

Development of Interactive Learning Media with a Discovery Learning Approach in Mathematics Subjects

Dira Febria Waty¹, Fetri Yeni J¹, Darmansyah¹, Rahmi Pratiwi¹, Rayendra^{1*}

¹Educational Technology, Postgraduate School, Universitas Negeri Padang, Padang, Indonesia

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Corresponding Author:

Rayendra

rayendra@fip.unp.ac.id

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Abstract: This research is motivated by the low interest and learning outcomes of students in the Matrix material because the learning process is still dominated by conventional methods and the lack of use of interactive learning media. This research aims to develop interactive learning media based on discovery learning on Matrix materials for grade XI high school students that are valid, practical, and effective for use in mathematics learning. This research is a research and development using the ADDIE model which consists of five stages, namely analysis, design, development, implementation, and evaluation. The research was carried out at SMA Negeri 2 Padang Panjang with research subjects including material experts, media experts, mathematics teachers, and grade XI students. Data collection techniques are carried out through observation, interviews, documentation, questionnaires, and learning outcome tests. The research instruments used consisted of expert validation sheets, teacher and student practicality questionnaires, and pretest and posttest questions. Data were analyzed using quantitative descriptive analysis and N-Gain calculation to determine the effectiveness of learning media. The results showed that discovery-based interactive learning media obtained a very high level of validity with an average of 91% of material expert validation and 92.5% of media expert validation. The results of practicality showed that the media obtained a very practical category with a percentage of teacher response of 93.75% and student response of 90.75%. In addition, the effectiveness results showed an increase in student learning outcomes with an average pretest score of 67.4 increasing to 88.6 in the posttest and an N-Gain value of 0.73 in the high category. Thus, discovery learning-based interactive learning media is declared valid, practical, and effective so that it is suitable for use as a mathematics learning innovation to increase student motivation, engagement, and learning outcomes

Keywords: ADDIE; Discovery Learning; Mathematics; High School; R&D

Introduction

Mathematics education has a strategic role in shaping students' critical, logical, creative, and problem-solving skills (Duma et al., 2024; OECD, 2022). These skills are important competencies needed to face the challenges of the 21st century while supporting the achievement of the Sustainable Development Goals (SDGs), especially the fourth goal, namely Quality Education (UNESCO, 2018). In the context of modern education, mathematics learning is no longer only oriented to mastering formulas and procedures, but is also directed at the development of higher order

thinking skills (HOTS) through an active, innovative, and technology-based learning process (Hwang et al., 2019; Li et al., 2024).

The development of information and communication technology (ICT) has provided great opportunities in the transformation of mathematics learning. The use of digital technology through interactive learning media is able to create a more interesting, contextual, and participatory learning experience (Mayer, 2017; Salsabila et al., 2025; Sumarwati et al., 2020). Interactive learning media allows students to interact directly with learning materials through visualization, simulation, animation,

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and automatic feedback so that abstract mathematical concepts become easier to understand (Arsyad, 2019; Hidayati, 2018). Various studies show that the use of interactive media in mathematics learning can increase students' learning motivation, student involvement, and ability to understand mathematical concepts (Choirudin et al., 2025; Nurmawati et al., 2020).

However, the implementation of mathematics learning in Indonesia still faces various problems. The results of international studies such as PISA and TIMSS show that the mathematical ability of Indonesian students is still relatively low, especially in solving reasoning-based problems, problem solving, and applying concepts in real life (Marhami et al., 2024; Safrudiannur & Rott, 2019). This condition indicates that mathematics learning still tends to be teacher-centered and emphasizes the memorization aspect rather than understanding concepts in depth (Eronen & Kärnä, 2018; Stephan, 2020). As a result, students have difficulty in developing critical and analytical thinking skills that are the demands of 21st century learning (Putri et al., 2020).

One of the learning approaches that is considered to be able to overcome these problems is discovery learning (Ridwan, 2021). This approach places students as active subjects in the learning process through the activity of finding concepts independently (Dari & Sudatha, 2022). In discovery learning, students are encouraged to explore, observe, analyze, and conclude concepts based on their own learning experiences (Alfieri et al., 2011). This approach not only improves the understanding of mathematical concepts, but is also able to develop students' critical thinking skills, creativity, and confidence in solving mathematical problems (Maifi et al., 2021; Simamora et al., 2018).

Along with the development of digital technology, the application of discovery learning becomes more optimal if supported by the use of interactive learning media. The integration of interactive media with the discovery learning approach allows students to have a more meaningful learning experience through visual, dynamic, and co-op exploration of concepts (Ashar et al., 2024). Interactive learning media can help students understand abstract concepts of mathematics through simulations, animations, interactive exercises, as well as the presentation of contextual problems relevant to daily life (Astarina et al., 2024; Hardika et al., 2024). Thus, learning becomes more engaging, active, and student-centered (Sudjana & Rivai, 2011).

