Development of Android-Based Algebra Educational Games: Student Responses and Learning Outcomes of Vocational Students

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ABSTRACT
Low learning motivation and mathematics achievement, particularly in basic algebra, remain common challenges in vocational high schools. This study aimed to develop an Android-based algebra educational game with a drag-and-drop mechanism and to identify students' responses and changes in learning outcomes after using the game. The product was developed using Kodular (block-based programming). The game contains 10 basic algebra questions (e.g., operations on like terms) with a scoring system of 10 points for correct answers and 0 points for incorrect answers, accompanied by immediate feedback (notifications and text-to-speech). Prior to the trial, the product was validated by a content expert and a media expert using a 1-4 validation sheet to ensure the appropriateness of content, interface, and functionality; the test and questionnaire instruments were also reviewed for content validity through expert judgment. A limited trial was conducted with five Grade X students at SMKN 2 Situbondo using a one-group pretest–posttest design. The results show that the average score increased from 70 (pretest) to 76 (posttest), although gains varied across students. Student responses tended to be positive, especially regarding learning interest, drag-and-drop interaction, and confidence in solving algebra problems. These findings indicate that the Android-based educational game has the potential to serve as an engaging algebra practice medium to support classroom learning; however, further testing with a larger number of participants is needed to strengthen the generalizability of the results.

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Development of Android-Based Algebra Educational Games: Student Responses and Learning Outcomes of Vocational Students

1. Introduction

Mathematics and numeracy literacy remain a persistent challenge in Indonesian education. Reviews of PISA-based studies report that Indonesian students' mathematical literacy is still far below the OECD average, indicating the urgency of more effective learning innovations (Anis Munfarikhatin et al., 2022). One of the materials that is often an obstacle is basic algebra because it requires an understanding of symbols, algebraic form operations, and precision in simplifying expressions. Research shows that students still have difficulty in understanding algebraic concepts and simplifying algebraic forms in basic operations, which has the potential to have an impact on low interest and learning performance if not handled with adequate practice (Purwanti & Pujiastuti, 2020).

Learning mathematics is often considered challenging, especially on abstract concepts. Therefore, media or approaches are needed that can make students more involved, not bored quickly, and motivated in learning. Interactive educational game media is reported to support motivation and learning outcomes because it combines challenges, feedback, and fun learning experiences (Nurhikmah et al., 2024). The game-based learning approach in mathematics has been extensively developed to build student engagement. The use of educational games designed as a training medium can help students practice concepts and procedures through repetitive activities that are more interesting than conventional exercises (Syaikhu et al., 2022).

The development of mathematics educational games has also been carried out at various levels and is generally evaluated from the aspect of product feasibility. The results of development research show that educational games can meet the eligibility criteria and support learning outcomes when integrated with learning objectives and student characteristics (Muhtarom et al., 2022). In terms of application development, no-code or block-based approaches such as Kodular allow for more practical Android application creation. The platform supports the creation of interactive features and makes it easier for beginner developers to build application-based learning media (Furima et al., 2022).

Several studies in Indonesia have reported that Android-based mathematics games and learning applications can increase students' engagement and support learning outcomes when the activities provide clear challenges, feedback, and practice opportunities (Karseno et al., 2021). In addition, no-code platforms such as Kodular are increasingly used to develop Android learning media efficiently, including e-modules and interactive mathematics materials (Arnaz et al., 2022). Based on this description, this study focuses on the development of an Android-based basic algebra educational game for grade X students of SMKN 2 Situbondo using Kodular. The game is designed with a drag-and-drop mechanism (students drag the answer selection into the answer box), containing 10 questions with a score of 10 for correct answers and 0 for incorrect answers. This study aims to describe students' responses after using games and analyze learning outcomes through comparison of pretest and posttest scores.

Digital quiz-and game-based platforms are also frequently reported to support mathematics learning because they provide immediate feedback, points, and short practice cycles that keep students engaged (Permana & Kasriman, 2022).

2. Method

Type of Research/Design

This research is a research and development (R&D) that produces a product in the form of an Android-based basic algebra educational game. The development flow follows the ADDIE stages, namely needs analysis, design, development, implementation, and evaluation (Fitriyah et al., 2021). Before implementation, the prototype was reviewed through expert validation

(material expert and media expert) and revised based on suggestions to ensure content suitability and usability. After the product is completed and revised, an initial trial is carried out using a one-group pretest-posttest pre-experiment design to see changes in learning outcomes before and after using the game. With a limited number of subjects (n = 5), the one-group pretest-posttest design was used as an initial evaluation to capture changes in learning scores after students used the game. Similar development studies in Indonesia also apply the ADDIE framework to produce Android-based mathematics media and evaluate feasibility in limited trials, especially for algebra-related content (Taufiqurrahman et al., 2023). Android educational game products have also been reported to support practice-based learning through short question sets and immediate feedback, which is aligned with the design of this study (Karseno et al., 2021).

