Hasanah et al. (2021) of 30 studies in Indonesia concluded that game-based math media positively impacts both learning outcomes and motivation, especially for complex topics such as algebra.

However, few studies have specifically developed or tested digital game-based media for geometric transformations in the context of the Merdeka Curriculum. Most previous works in Indonesia have focused on algebra, geometry in general, or basic arithmetic. This creates a research gap regarding how interactive, game-based environments can support students' understanding of spatial and transformational geometry concepts—areas that require visualization and reasoning rather than procedural repetition.

Theoretically, this study is grounded in constructivist learning theory, which emphasizes that learners build their own knowledge through active engagement and exploration (Piaget, 1972; Bruner, 1996). Game-based learning aligns with this framework because it situates learners in meaningful contexts where they can manipulate objects, receive feedback, and reflect on their actions. In addition, the Cognitive Theory of Multimedia Learning (Mayer, 2009; Aziz et al., 2025; Lestari et al., 2024) provides the foundation for designing digital media that integrates visual and verbal information effectively to reduce cognitive load and improve conceptual understanding. Together, these theories justify the development of a 3D educational game that allows students to experience geometric transformations interactively.

Given the problems identified and the theoretical perspectives described, this research aimed to develop a digital educational game titled *Petualangan Ryna di Desa yang Hilang* as a learning tool for geometric transformations—specifically translation and reflection—for junior high school students. The development employed the ADDIE model and focused on producing a valid, practical, and effective media product.

## RESEARCH METHODS

This study employed a research and development (R&D) approach, packaged in the form of an educational game. The development model adopted was the ADDIE model (Analysis, Design, Development, Implementation, Evaluation), as illustrated in Figure 1.

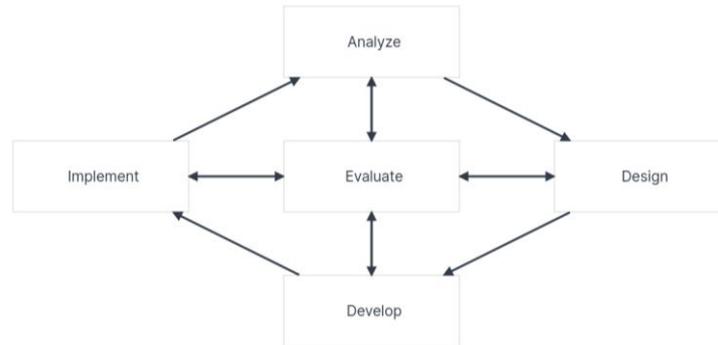


Figure 1. Stages of the ADDIE Model (Tegeh, Jampel, dan Pudjawan, 2014)

In the analysis stage, the researcher identified development needs through diagnostic testing, classroom observation, and interviews with the subject teacher. This stage aimed to uncover students' difficulties in understanding geometric transformation concepts and to assess the school's readiness to adopt digital learning media. The analysis also involved reviewing the learning objectives outlined in Phase D of the national curriculum to determine the competencies to be addressed in the media. Additionally, the characteristics of educational games were studied as references for design decisions.

The design stage involved formulating the instructional content to be integrated into the game, outlining the gameplay flow, user interface (UI) layout, and mini-game structure aligned with the learning indicators. Initial designs were visualized using wireframes and flowcharts, accompanied by the construction of assessment items targeting students' abilities in performing translations and reflections on a Cartesian plane.

During the development stage, the game *Petualangan Ryna di Desa yang Hilang* was developed using the Unity platform and C# programming language based on the approved design. The initial prototype was validated by subject matter experts and media specialists using structured validation instruments. Feedback from validators was used to revise the technical elements, instructional content, and the quality of game interactions. A small-scale trial was then conducted with a limited group of students to assess technical functionality and usability.

The implementation stage was carried out in a full classroom setting, involving a class of 30 seventh-grade students. The game was integrated into classroom learning activities, followed by a post-test to measure student mastery of the subject. Additionally, a student response questionnaire was administered to evaluate the practicality of the media in terms of content comprehension, ease of use, and learning motivation.

In the evaluation stage, the researcher ensured that the developed media aligned with instructional goals, student needs, and the design principles of educational games. Evaluation was conducted in two forms: formative and summative. Formative evaluation took place throughout the analysis to implementation stages and included expert validation, small-group testing, and observation during media use. Summative evaluation was

conducted after large-scale implementation, involving the analysis of post-test results and student response questionnaires. The media was considered effective if at least 80% of students achieved a post-test score of  $\geq 70$ , following the Criterion-Referenced Assessment (CRA) approach as outlined by Hobri (2009). These evaluation results were used to conclude the validity, practicality, and effectiveness of the media, as well as to inform recommendations for future development.