However, the use of interactive learning media in mathematics learning in schools is still not optimal. Based on the results of initial observations at SMA Negeri 2 Padang Panjang, mathematics learning is still dominated by lecture methods and the use of textbooks and whiteboards as the main learning medium. This condition causes the learning process to tend to be

monotonous so that students are less interested and less active in participating in mathematics learning (Arsyad, 2011; Sanjaya, 2016). In addition, most students have difficulty in understanding math material because the presentation of the material is still abstract and lacking contextual (OECD, 2020).

This problem is strengthened by the results of daily student assessments on the Matrix material which shows that the majority of students are still in the sufficient to insufficient category with an average class score of 71.2, while the Learning Goal Achievement Criteria (KKTP) set is 85. The data shows that students' understanding of the concept of matrix material is still low and requires learning innovations that are able to improve the quality of the process and student learning outcomes.

In addition, the results of the initial mathematics learning questionnaire showed that 65% of students considered mathematics to be a boring subject, 60% of students had difficulty understanding the material, and 85% of students hoped that there would be the use of technology-based learning media in the learning process. These findings show that there is an urgent need for the development of learning media that is more innovative, interactive, and in accordance with the characteristics of the current digital generation (Alfarizi & Mahmud, 2024; Hafiedz & Nurhamidah, 2023).

Based on this description, the development of interactive learning media with a discovery learning approach is one of the relevant alternative solutions to improve the quality of mathematics learning in high school (Fatahillah et al., 2023; Swasti et al., 2022). The learning media developed is expected to be able to create an active, interesting, and meaningful learning atmosphere so that it can increase learning motivation, student involvement, and understanding of the concept of (Irma Maulidia & Ibnu Muthi, 2025; Najma Ulya et al., 2025).

Method

This research is a research and development (R&D) that aims to produce interactive learning media based on discovery learning on Matrix materials in high school that are valid, practical, and effective in the mathematics learning process. Development research was chosen because it is able to produce learning products while testing product quality through a systematic validation, implementation, and evaluation process (Branch, 2009; Sugiyono, 2018). The development of interactive learning media is important because mathematics learning requires visualization, interactivity, and active involvement of students to make abstract concepts easier to understand (Anggara & Supardji, 2024; Ningsih et al., 2022).

The development model used in this study is the ADDIE (Analysis, Design, Development, Implementation, Evaluation) model. The ADDIE model was chosen because it has systematic, flexible, and suitable stages for use in the development of technology-based learning media (Hidayat & Nizar, 2021; Suratnu, 2023). In addition, the ADDIE model is widely used in mathematics learning media development research because it is able to produce valid, practical, and effective products (Sugihartini & Yudianta, 2018; Tanty & Yuniseffendri, 2025). The use of the ADDIE model in the development of interactive learning media has also been proven to improve the quality of learning and student involvement in the learning process.

This research was carried out at SMA Negeri 2 Padang Panjang in the even semester of the 2025/2026 school year. The research subjects consisted of grade XI students of SMA Negeri 2 Padang Panjang, while the research validators consisted of material experts, media experts, and linguists. Mathematics teachers and students are involved in the process of testing the practicality and effectiveness of the developed learning media.

Stages of Analysis

The analysis stage is carried out to identify learning needs and problems that occur in mathematics learning. The analysis includes the analysis of students' needs for mathematics learning media, the analysis of student characteristics, the analysis of the curriculum and learning outcomes of the Matrix material, the analysis of the learning media used by teachers, and the analysis of mathematics learning problems at SMA Negeri 2 Padang Panjang (Adriani et al., 2020).

Data collection at this stage is carried out through observation, interviews with mathematics teachers, distribution of questionnaires to students, and documentation studies of student learning outcomes. The analysis stage aims to obtain information about the needs for the development of learning media that is in accordance with student characteristics and mathematics learning objectives (Triana et al., 2024). The results of the analysis show that mathematics learning is still dominated by lecture methods, the use of technology-based learning media is still limited, and students have difficulties in understanding abstract matrix concepts.

Design Stage

The design stage is carried out by preparing a design of interactive learning media based on discovery learning. Activities carried out at this stage include the preparation of the structure and flow of learning media, determination of learning materials and indicators, design of media interface displays, preparation of learning activities according to the discovery learning

syntax, and preparation of research instruments (Anggraini et al., 2024; Uliyandari et al., 2025).

The discovery learning syntax applied includes stimulation, problem statement, data collection, data processing, verification, and generalization (Nadira et al., 2026). The discovery learning approach was chosen because it was able to increase student involvement, critical thinking skills, and understanding of students' mathematical concepts (Eriansyah & Baadilla, 2023). At this stage, research instruments were also designed in the form of validation sheets, practicality questionnaires, and student learning outcome tests.

Development Stage

The development stage is carried out by creating interactive learning media using supporting software according to research needs. Learning media is developed by containing matrix materials, animations, simulations, learning videos, interactive exercises, and learning evaluations so that it is able to create more interesting and interactive learning (Annajati & Wikarya, 2023).

