Kognitif
Jurnal Riset HOTS Pendidikan Matematika
Volume - 6 No - 1 2026 Page 158 – 170
ISSN 2776-9704 P-ISSN 2776-9984
https://doi.org/10.51574/kognitif.v6i1.3281

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How to cite: Farhani , V. C., Santika, S., & Mulyani, E. (2026). Development of Android-Based Interactive Learning Media to Facilitate the Flipped Classroom Learning Model. *Kognitif: Jurnal Riset HOTS Pendidikan Matematika*, *6*(1), 158–170. https://doi.org/10.51574/kognitif.v6i1.3281

To link to this artcle: https://doi.org/10.51574/kognitif.v6i1.3281

Kognitif: Jurnal Riset HOTS Pendidikan Matematika
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Development of Android-Based Interactive Learning Media to Facilitate the Flipped Classroom Learning Model

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Article Info

Article history:

Received Nov 03, 2025
Accepted Jan 24, 2026
Published Online Feb 08, 2026

Keywords:

Development
Interactive Learning Media
Android
Flipped Classroom

ABSTRACT

The urgency of developing learning media in the flipped classroom lies in the need for digital tools that can facilitate pre-class independent learning, as existing media are generally linear and lack interactivity. This study aims to develop interactive Android-based learning media called Math Venture Algebra to support ninth-grade junior high school algebra learning through the flipped classroom model. The development was carried out using an R&D approach based on the ADDIE model (Analysis, Design, Development, Implementation, Evaluation), which is relevant because it provides a systematic process for designing interactive Android-based media. Data was collected through semi-structured interviews and questionnaires validated by two subject matter experts and two media experts, and tested on 30th grade students at Tasikmalaya State Junior High School 5. The instrument uses a Likert scale that has been tested for validity and reliability, while the data is analyzed descriptively. Math Venture Algebra media is designed with key features such as instructional videos, interactive exercises, quizzes, and adaptive navigation that support the pre-class flipped classroom phase, so that students can learn independently before face-to-face discussions. The results of the study show that this media is in the "highly feasible" category according to expert assessment, as well as "very practical" according to students with a practicality level of 87%. These findings confirm that Android-based interactive media integrated with the flipped classroom contributes to increased independence, engagement, and quality of mathematics learning, while enriching 21st-century technology-based educational practices.

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Introduction

The implementation of the flipped classroom model in developing countries, particularly Indonesia, faces significant challenges that have been identified in various recent international studies. Recent research identifies difficulties with time management and self-regulation, uneven access to technology and unstable internet, reluctance to actively participate in class, difficulties with independent content comprehension, and challenges in adapting to the demands of the flipped model (Pilu et al., 2025). Although flipped learning has received substantial attention as a potential means to increase student engagement and improve learning outcomes, several challenges and areas of concern still persist (Baig & Yadegaridehkordi, 2023). This problem is increasingly complex in mathematics, particularly algebra, which requires in-depth conceptual understanding and continuous practice that is not yet supported by appropriate learning media.

According to previous research, the Fourth Industrial Revolution has witnessed rapid developments in digital learning resources. Learning becomes more innovative, engaging, and efficient when technology is used (Heliawati, Lidiawati, & Pursitasari, 2022; Munawir, Rofiqoh, & Khairani, 2024). The development of higher-order thinking skills (HOTS) has become a key focus in 21st-century mathematics learning, where interactive learning media plays a crucial role in enhancing students' critical thinking skills (Yusuf & Ma'rufi, 2022). Many technology-based learning tools have been developed for mathematics education, such as web-based resources (Aditya, 2018), Android applications that make mathematics more engaging (Sarifah et al., 2022; Fitriya & Faizah, 2021), and tools that use Articulate Storyline 3 to enhance algebraic thinking (Azrillia et al., 2024). According to recent studies, the Articulate Storyline 3 tool is effective in improving mathematical problem-solving skills and facilitating geometry learning (Azrillia et al., 2024; Santika et al., 2025). The development of interactive learning media designed with a discovery learning approach has also proven effective in improving students' critical thinking skills (Habsyi, Saleh, & Nur, 2022). However, most of these resources are designed for conventional education and are not compatible with the flipped classroom model, which combines active classroom instruction with home learning.