Subjects/Population and Sample

The research was carried out at SMKN 2 Situbondo. The subjects of the initial trial (pilot) were 5 students of class X. All students participated in a series of activities: pretest, use of games (10 questions), posttest, and filling out a response questionnaire.

Instrument

The research instruments consist of: (1) Android educational game products developed (as media/treatment), (2) learning outcome tests (pretest and posttest), (3) student response questionnaires, (4) functional test sheets (black-box testing), (5) documentation (screenshots), and (6) expert validation sheets for the product and research instruments.

1. Basic algebraic educational game based on Android (Kodular)

The game contains 10 basic algebra questions, each with four answer choices. The interaction mechanism uses drag-and-drop, where students drag the answer selection to the answer box. The system provides true/false feedback through Notifier and Text-to-Speech, then loads the next question. When all the questions are complete, the system displays a message that the question is out of print and calls the reset process. The game is developed using Kodular (block-based programming) which provides a block-based (visual) programming environment so that the creation of the interface and application logic can be done by compiling drag-and-drop blocks; this approach reportedly facilitates the development of Android learning media for beginner developers (Salsabila et al., 2023).

2. Learning outcome tests (pretest and posttest)

The pretest and posttest each consist of 10 basic algebra questions that are equivalent in difficulty. Score per item: 10 for correct answers and 0 for incorrect answers, so the maximum value is 100.

3. Student Response Questionnaire

The questionnaire contains 8 statements about learning interest, ease of use, drag-and-drop display and interaction, focus on learning through points, material suitability, understanding of similar tribes, benefits for practice, and quality of feedback. The scale uses a 4-level Likert (1-4).

4. Functional test sheets (black-box testing)

Functional test sheets are used to ensure core features run as designed (drag-and-drop, question move, question out condition, reset button, and grade calculation). Testing is carried out with a black box approach, which is to check the output of each function based on the test scenario without reviewing the program code structure (Febriyanti et al., 2021).

5. Documentation

Documentation in the form of screenshots of game displays and Kodular program blocks is used to support feature descriptions and program logic.

Expert Validation Sheet (Product and Instruments)

Expert validation sheets were used to assess the feasibility and content suitability of the

developed game before the limited trial. Two validators (a mathematics content expert and a learning media expert) reviewed the product and provided suggestions for revision. The validation used a 4-point rating scale (1-4) covering aspects of content accuracy, clarity of instructions, interface design, and functionality. The pretest-posttest items and student response questionnaire were also reviewed through expert judgment to ensure content validity and readability (Puspitasari & Febrinita, 2021).

Table 1. Research instruments summary

Instrument	Description / measured aspect
Pretest (10 items)	Measure basic algebraic initial ability before using the game; score 0-100.
Educational game (10 items)	Learning media: drag-and-drop answers, direct feedback, and Automatic scoring (true × 10).
Posttest (10 items)	Measure basic algebraic skills after using the game; Score 0-100.
Student response questionnaire (8 statements)	Student responses to interest, convenience, benefits, and feedback (Likert 1-4).
Black-box testing checklist	Examination of application functionality based on test scenarios and resulting outputs.
Documentation (screenshots)	Proof of game display and Kodular program blocks that support feature descriptions.
Expert validation sheet	Feasibility and content validity assessment by material and media experts (Likert 1-4), including revision suggestions.

Table 1 summarizes the instruments used to develop and evaluate the product, including learning outcome tests, student response questionnaires, functional testing, documentation, and expert validation sheets used to check feasibility before the limited trial.

Procedure/Data Collection

The stages of the research implementation are as follows:

1. Analysis stage: identify the basic algebraic material needs and characteristics of class X students.
2. Design stage: designing the game flow, question display, answer options, answer box, feedback, and scoring scheme.
3. Development stage: implement the design on Kodular, including the logic of moving questions, the condition of the problem being finished, the reset button, and the calculation of values (value = the correct number × 10).
4. Expert validation stage: conduct expert judgment (material expert and media expert) using validation sheets to evaluate content suitability, interface design, and core functionality; revise the product and instruments according to expert suggestions before the limited trial.
5. Functional test stage: conduct black-box testing on core features until the application runs stable. In this study, functional testing focused on input-output behavior of each feature; equivalence partitioning can be used to group valid and invalid input conditions to ensure more systematic coverage (Muslimin et al., 2020).
6. Implementation stage: carrying out pretest, using games (10 questions), and posttest on 5 students.
7. Evaluation stage: processing the results of the pre-test and analyzing the student response questionnaire.

