

Development of A Snakes and Ladders Educational Game on Complex Numbers For Grade 11 Students

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ABSTRACT

Mathematics is an important field of study in education, which is always present and often applied in everyday problems. However, most people still find mathematics difficult, scary and confusing. This research aims to develop educational games on complex number material that are valid and practical for use in class XI student learning. This research uses the Research and Development (R&D) method with the ADDIE development model which includes analysis, design, development, implementation and evaluation stages. The validity of the game is assessed by material experts and media experts, while practicality is obtained through a student response questionnaire after using the game. The research results showed that material expert validation obtained a percentage of 87% in the very valid category, while media expert validation obtained a percentage of 86% in the very valid category. The results of the student response questionnaire obtained a percentage of 87.4% in the very practical category, which shows that practical games are used in learning. Based on these results, the educational game with complex number material that was developed was declared valid and practical so that it could be used as a learning medium to support the learning process of class XI students.

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1. INTRODUCTION

Education is crucial for shaping individuals who are knowledgeable, cultured, and devout, as well as prepared to compete amidst the challenges of the current era of globalization (Sidik et al., 2024). Through education, a young generation emerges that is intelligent and possesses competencies and skills that can be further developed within society. Furthermore, education plays a vital role in molding high-quality individuals. (Hayani Wulandari & Dhena Agniya Zahra Nisrina, 2020) state that various innovations in the field of education are required to enhance students' competence and creativity.

Mathematics is a significant field of study in education; it is ever-present and frequently applied to everyday problems (Tampubolon et al., 2025). However, many people still perceive mathematics as

difficult, intimidating, and confusing. A prime example is the topic of complex numbers. Complex numbers are often considered challenging by high school students due to their abstract nature and lack of direct connection to concrete, real-life experiences (ARIANSYAH, 2017). This situation aligns with findings by Kurnia Wati et al. (2024), who noted that abstract mathematical objects lead to conceptual difficulties, and by Winoto et al. (2022), who explained that many students find mathematics difficult because of its abstract nature.

Based on the researcher's experience during the Field Experience Program (PPL), the topic of complex numbers remains difficult for students to grasp. This is evident from students' struggles to understand concepts and solve problems, as well as test results showing that the majority of students scored below the Minimum Mastery Criteria (KKM). These circumstances highlight the need for more engaging and interactive learning media to help improve students' understanding of complex numbers.

One innovative tool suitable for learning in this digital age is the educational game. Educational games such as board games serve as learning media that directly involve students in the learning process (Purnamasari et al., 2024). Incorporating educational games into mathematics instruction offers advantages such as creating an interactive and enjoyable learning atmosphere. Through educational games, students can acquire information by engaging in activities such as discussion, decision-making, and problem-solving within the game environment. Furthermore, educational games foster teamwork, concentration, and an understanding of complex number concepts through contextual learning experiences (Iqrom et al., 2026). To address student needs, this study proposes the "Development of a Snakes and Ladders Educational Game on Complex Numbers for Grade XI Students." This Snakes and Ladders educational game will be developed using the GDevelop application. The objective of this research is to develop an educational game on complex numbers for Grade XI that meets the criteria of validity and practicality.

2. METHODS

In this research, researchers used a development model with the ADDIE learning design model to create educational game media snakes and ladders on complex number material. According to (Hidayat Fitria, 2021) the ADDIE development model consists of five stages, namely analysis, design, development, implementation and evaluation. Analysis is the initial stage in the ADDIE development model which aims to identify needs in developing Gdevelop-based snakes and ladders educational game learning media. This first stage was taken from observations during PPL activities, where students' daily test scores were on average below the KKM on complex number material and students' complaints when studying in class and outside of class, as well as conducting direct interviews with mathematics teachers as the first step of the research. In the second stage, namely design, where the researcher designs a design concept in the form of a main program which is prepared to describe the game flow, relationships between scenes, as well as navigation of the interface in the game, and a storyboard which is the design of the main program in the Snakes and Ladders educational game media application.