The flipped classroom model is theoretically based on the principle of inverted learning, where students independently study basic material at home using digital media, then use face-to-face time for discussion, problem-solving, and concept reinforcement (Riska et al., 2024). This model allows for the optimization of classroom learning time for higher-level activities that require direct guidance from educators. However, the effectiveness of this model is highly dependent on the quality of the assessment or learning tools used for the independent learning phase. These media must be able to present material clearly, provide adequate interaction, and provide constructive feedback to facilitate conceptual understanding before face-to-face learning. The main gap identified is the lack of interactive Android-based learning media aimed at facilitating the flipped classroom model for junior high school algebra. Existing learning media are generally linear and do not provide adequate interactive features for independent learning. On the other hand, platforms like Articulate Storyline 3 have proven capable of combining text, images, videos, animations, and interactive questions in a single platform that can be exported to Android formats (Nurhayati, Dewi, Mulyani, & Nurjamil, 2024; Sapitri & Bentri, 2020). This potential has not been optimally utilized to develop learning media that explicitly support the implementation of flipped classrooms.

Based on observations at SMP Negeri 5 in Tasikmalaya City, algebra lessons are largely taught through traditional learning methods such as textbooks and whiteboards. Although some students have access to Android-based smartphones, these devices have not been optimally utilized for learning. Media such as YouTube, Quizizz, or PowerPoint, which are occasionally

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used, are not yet able to facilitate structured, independent learning integrated with face-to-face learning within a flipped classroom framework. This situation complicates and makes it difficult for students to grasp basic algebraic concepts and transform word problems into communicable mathematical forms.

The development of an interactive learning tool for Android intended to support the flipped classroom method in teaching algebra topics is the main advantage of this research. The expanded media uses Articulate Storyline 3 with an interactive multimedia approach that combines various learning elements in a single platform accessible through Android devices. Unlike existing learning media, this media is designed by considering the learning phases in the flipped classroom, starting from independent material delivery, interactive exercises, to preparation for class discussions. Based on the gap analysis, this study attempts to develop interactive learning materials based on Android called Math Venture Algebra to facilitate the implementation of the flipped classroom learning model on algebra material for grade IX of junior high school. This media was developed using the ADDIE model and validated through assessments by material experts and media experts, and its practicality was tested through student responses at SMP Negeri 5 Tasikmalaya City. Indicators of media success are determined by how well they meet certain standards. These standards include content quality, the objectives to be achieved by the media, and its technical features. In addition, these standards consider how well the media is useful for learning, how easy it is to use in various teaching situations, and how effective the media is in maintaining student interest and motivation.

Method

Types and Subjects

This study applies the Research and Development (R&D) method with the ADDIE model, which has been proven as a systematic and flexible framework for effective instructional design. The ADDIE model was chosen because of its ability to accommodate diverse learning needs in online and blended educational environments, and has proven reliable and valid as a pedagogical approach in technology-based learning contexts (Niswati et al., 2020; Sarifah et al., 2022). To ensure design validity, this study implemented a systematic development protocol with comprehensive documentation of each stage, an iterative review and revision process, and a clear alignment between research objectives, media design, and evaluation instruments. In addition to development, this method also includes an evaluation and validation process by experts and users to ensure the product is feasible and effective for use in educational environments.(Sugiyono, 2022).

Analysis Stage includes needs assessment through semi-structured interviews and learning observations, with systematic front-end analysis criteria: (1) Audience Analysis to identify the characteristics of grade IX students; (2) Technology Analysis to evaluate access and compatibility of Android devices; (3) Media Analysis to identify gaps in flipped classroom learning media; (4) Extant-data Analysis to analyze learning outcomes and difficulties in algebra learning.