Data Analysis

The analysis was conducted descriptively because the number of trial subjects was limited (n = 5). The data on learning outcomes were analyzed through individual scores, pretest averages, posttest averages, and score differences (Δ = posttest − pretest). The response questionnaire data was analyzed by calculating the frequency and percentage in each category

on a scale of 1-4, then interpreted to describe the students' response to the game. Expert validation data were analyzed by calculating the mean rating for each assessed aspect to determine product feasibility before implementation.

Product Documentation (Screenshots)

The following screenshot documents the appearance of the game and the main program blocks on Kodular (question moves, question outgoing conditions, reset, and score calculation).

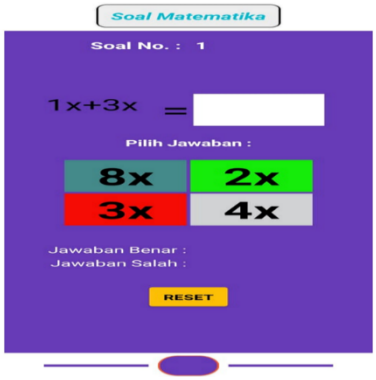

Figure 1. Display algebra questions and answer boxes (drag-and-drop)

Figure 2. Final score display after completing 10 questions

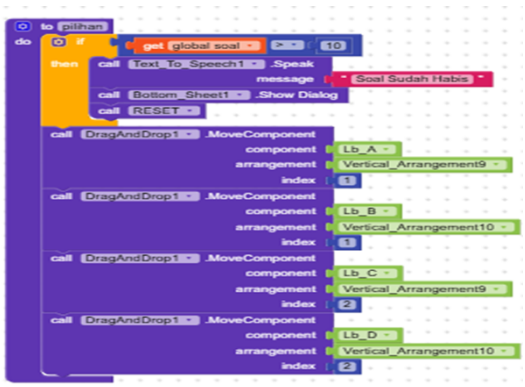

Figure 3. Block Kodular Procedure Choice: moves the answer option, as well as the condition of the question is out (displaying messages and calling a reset)

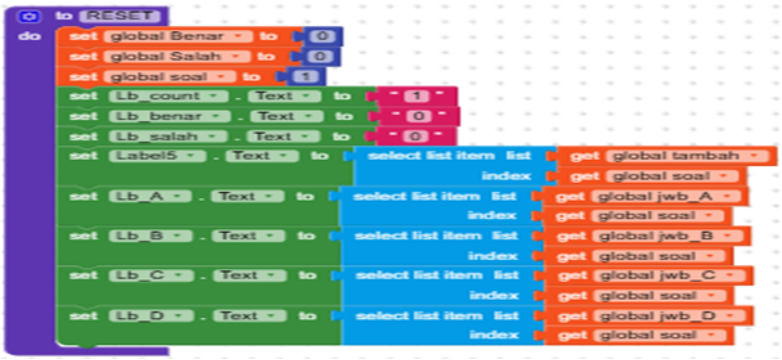

Figure 4. Reset button Kodular block: returns variables and reloads question/answer data

Figure 5. Kodular block calculation of final value (correct number × 10)

3. Research Findings

The limited trial was carried out on 5 students of class X at SMKN 2 Situbondo. Students do the pretest and posttest (score 0-100). After using the Android-based algebra education game, students also filled out a response questionnaire (scale 1-4) of 8 statements.

Product Validation (Expert Review)

Before the limited trial, the developed game and research instruments were reviewed through expert validation. A mathematics content expert assessed the suitability and accuracy of the basic algebra material, while a learning media expert evaluated interface design, clarity of instructions, and functional usability. The experts concluded that the product was feasible for a limited trial with minor revisions (e.g., improving wording and navigation clarity), and the prototype was revised accordingly.

Learning Outcomes (Pretest-Posttest)

Table 2 presents the pretest and posttest scores of each student. Reporting individual scores and descriptive summaries helps make before-after changes visible in a limited trial setting (Dwiana, 2025).