Table 1. Likert Scale Rating Categories

Scor	Description
5	Very Good
4	Good
3	Good Enough
2	Not Good
1	Very Not Good

Table 2. Percentage Criteria for Media Feasibility Assessment

Achievement Level (%)	Qualification	Description
$80 < p \leq 100$	Highly Valid	Highly suitable, no revision needed
$60 < p \leq 80$	Valid	Suitable, no revision needed

$40 < p \leq 60$	Moderately Valid	Moderately suitable, revision needed
$20 < p \leq 40$	Less Valid	Unsuitable, revision needed
$0 < p \leq 20$	Very Low Validity	Highly unsuitable, revision needed

Table 3. Practicality Assessment Criteria Percentages

Achievement Level (%)	Qualification	Description
$80 < p \leq 100$	Highly practical	Highly practical, no revision needed
$60 < p \leq 80$	Practical	Practical, no revision needed
$40 < p \leq 60$	Reasonably practical	Reasonably practical, revision needed
$20 < p \leq 40$	Not very practical	Not practical, needs revision
$0 < p \leq 20$	Highly impractical	Highly impractical, revision needed

At the development stage, the game is realized based on a previously prepared design. Various multimedia elements, such as images, animation and sound, are then applied to support the creation of interactive and interesting learning. After the game has been developed, the product is validated by material experts and media experts to determine its suitability as a learning medium. Material experts assess the suitability of the material to the curriculum and learning objectives, while media experts assess aspects of the game's appearance, navigation and ease of use. After the product has gone through the validation process and obtained results that show that the product is suitable for use, the next stage is to test it on students. Trial activities were carried out to see the use of games directly in the learning process and to obtain information regarding student responses to the games being developed. At this stage, students use the game via the devices that have been prepared, then provide responses via the questionnaire that has been provided.

Data obtained from the results of expert validation and student trials are then used as evaluation material for the product being developed. Evaluation is carried out to determine the level of suitability and use of games as a learning medium and determine any improvements needed. If deficiencies are still found in the product, revisions are carried out by considering the assessment results and suggestions provided by the validator. Data collection was carried out using instruments in the form of expert validation questionnaires and student trial questionnaires. The instrument was prepared using a Likert scale as shown in Table 1. The data obtained in the form of scores was then processed quantitatively by determining the score obtained and comparing it with the maximum score to obtain a percentage value. This percentage is then used as a basis for determining product assessment criteria using the following formula:

$$P = \frac{\sum R}{N} \times 100\%$$

Where P is the percentage, $\sum R$ is the number of scores obtained, and N is the number of respondents. Qualitative data in the form of suggestions and input from validators is used as consideration in revising the product. Next, the results of quantitative data analysis are interpreted based on the validity assessment criteria presented in Table 2. A product is declared valid if it obtains a valid or very valid category. Meanwhile, data obtained from student responses was analyzed to determine the level of practicality of the product based on the criteria presented in Table 3. A product is declared practical if it is categorized as practical or very practical.

3. FINDINGS AND DISCUSSION

This learning media development research uses research and development (Research & Development) methods by applying the ADDIE model which consists of five main stages, namely analysis, design, development, implementation and evaluation. The following are the results of the development carried out based on the stages in the ADDIE model. The analysis stage was carried out based on the results of observations during PPL activities and interviews with mathematics teachers.

Observation results show that students' daily test scores on complex numbers are still below the KKM and students' learning motivation tends to be low. The teacher also said that this condition still occurs this year. Based on these problems, researchers developed educational games using complex number material as a learning medium which is expected to help overcome students' learning difficulties. The game design is adapted to the characteristics of class XI students and complex number material, with an attractive appearance, simple layout and easy to use navigation. Once the design was complete, the game was developed using GDevelop. The results of game development are presented as follows.

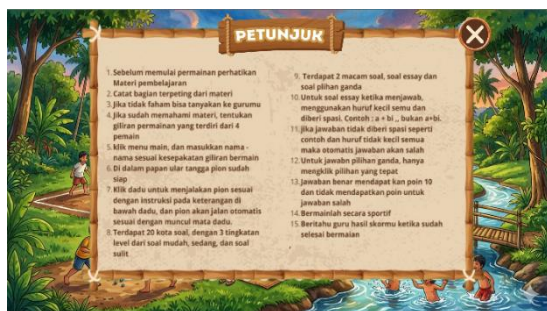


(A)



(B)

Figure 1. Main Menu Page Display



(A)



(B)

Figure 2. View of the Instructions and Materials page.