Design Stage produce a navigation structure that supports independent and collaborative learning, a user interaction flowchart, a storyboard that integrates multimedia elements according to the characteristics of a flipped classroom, and a content blueprint that accommodates the pre-class and in-class learning phases.

Development Stage Using Articulate Storyline 3 with an iterative approach, the project produced media with interactive features such as drag & drop, multiple choice, simulation, and adaptive navigation. Expert validation was conducted in two rounds with a systematic revision protocol based on validator input. Implementation Stage was conducted in two phases: small group evaluation with 10 students and field test with 30 students, accompanied by process documentation and collection of user response data. Evaluation Stage using the Kirkpatrick Level 1 (reaction) model to measure the practicality of media from the end user perspective. The trial location was SMP Negeri 5 Tasikmalaya, which was held on April 13-15, 2025. This study involved 40 ninth-grade students selected using purposive sampling based on the criteria of having access to Android devices and having studied the prerequisite algebra material. The research object was an Android-based interactive learning media to facilitate the flipped classroom learning model on Algebra material.

Research Instruments

Research instruments serve as the primary means for researchers to collect data. These instruments can take the form of tests, interview guides, observation sheets, or questionnaires designed to meet the research needs.(Sugiyono, 2022). This study utilized a questionnaire as a data collection instrument to assess the feasibility of Android-based interactive learning media created using Articulate Storyline 3 on algebra material to facilitate the flipped classroom learning model. Content validity was tested using the Content Validity Ratio (CVR) involving a panel of 5 experts in mathematics education and learning technology. The instrument was declared valid if the CVR ≥ 0.62 (Lawshe, 1975). Internal reliability was tested using the Cronbach's Alpha coefficient with the criteria of $\alpha \geq 0.70$ for acceptable consistency (Tavakol & Dennick, 2011). The results of the reliability test showed a value of $\alpha = 0.89$ for the expert validation instrument and $\alpha = 0.92$ for the student response questionnaire, which indicated high reliability (Tavakol & Dennick, 2011).

Material Expert Validation Sheet consists of 15 indicators that measure six aspects of content quality and learning objectives: accuracy (conceptual and exemplary accuracy), importance (relevance to learning objectives), completeness (adequate coverage of material), balance (proportion between components), interest/attention (ability to attract interest), and suitability to student conditions (appropriate level of difficulty). Each indicator uses a 5-point Likert scale with clear descriptors to ensure objectivity of assessment. Media Expert Validation Sheet measuring 6 technical aspects through 7 indicators: readability (text clarity and navigation), ease of use (intuitive user interface), display quality (visual and audio design), response management quality (system feedback), program management quality (application stability), and documentation (completeness of user instructions). Student Response Questionnaire contains 15 questions that measure 6 aspects of practicality: learning assistance (media effectiveness in facilitating understanding), instructional flexibility (ease of access and independent use), learning motivation (increased interest and engagement), ease of navigation (user experience), suitability to learning styles (adaptability), and effectiveness of interactive features (system responsiveness).

Procedure

The research and development procedures applied follow the stages of ADDIE model development research. First, the analysis stage is carried out with a needs assessment, which examines gaps related to current mathematics learning, media use, models, learning techniques, and student reactions during the learning process, especially on algebra material. After finding the gaps, a further analysis (Front-end analysis) is carried out which includes Audience

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Analysis, Technology Analysis, Media Analysis, and Extant-data Analysis. Second, the design stage is carried out by creating a navigation structure, flowchart, storyboard, and compiling a draft of algebra material that will be included in the media. Third, the development stage, at this stage, the storyboard that has been created is realized and product validation is carried out by 2 media experts and 2 material experts. Fourth, the implementation stage, namely by conducting product trials twice, consisting of a group trial of 10 people and a field trial of 30 students. Finally, the evaluation stage, the evaluation carried out is level one, with the aim of finding out the response of students as users of the interactive learning media that has been produced.