Table 2. Pretest and posttest scores of students (n = 5)

Student	Pretest	Posttest	Gain
Reni Wiyana	70	80	10
Aminatul Hilmia	50	70	20
Ayu Dwi L	80	90	10
Diana Fitri Widiarini	80	60	-20
Rozi Khoirun N	70	80	10

As shown in Table 2, four out of five students experienced score gains after using the game, while one student showed a decrease (negative gain).

Table 3. Descriptive statistics of pretest and posttest scores

Test	N	Min	Max	Mean	Std. Dev.
Pretest	5	50	80	70.00	12.25

Test	N	Min	Max	Mean	Std. Dev.
Posttest	5	60	90	76.00	11.40

Based on Table 3, the average score increased from 70.00 (pretest) to 76.00 (posttest) (average gain = 6.00 points). However, there was one student whose score decreased (negative gain), so this finding is positioned as a result of a limited trial (small N) and reported descriptively.

Student Responses (Questionnaire)

Student responses were analyzed in the form of percentages of each choice scale (1-4) and average scores per item to show response tendencies. The positive response percentage approach (e.g. agree/strongly agree category) is often used in the evaluation of Android learning media in Indonesia (Lestary et al., 2023).

Table 4. Student response questionnaire results (n = 5)

Item	Statement (concise)	Score 1	Score 2	Score 3	Score 4	Mean	Dominan
1	This game made me more interested in learning basic algebra.	0	0	5	0	3.00	Skor 3
2	The display and drag-and-drop interaction make me not get bored quickly.	0	0	5	0	3.00	Skor 3
3	The points system makes me more focused when working on the problem.	0	1	4	0	2.80	Skor 3
4	The in-game questions correspond to the basic algebra material I learned.	0	1	4	0	2.80	Skor 3
5	This game helped me understand the concept of a tribe of its kind (e.g. 4x-1x...	0	1	3	1	3.00	Skor 3
6	This game is useful for practice before exams.	0	0	4	1	3.20	Skor 3
7	I feel more confident working on algebra problems after I have	0	0	5	0	3.00	Skor 3

Item	Statement (concise)	Score 1	Score 2	Score 3	Score 4	Mean	Dominan
8	learned... True or incorrect feedback helps me correct errors.	0	2	3	0	2.60	Skor 3

Based on Table 4, if averaged across 8 items, the student response score was 2.93 out of 4 (≈ 73.1%). Almost all of the answers were on a score of 3-4, indicating a tendency for positive responses to the game.

Documentation of Questionnaire Diagrams

To keep the manuscript concise, only two diagrams are shown as representative examples: items with full agreement and items with variation of answers. The full diagram is available on the research questionnaire data.

Figure 6. Student response diagram for item 1: This game made me more interested in learning basic algebra

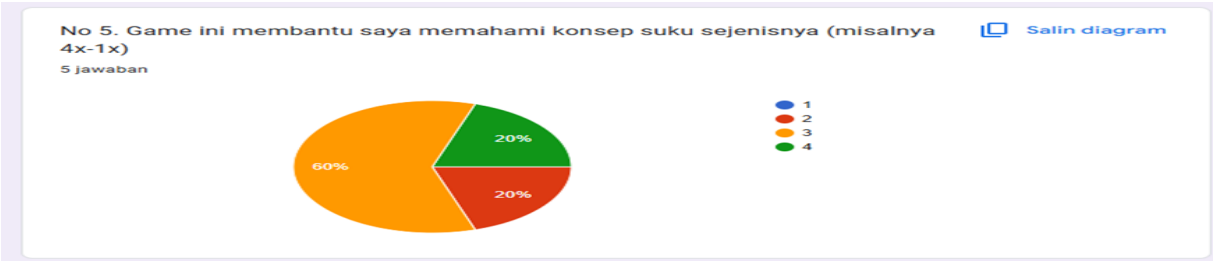

Figure 7. Student response diagram for item 5: This game helped me understand the concept of a similar tribe (e.g. 4x-1x)

4. Discussion

Interpretation of Learning Outcomes

The results of the study showed a tendency to increase learning outcomes from pre-test to post-test even though the test subjects were only 5 students. Descriptively, most students experienced an increase in grades after using the game, so it can be interpreted that Android-based algebraic educational games have the potential to help reinforce the material through short, repetitive exercises. Findings like these are in line with research and reviews on interactive educational games and mobile learning that emphasize structured practice and immediate feedback as important features to support learning outcomes (Nurhikmah et al., 2024; Muhtarom et al., 2022). In addition, quiz-game-based mathematics learning is also often associated with improved learning outcomes because it encourages students to respond more actively to questions (Mulyati & Evendi, 2020).