The main menu page features a "Start" icon button (shown in Figure 1a), alongside other icon buttons for instructions, learning materials, gameplay, and returning to the previous screen. The instructions page (Figure 2A) outlines the rules and gameplay mechanics, while the learning materials page (Figure 2A) presents content on complex numbers to serve as a study resource for students before they play the game.

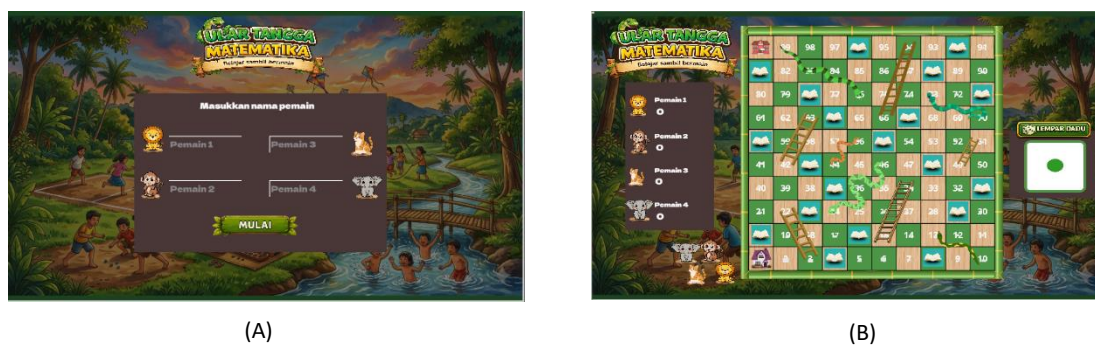


Figure 3. View of the name input page and game board.

In Figure 3(A), players are asked to enter their names and select their game pieces based on a mutual agreement; subsequently, they are directed to the Snakes and Ladders board to begin the game, as shown in Figure 3(B). Certain squares contain a total of 20 questions comprising two formats: essay and multiple-choice. Additionally, the questions are categorized into three difficulty levels easy, medium, and hard as illustrated in Figure 4 below.



Figure 4. Display of the essay and multiple-choice question page.

If the user answers a question correctly, they receive feedback indicating a correct answer; if the answer is incorrect, they receive feedback indicating an incorrect answer, as shown in Figure 5 below.



Figure 5. Display of the Correct and Incorrect Answer Feedback Page

At the development stage, the designed game is then realized in the form of an Android application using GDevelop software. GDevelop software was chosen for development because it is open source and supports interactive multimedia elements. The game's initial product is tested by subject matter experts and media experts to ensure its quality.

a. Material Expert Validation

Material expert validation aims to ensure that the game content is in accordance with the curriculum and learning objectives. The assessment was carried out by two validators, namely a Mathematics Education lecturer and a Mathematics teacher. The assessment results show a validity percentage of 87%, so the game is included in the "Very Valid" category, as presented in Table 4.

Table 4. Content Expert Validation Results

Aspect	Indicator	Content Expert	
		1	2
Alignment of Material with the Curriculum	The material aligns with learning outcomes and objectives.	4	5
	The material covers all aspects of the complex numbers topic.	5	5
	The material is presented effectively.	4	5
	The video content is appropriate for the students' developmental level.	4	5
Alignment of Video Material with Student Needs	The video content is easy to understand.	4	4
	The video content fosters an enjoyable learning experience.	4	4
	The video content helps students understand the material on complex numbers.	4	4
	The learning topic is presented clearly.	5	5
Language	The narrative flow is easy to follow.	4	5
	The language used is simple and easy to	4	5

understand..

Total	40	47
Percentage	87%	

b. Media Expert Validation

Media expert validation was conducted to assess aspects of the game's visual design, navigation, and ease of use. The assessment was performed by a media expert competent in the development of instructional media. The validation yielded a score of 86%, placing the game in the "Highly Valid" category, as shown in Table 5.