Analysis

The data obtained consisted of two types: qualitative and quantitative. Qualitative data, which is non-numerical, encompasses the media development process, input, and criticism from validators and teachers. Meanwhile, quantitative data, which is numerical, was obtained through assessments of the learning media by media experts, subject matter experts, and students regarding their use. The final percentage was calculated using the following formula (Mairani, Enawaty, Putra Sartika, Muharini, & Rasmawan, 2022).

$$NP = \frac{\sum x}{\sum x_i} \times 100\%$$

Information:
NP : Percentage Value
$\sum x$: The number of values from the validator
$\sum x_i$: maximum value

In this study, the calculation of the instrument assessment in the media and material validation sheet is divided into five categories of suitability according to Mairani et al., (2022) based on the criteria presented in Table 1

Table 1. Eligibility Criteria

Percentage Score Interval	Criteria
81%–100%	Very feasible
61%–80%	Feasible
41%–60%	Fairly feasible
21%–40%	Not feasible
0%–20%	Highly not feasible

Meanwhile, the calculation of the instrument item responses in the student response questionnaire is grouped into five practicality categories based on the criteria presented in Table 2

Table 2. Practicality Criteria

Percentage Score Interval	Criteria
81%–100%	Very practical
61%–80%	Practical
41%–60%	Moderately practical
21%–40%	Not practical
0%–20%	Highly impractical

This study used a questionnaire as an instrument delivered to media experts and material experts, as well as students as the main respondents. Assessment of material feasibility was

obtained through a questionnaire completed by the material experts, consisting of 15 statements covering 6 aspects related to content quality and objectives. Meanwhile, a questionnaire to consider the feasibility of learning media was given to media experts, which included 7 statements based on 6 aspects related to appearance and technical aspects. To obtain student responses to the learning media, a response questionnaire containing 15 questions was used as well as a column for criticism and suggestions, which were arranged based on 6 aspects of student responses.

Research Results

Research on the development of Android-based interactive learning media to facilitate the flipped classroom learning model has produced the following results.

Analysis Stage

This stage was conducted through an interview with a ninth-grade mathematics teacher at SMP Negeri 5 Tasikmalaya. The purpose of this interview was to obtain an overview of the learning conditions, student responses, and the media commonly used in the learning process. The interview results showed that mathematics learning at SMP Negeri 5 uses a block system, which differs in its implementation compared to other schools. Furthermore, educators often use traditional media when teaching, meaning technology is not used significantly in the learning process. As a result, many students still have difficulty understanding the material and appear uninterested in learning. Currently, algebra instruction at the school has implemented a flipped classroom model, where educators present material in the form of instructional videos for students to study at home, while class time is devoted to discussions. However, in practice, many students find the instructional videos boring because the presentation is less engaging and interactive.

The target users of this learning media are ninth-grade students of SMP Negeri 5 Tasikmalaya. Based on the interview results, ninth-grade students at SMP Negeri 5 Tasikmalaya have difficulty understanding the basic concepts of algebraic forms. The technology used by students or users is an Android-based smartphone device with a minimum version of 5.0 (Lollipop) or higher. The smartphone must have the following specifications: a minimum CPU of 1.2 GHz, a minimum RAM of 2 GB, and a minimum available storage space of 100 MB. Researchers recommend that users use an Android device with specifications higher than the minimum requirements mentioned, to ensure optimal performance when installing and operating interactive learning media products. Using a device with higher specifications will reduce the possibility of problems, such as lack of storage space, or performance disruptions due to other applications running simultaneously on the Android device.