However, the existence of students whose scores decreased on the post-test needs to be

discussed as an important note. In classroom practice, test achievement is not only influenced by the media, but also influenced by initial readiness, focus during the test, and situational factors (e.g. physical/emotional condition or lack of thoroughness). Therefore, the results of these trials are more appropriately positioned as an initial indication (pilot) that the product has the potential to help learn, rather than final evidence for the wider population. In media development research, limited trials are usually carried out before large-scale implementation, then refined through repeated evaluation (Damarjati & Miatun, 2021).

Student Responses Toward Game Features

Students' positive responses can be explained from the game design side: (1) drag-and-drop answers to the answer box make the answering activity feel active, (2) scoring (10 points true, 0 false) acts as reinforcement, and (3) direct feedback through true/false notifications helps students find out mistakes quickly. This design aligns with gamification-based learning that emphasizes challenges, points, and immediate feedback to support student engagement and learning outcomes (Mulyati & Evendi, 2020; Permata & Kristanto, 2020).

Positive student responses (e.g. games help understand concepts and feedback helps correct mistakes) are also consistent with studies reporting that Android-assisted educational games can facilitate mathematical thinking exercises through repetitive activities and structured problem presentation. In the context of SMK class X in basic algebra material, a short but intensive practice model like this is relevant for strengthening concepts before exams. Even so, games are still most appropriately used as a companion media, so that teachers continue to reinforce concepts and discuss mistakes after students play.

Novelty and Practical Implications

The novelty of this research lies in (a) the focus of basic algebraic material for class X of SMK, (b) the implementation of drag-and-drop interaction (not just click options), and (c) the development of using Kodular which is relatively easy to replicate by novice teachers/researchers. Practically, this game can be used by teachers as a self-paced exercise before exams, reinforcement of material at the end of lessons, and quick discussion materials to discuss common mistakes (e.g. simplifying algebraic forms).

Limitations and Future Work

The main limitation of this study is that the number of samples is very small (5 students) and it is only conducted in one school, so the generalization of the findings is still limited. The next development recommendations: (1) expand the number of participants and add a comparison group (control); (2) increase the variation of levels/categories of basic algebra questions; and (3) keep a track record of answers to analyze student error patterns so that learning follow-up is more appropriate. This broader trial step and repeated evaluation is in accordance with media development research practices that emphasize refinement before large-scale implementation (Safitri et al., 2020).

5. Conclusion

This research resulted in an Android-based algebra education game developed using Kodular with a drag-and-drop mechanism to help grade X students of SMK work on basic algebra problems. The game contains 10 questions with a scoring system of 10 points for correct answers and 0 for incorrect answers, and provides live feedback. Based on a limited trial of 5 students of SMK Negeri 2 Situbondo, the results of the pre-test and post-test showed a tendency to increase scores in most students after using the game. In addition, the students' responses showed that games were considered to help practice and understanding concepts and make problem-solving activities feel more interesting.

The contribution of this research is to provide a practical and easy-to-use alternative to basic algebra practice media through gadgets, while displaying a form of drag-and-drop interaction that encourages active engagement when choosing answers. This product can be

used by teachers as a companion medium for independent practice before exams or as reinforcement of material at the end of learning.

The limitation of this study lies in the fact that the number of subjects is still very small and the implementation of the trial is only in one school, so the generalization of the findings is still limited. In addition, the research design did not involve a control group and the number of questions was still limited to 10 items, so the variation in the difficulty level and scope of algebraic material indicators had not been fully tested.

Subsequent research suggests involving a larger number of participants, using a quasi-experimental design with a control group, and expanding the question bank to several difficulty levels. Feature development can also be improved through the addition of a brief explanation when an answer is incorrect and the recording of an answer track record (log) to map student error patterns, so that the game not only serves as an exercise, but also as a source of diagnostic information for teachers.

6. Acknowledgments

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7. Conflict Of Interest

The authors declare no conflict of interest.

8. Author Contributions

A.S. conceptualized the study, developed the Android-based algebra educational game using Kodular, conducted the limited trial, collected the data, performed data analysis, and drafted the manuscript. F.J. contributed to methodology development, expert validation and revision suggestions, and supervision, as well as manuscript review and editing. R.S.R. contributed to software testing, data curation, visualization, and manuscript review and editing. All authors approved the final version of the manuscript.

9. Data Availability Statement

The data supporting the findings of this study are available from the corresponding author, A.S., upon reasonable request.

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