Table 5. Media Expert Validation Results

Aspect	Indicator	Media Expert
Design	Background color selection provisions	5
	Animated charm	4
	Image clarity	4
Alignment of Video Content with Student Needs	Terms of use of images	5
	Audio matching with animation	3
	Ease of interacting with the media	5
	Instructions for use are clear	4
	Font type determination	5
Language	The game's storyline matches the material	4
	Level of feedback on student responses	4
Total		43
Percentage		86%

c. Student Trial Questionnaire Results

The practicality of the game was assessed based on student responses after using it during instruction. The questionnaire results yielded a score of 87.4%, falling into the "Highly Practical" category, which indicates that the game is practical for use as an instructional medium. The assessment results are presented in Table 5.

Table 5. Results of student response questionnaires

Student No	Assessment Item Number							Total Score
	A	B	C	D	E	F	G	
1	5	4	5	5	5	4	5	33
2	5	4	5	5	5	4	5	33
3	5	5	4	4	5	5	5	33
4	5	5	4	4	4	4	4	30
5	4	5	4	5	4	4	3	29
6	5	5	3	4	3	3	4	27
7	3	5	4	5	4	5	4	29
8	4	5	3	4	4	5	4	29
9	5	5	4	4	4	5	4	31
10	5	5	4	4	3	5	4	29
11	4	5	4	5	4	5	5	32
12	5	5	5	5	4	5	5	34
13	5	5	4	4	3	5	4	30
14	5	5	5	5	5	5	5	35

15	5	5	5	5	4	5	5	34
16	5	4	3	5	4	4	3	28
17	5	4	3	5	4	4	3	28
18	4	5	3	5	4	5	3	29
19	5	4	3	5	4	4	5	29
20	5	4	3	5	4	4	3	29
21	5	5	2	3	3	4	5	27
22	5	5	5	5	5	5	5	35
Total								673
Percentage								87,4%

Description:

- A. This educational game is easy to use.
- B. The design is engaging.
- C. This educational game helps me better understand complex number concepts.
- D. This educational game aligns with the complex number curriculum material.
- E. I feel more confident solving complex number problems after using this game.
- F. This game provides an enjoyable experience.
- G. This game helps improve my overall mathematical skills.

Based on the trial data analysis presented in Table 5, the maximum total score across all indicators is 770, while the score obtained from the trial was 673. Consequently, the resulting trial score percentage is 87.4%, indicating a high level of practicality. Based on the development work previously conducted, this educational game medium is suitable for use. Observations made during the trial yielded an 80% rating, and students provided positive responses in the completed questionnaires. Thus, it can be concluded that the developed interactive medium has proven to be highly valid and practical for use in the learning process. Based on the development results, conclusions can be drawn regarding the strengths and weaknesses of this educational game medium.

4. CONCLUSION

Based on the research findings detailed in the preceding chapters regarding the development of an educational "Snakes and Ladders" game on complex numbers for Grade XI students, it can be concluded that this learning medium was successfully developed using the ADDIE model, which comprises five stages: Analysis, Design, Development, Implementation, and Evaluation. In the Analysis stage, the researcher drew upon insights from the field teaching experience (PPL), noting that students' average daily test scores on complex numbers fell below the Minimum Mastery Criteria (KKM) and observing student complaints regarding the learning process both inside and outside the classroom. Subsequently, the Design stage involved planning the medium, including outlining the main program flow and creating a storyboard. The Development stage involved implementing the design using the GDevelop application, followed by validation from media and subject matter experts. Validation results indicated a feasibility score of 86% from the media expert (categorized as "highly valid") and 87% from the subject matter expert (also categorized as "highly valid"). In the Implementation stage, the validated medium was tested with Grade XI students at MAN 1 Probolinggo. The trial results showed a positive student response rate of 87.4% and an 83.6% success rate in answering questions, indicating that the educational game possesses a high level of practicality for teaching complex numbers. Based on these results, it is concluded that the developed educational game is suitable for use as a learning medium, as it helps students understand complex number concepts through a learning process that is more engaging, interactive, and enjoyable.

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