This study was conducted in May 2024 at a junior high school in Pasuruan Regency, Indonesia. The research subjects were selected purposively based on initial diagnostic test results. The data collected consisted of both quantitative data (validation results, post-test scores, and student response questionnaires) and qualitative data (comments, suggestions, and feedback from validators and students). Data collection instruments included validation sheets, questionnaires, and learning achievement tests.

Data were analyzed both quantitatively and qualitatively. Qualitative data were analyzed descriptively, presenting and interpreting open-ended responses and observations. Quantitative data were analyzed using percentage-based descriptive statistics to determine the media's validity, practicality, and effectiveness.

Media validity was assessed by expert evaluators based on two main aspects: media feasibility and content relevance. Each indicator was rated on a 1–5 scale, then averaged to produce scores per indicator, per aspect, and an overall validity score. Final scores were interpreted using Hobri's (2009) validity scale. Practicality was determined based on the average student response scores concerning content comprehension, ease of use, and learning motivation. Effectiveness was measured by the percentage of students scoring  $\geq 70$  out of a maximum of 100 on the post-test. The media was considered effective if at least 80% of students achieved this benchmark, following the CRA approach.

## **RESULTS AND DISCUSSION**

### **Analysis**

At this stage, the researcher conducted a diagnostic test and classroom observation in one of the junior high schools located in Pasuruan Regency. The diagnostic test was administered to all seventh-grade students across four classes. The results showed that three classes achieved an average score of  $\geq 70$ , while one class scored an average of 60 below the CRA. This particular class was selected as the research subject using purposive sampling, due to its higher need for instructional intervention.

Observations revealed that the mathematics learning process remained conventional, dominated by lectures and written assignments, with limited student engagement in interactive activities. Although the school was equipped with facilities such as a computer lab and Chromebooks, the use of digital learning media in mathematics was not yet optimal.

Therefore, the media to be developed aimed to provide a more contextual and interactive learning experience. Unity was chosen as the development platform for its capacity to support interactive 2D spatial visualizations, flexibility in asset usage, and extensive documentation and community support (Blackman, 2011). Furthermore, according to Pratama and Setyaningrum (2018), the integration of digital games in mathematics learning can enhance students' conceptual understanding and motivation by allowing them to visualize abstract mathematical ideas.

## Design

In this stage, the researcher designed an educational game titled *Petualangan Ryna di Desa yang Hilang*. The game focuses on two types of geometric transformations, translation and reflection, in alignment with the learning outcomes of Phase D in the Merdeka Curriculum. This focus was determined based on needs analysis, which revealed that students experienced difficulty understanding these two types of transformations, as identified through diagnostic tests and interviews with the mathematics teacher.

The design included the game's narrative structure, user interface (UI), and the structure of mini-games aligned with specific learning indicators. The learning materials were embedded in game-based challenges allowing students to perform translations and reflections directly within a Cartesian coordinate plane. Key visual components of the interface and game features are illustrated in Figures 2 through 5.



Figure 2. In-Game Story View



Figure 3. Main Gameplay Interface

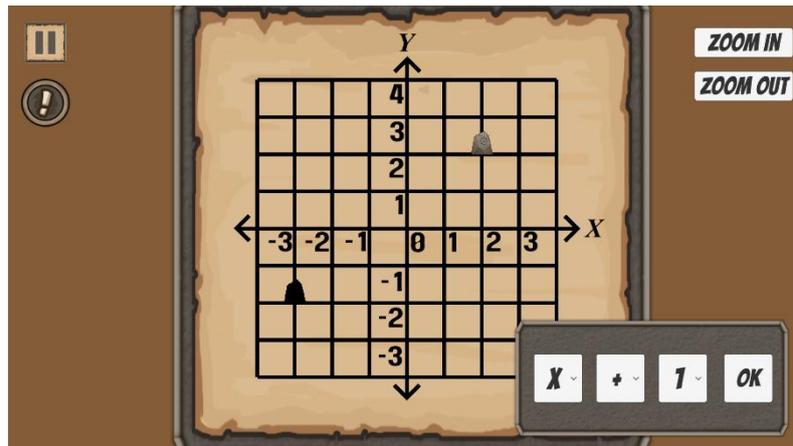


Figure 4. Mini-Game Challenge on Geometric Transformation

The researcher also developed a set of problems integrated into the mini-games, aimed at reinforcing students' understanding of translation and reflection concepts through direct interaction on a coordinate grid. All design elements were structured to form an engaging and interactive learning experience, consistent with the principles of educational game media development.

### Development

In this stage, the media design was realized into a final product, an educational game titled *Petualangan Ryna di Desa yang Hilang*, developed using the Unity platform and C# programming language. The game presents geometric transformations, particularly translation and reflection, in a narrative adventure format interspersed with object manipulation mini-games.