Design Stage

At this stage, the method design remains a concept that will serve as the foundation for the development process in subsequent stages. Media design begins at the design stage, which includes the collection and organization of teaching materials, including questions and their discussions. Furthermore, at this stage, a navigation structure is created to illustrate the interrelationships between pages within the developed media. The navigation structure of interactive learning media is presented as follows:

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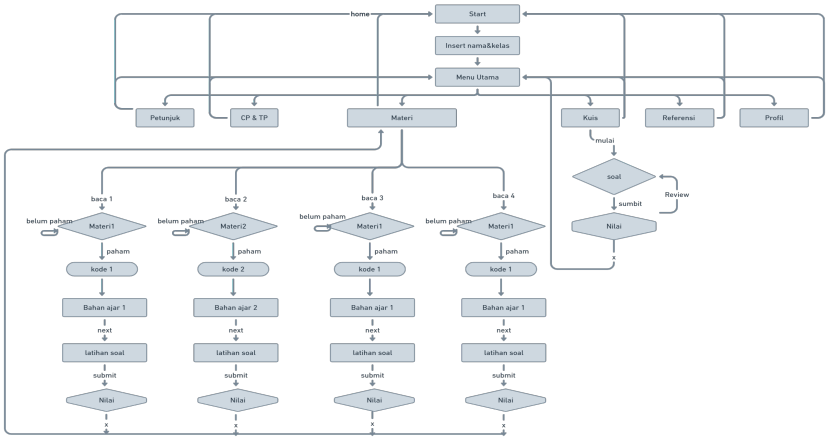

Figure 1. Navigation Structure

After the navigation structure is complete, the next step is to create a flowchart containing specific symbols to illustrate the website's workflow, thus simplifying the media development process. The next step is creating a storyboard. This storyboard serves as an initial visual representation of the pages within the media designed to support the flipped classroom model. This storyboard also serves as the primary reference in the media design process. Some of the pages to be designed include: the initial display page,identity page, main menu, instruction page, CP & TP, material menu, teaching materials, teaching materials, practice questions, quizzes, references and developer profiles. Finally, a design was made regarding the learning materials to be created, namely on algebra material in accordance with core competencies (KI) and competency achievement indicators (IPK).

Development Stage

This stage is carried out to realize the media design into a real product. Development uses Articulate Storyline 3 and involves a validation process by experts to ensure the feasibility of the media. Media creation begins with preparing the necessary software and hardware and collecting content such as text, images, videos, audio, and music. Backgrounds and videos are created in Canva, edited using CapCut, and arranged in Articulate Storyline 3. This media includes interactive navigation and practice questions such as drag & drop, multiple choice, and others. Once completed, the media is exported to HTML5 format, then converted into a website using GitHub Desktop, and converted into an Android application (APK) using Website 2 APK Builder Pro. After that, the created media is validated by material experts and media experts. The following is a small display of the media.

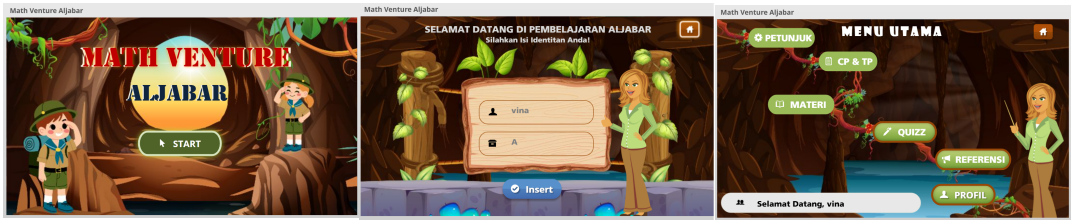

Figure 2. The resulting learning media

The validation results of the material experts on the developed media, in this case, Android-based interactive learning, were assessed in six aspects: accuracy, importance, completeness, balance, interest/attention, and suitability to student conditions. Both material

experts gave a "very appropriate" rating for all aspects. This finding indicates that the content presented in this learning media has met the standards of content quality and good learning objectives, and is in accordance with the characteristics and needs of students.

Furthermore, validation from media experts showed that the developed media was assessed based on 6 technical aspects, namely: readability, ease of use, display quality, response management quality, program management quality, and documentation. In five aspects, namely readability, ease of use, media display quality, and program management quality, both media experts gave a rating of "very appropriate". Meanwhile, in the aspect of response management quality and documentation, one of the two media experts gave a rating of "appropriate", while the other expert still gave a rating of "very appropriate". The Android-based interactive learning media meets the required content and technical standards, so it is considered "very appropriate" for use during the learning process, although there are minor differences in these two areas.