Validation was conducted for two main components: media and learning content, as well as the test instrument for student assessment. The validation results yielded an average score of 3.84 for the media and content (Valid), and 4.00 for the test instrument (Valid) based on Hobri's (2009) criteria. This indicates that both components were feasible and relevant to the intended learning objectives.

Based on validator feedback, minor revisions were made to improve clarity and usability. A small-scale trial was then conducted to evaluate technical performance and user experience. Students reported that the game was engaging and easy to navigate, consistent with findings from Garris, Ahlers, and Driskell (2002), who emphasized that game-based environments can maintain learners' attention through goal-oriented interaction and immediate feedback.

### Implementation

The implementation stage involved full-classroom testing of the game after it was validated and revised. The trial was conducted in a seventh-grade class comprising 30 students as research subjects.

Instruments used during this stage included a post-test aligned with Phase D learning outcomes and a student response questionnaire assessing content understanding, usability, and learning motivation. The post-test results showed that 26 out of 30 students (86.7%) achieved a score of  $\geq 70$ , surpassing the minimum mastery criterion, indicating that the media

met the effectiveness threshold defined by the Criterion-Referenced Assessment (CRA) approach (Hobri, 2009).

Additionally, results from the student response questionnaire showed a total score of 1,328 out of a maximum of 1,500 (30 students  $\times$  10 indicators  $\times$  5-point scale), yielding an average score of 4.43. According to Hobri's (2009) interpretation, this score falls within the "Practical" category. This indicates that the developed educational media was not only effective in improving student understanding but also practical for use in real classroom settings in terms of interface design, interactivity, and usability.

### **Evaluation**

The evaluation phase included both formative and summative assessments. Formative evaluation was conducted through expert reviews and limited trials, leading to improvements in gameplay flow, visual elements, and navigation. Summative evaluation after implementation confirmed that the game met the criteria of being valid, practical, and effective.

The effectiveness of *Petualangan Ryna di Desa yang Hilang* can be attributed to several pedagogical mechanisms inherent in educational games. Firstly, interactive manipulation of geometric objects promotes active learning and visual reasoning (Papastergiou, 2009). Secondly, narrative-driven gameplay supports student motivation and curiosity, which are key factors in maintaining engagement (Habgood & Ainsworth, 2011). Thirdly, the game's structure encourages autonomy and exploration, fostering learning independence (Lee & Hammer, 2011).

While the developed media proved effective, its current scope is limited to translation and reflection. Future work could extend the content to include rotation and dilation to cover the full range of geometric transformations in Phase D. Nonetheless, the findings demonstrate that digital game-based learning can serve as an effective tool for improving both conceptual understanding and learning motivation in mathematics.

*Petualangan Ryna di Desa yang Hilang* offers notable strengths in accessibility, as it can be played online via the itch.io platform in both PC and mobile versions, allowing flexible access across devices. The game is also designed for independent use and features a storyline that supports conceptual understanding. However, the scope of the material remains limited to two types of transformations translation and reflection excluding rotation and dilation, which are also part of Phase D learning outcomes. This limitation provides direction for future development to expand the material coverage and further enhance the educational value of the media.

Overall, *Petualangan Ryna di Desa yang Hilang* is deemed valid, practical, and effective as a learning media for teaching geometric transformations at the junior secondary level.

### **CONCLUSION**

This study aimed to develop an educational game-based learning media titled *Petualangan Ryna di Desa yang Hilang*, designed to improve junior high school students' understanding of geometric transformations, particularly translation and reflection. The development process followed the ADDIE model, which includes: analysis of learning

needs, media and content design, product development and validation, classroom implementation, and evaluation of media effectiveness.

The validation results from expert reviewers indicated that the media was categorized as valid. Practicality testing through student questionnaires showed that the media was considered practical in terms of ease of use, comprehension of content, and learning motivation. Moreover, post-test results revealed that more than 80% of students achieved scores of  $\geq 70$ , indicating that the media met the effectiveness criteria based on the Criterion-Referenced Assessment (CRA) approach. Therefore, *Petualangan Ryna di Desa yang Hilang* is concluded to be a valid, practical, and effective tool for enhancing students' understanding of geometric transformation concepts.

The scope of the material in this media focused on two types of transformations: translation and reflection. This focus was determined based on the needs analysis and technical considerations during development. Future studies are encouraged to expand the media by incorporating additional transformation topics such as rotation and dilation to provide a more comprehensive coverage of the learning outcomes.

The developed learning media is available online and can be accessed via the itch.io platform under the title *Petualangan Ryna di Desa yang Hilang*. It is compatible with both mobile and PC devices, enabling flexible use in various learning environments.

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