Implementation Stage

In this implementation phase, the interactive learning media was tested on students. This was done after the media was reviewed and approved by media and subject matter experts through a validation process. The interactive learning media was tested twice: a group trial with 10 participants and a field trial with 30 participants.

Evaluation Stage

In this evaluation step, researchers conducted an initial evaluation (level 1) to determine students' responses to the media created. Data from field and group trials were then analyzed.

Table 3. Student Responses to Group Trials

No.	Aspect	Students' Responses
1	Providing learning opportunities	Very practical
2	Providing learning support	Very practical
3	Quality of motivation	Very practical
4	Instructional flexibility	Very practical
5	Quality of tests and assessment	Very practical
6	Impact on students	Very practical

Discussion

The results of the research conducted indicate that the learning media named Math Venture Algebra is declared "very practical" and "very suitable" for use in supporting the flipped classroom learning model in algebra material. This media obtained an average practicality score of 87% based on field trials, with each aspect such as learning assistance, instructional flexibility, and learning motivation receiving a score above 85%. These results indicate that students feel helped, more interested, and better prepared to participate in the mathematics learning process independently and actively.

The media was designed using Articulate Storyline 3 software, using an interactive multimedia-based approach that combines text, video, audio, animation, and interactive questions. This aligns with Multimedia Learning theory by Mayer (2009) which indicates that the combination of visual, verbal, and interactive elements in learning media can deepen conceptual understanding and long-term retention. Furthermore, this study also supports the findings Inayah & Prasetyo (2025) which states that Android-based media is able to increase students' independence and active involvement in learning.

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The trials involved two stages: group trials and field trials. The group trials showed an average practicality score of 93%, higher than the 87% achieved in the field trials. This difference was due to the different implementation conditions; group trials were conducted in a guided setting with fewer participants and more uniform equipment. In contrast, field trials were conducted in a real-life learning context, with varying equipment and network conditions. This indicates that the effectiveness of media use is also influenced by technical factors and the implementation context.

Math Venture Algebra is designed to support every phase of the flipped classroom model. In the pre-class phase, students utilize instructional videos available on the platform to independently study algebra concepts at home. By engaging in self-study, students arrive at class with a prior understanding of the material (Marta et al., 2025). Furthermore, in the in-class phase, interactive practice questions and quizzes are used to discuss concepts and work on problems together (Mahuda, et al., 2021). This interactivity facilitates discussion and application of concepts in class, in accordance with flipped classroom principles (Hodiyanto et al., 2020). Thus, the instructional videos specifically prepare students before class, while the interactive questions and quizzes encourage active student engagement during class.

Although the media was generally well-received, there were some technical challenges such as lag or slow loading on low-spec devices. Therefore, researchers recommend media optimization, such as file size compression, reducing heavy animations, and developing a lite version, to make the media more accessible to all students (Branch, 2009). Several technical challenges need to be addressed to ensure optimal use of the media. Device Techniques: In field trials, some users experienced lag or slow loading on low-spec smartphones (Baig & Yadegaridehkordi, 2023). . This indicates the need for media optimization, such as file compression and developing a lite version, to ensure equitable access for all students. Infrastructure: Variations in internet network quality also affect the effectiveness of the media. Unstable connections can limit access to videos and interactive content, so infrastructure readiness needs to be considered. Educator Readiness: The use of this interactive media requires trained educators who are ready to integrate the media into learning. Training and mentoring for educators need to be provided so that each media feature can be optimally utilized in the classroom (Azrillia et al., 2024). The Math Venture Algebra media also successfully addressed the challenges of algebraic learning, which had previously been considered difficult. Based on data and interviews, previously, students had difficulty understanding the concept of algebraic forms and converting word problems into mathematical forms. However, with interactive visual presentations and problem-solving-based activities included in the media, students find it easier to understand the material contextually and more enjoyable.

This research provides the following theoretical and practical contributions. The research results support Mayer's (2009) multimedia learning theory, which emphasizes the importance of integrated visual and verbal elements to enhance conceptual understanding. These findings are also consistent with Inayah & Prasetyo (2025) who stated that interactive Android media can increase student independence and engagement. Thus, this media strengthens the understanding of student cognitive engagement in multimedia-based learning. Practically, this research encourages the development of similar media for other materials and at different educational levels. Math Venture Algebra's interactive and user-friendly design can serve as a model for Android-based learning media for other mathematics topics (e.g., geometry or statistics) and science subjects. The proven effective video, quizzes, and navigation features can be adapted to increase student engagement in other materials. These results also inspire teachers and developers to utilize similar platforms in flipped classroom implementations, particularly in junior high schools. Overall, the development of this media shows that the use

of Android-based technology designed with user-friendly principles, multimedia-based, and aligned with learning models such as flipped classrooms can be a practical solution to overcome the challenges of learning mathematics, especially algebra material at the junior high school level.

Conclusion

Based on the research results, the development of this Android-based interactive learning media has shown positive effects in enriching the mathematics learning process through the flipped classroom model. This media allows junior high school students to learn independently outside the classroom with the support of various multimedia elements, so that face-to-face time can be focused on discussion and application of concepts. The success of this media is not only seen from the improvement in learning outcomes or positive student responses alone, but more on the scientific meaning of its success in the context of 21st-century learning. By providing interactive and easily accessible learning tools, this media emphasizes the importance of mobile technology innovation in enabling more independent, creative, and meaningful learning for students.

This research also makes important contributions to learning theory and educational practice. From a theoretical perspective, this media reinforces the principles of multimedia learning theory, which states that the simultaneous presentation of information through various media (such as text, images, sound, and interactive animation—can enhance students' comprehension). The integrated design of this learning media reflects the implementation of Mayer's principles, including dual coding and active learning. Practically, this media serves as a concrete example of the application of the flipped classroom model in junior high school mathematics learning. With this media, teachers can encourage students to access materials outside of class and utilize class time for in-depth discussions. As a result, students' independence and motivation to learn increase, and innovation in mathematics teaching can be more dynamic, tailored to students' needs. More broadly, the success of this media reveals the lesson that the development of Android-based learning media can be adapted to a variety of other topics and contexts. This success demonstrates that the combination of interactivity and accessibility of mobile technology has great potential to enrich the learning experience, not only in mathematics but also in other subject areas. The implications for the development of similar media are that developers can emulate this approach to create new learning media that support the flipped classroom model or other active learning models. This media provides inspiration that digital innovation in education can improve the quality of learning overall and support the transfer of multimedia learning principles to various platforms and learning materials.

This study has certain limitations that need to be considered. One of these is the limited availability of devices; not all students have access to Android devices with adequate specifications, resulting in uneven use of this media. The relatively short trial period also poses a constraint, as it does not allow for the long-term impact of media use on the learning process to be observed. For further development, it is recommended that this media be enriched with advanced features such as the application of artificial intelligence (AI) for adaptive learning, a cloud-based analytics system to monitor student performance, and the expansion of content to other subjects or levels of education. By considering technological improvements and these inputs, this Android-based interactive learning media can be further developed to achieve greater effectiveness and a broader scope of use..

Conflict of Interest

The author declares no conflict of interest.

Authors' Contributions

V.C.F. contributed to understanding the core research idea and collecting the data. S.S. actively contributed to theory development, methodological design, and data organization and analysis. E.M. contributed to the discussion of the findings and ensured that the final version of the document was approved. All authors confirm that they have read and approved the final version of this article. The contribution proportions for conceptualization, writing, and revision are as follows: V.C.F.: 60%, S.S.: 25%, and E.M.: 15%.

Data Availability Statement

The author declares that data supporting the results of this study will be made available by the corresponding author, [V.C.F.], upon reasonable request.

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