After the media is developed, a validity test is carried out by material experts, media experts, and linguists to determine the feasibility level of the product (Eriansyah & Baadilla, 2023). Validation was carried out on aspects of material content, language, appearance, presentation, interactivity, and media suitability with the discovery learning approach. Suggestions and feedback from validators are used as the basis for product revision before testing.

Implementation Stage

The learning media that has been declared valid is then tested on a limited basis for grade XI students of SMA Negeri 2 Padang Panjang. The implementation stage aims to determine the level of practicality and effectiveness of the learning media developed.

The practicality of the media was obtained through a questionnaire of the response of teachers and students to the use of learning media. The aspects measured include ease of use, media display, usefulness, interactivity, and feasibility of learning. Meanwhile, the effectiveness of the media is measured through a test of student learning outcomes after using interactive learning media based on discovery learning. The use of interactive media based on discovery learning is expected to be able to increase understanding of mathematical concepts and student involvement in learning.

Evaluation Stage

The evaluation stage is carried out formatively at each stage of development to correct the product's weaknesses based on the input of validators, teachers,

and students. Evaluation was also carried out summatively at the end of the study to determine the overall quality of learning media. The evaluation aims to produce learning media that is feasible, practical, and effective for use in mathematics learning.

Data Analysis Techniques

Validity and practicality data were analyzed using the Likert scale to determine the feasibility level of the developed e-module. The validity and practicality formulas used Formula 1.

$$V = \left(\frac{TSe}{TSh} \right) \times 100\% \quad (1)$$

The effectiveness of the e-module was analyzed using students' pretest and posttest scores through the calculation of N-Gain used Formula 2.

$$N - Gain = \left(\frac{Skor Posttest - Skor Pretest}{Skor Max - Skor Pretest} \right) \quad (2)$$

Result and Discussion

Research Results

This research produced a product in the form of interactive learning media based on discovery learning on Matrix materials for grade XI high school students. Media development is carried out using the ADDIE model which consists of five stages, namely analysis, design, development, implementation, and evaluation. The results of the research at each stage are explained as follows:

Stages of Analysis

The analysis stage was carried out to identify the needs of mathematics learning at SMA Negeri 2 Padang Panjang. Analysis activities were carried out through observation, interviews with mathematics teachers, distribution of questionnaires to students, and analysis of student learning outcome documents. The results of the observation show that the mathematics learning process is still dominated by lecture methods and the use of conventional learning media such as package books and whiteboards. Teachers have not used interactive learning media optimally in the learning process. As a result, students tend to be passive and less interested in learning mathematics.

Based on the results of the initial questionnaire analysis and student learning outcomes in Table 1, it can be seen that most students still have difficulties in understanding the matrix material and feel that mathematics learning is not interesting. In addition, the average student learning outcomes are still below the KKTP that has been set by the school. The data shows that students' understanding of concepts in matrix

materials is still relatively low, so more interactive and innovative learning media are needed to increase student motivation and learning outcomes.

Table 1. The results of the initial questionnaire analysis and student learning outcomes.

Indicator	Results
Students consider mathematics to be a boring subject	65%
Students have difficulty understanding matrix material	60%
Students want technology-based learning media that is engaging and interactive	85%
Average daily assessment score of students	71.2
The KKTP set by the school	85

Based on the results of this needs analysis, it is necessary to develop interactive learning media that is able to increase student involvement, visualize abstract mathematical concepts, and support active learning through the discovery learning approach.

Design stage

The design stage is carried out by compiling an interactive learning media design in accordance with the discovery learning syntax. The media is designed to contain several main components, namely the opening page, instructions for use, learning competencies, matrix materials, interactive animations and simulations, practice questions, learning evaluation, and automatic feedback.



Figure 1. Initial Appearance of Media and Learning Activities

The learning materials are arranged based on the stages of discovery learning which include stimulation, problem statement, data collection, data processing,

verification, and generalization. In addition, at this stage, research instruments were also prepared in the form of expert validation sheets, teacher and student practicality questionnaires, as well as pretest and posttest questions.

Development Stage

At the development stage, interactive learning media is made according to the design that has been designed. Learning media is developed using a digital-based application that combines text, images, animations, learning videos, interactive exercises, and automatic evaluations. The products that have been developed are then validated by material experts and media experts. Validation is carried out to determine the level of feasibility of learn.

Material Expert Validation Results

Material expert validation includes aspects of content feasibility, language, material presentation, and suitability with the discovery learning approach.

Table 2. Results of the Material Expert Assessment

Assessment aspects	Percentage %	Categories
Content Eligibility	92	Very valid
Language	88	Very valid
Presentation of the material	90	Very valid
Compatibility Discovery Learning	94	Very valid
Average	91	Very valid

Based on the results of the validation of material experts, an average percentage of 91% was obtained with a very valid category. This shows that the material presented in the learning media is in accordance with the learning competencies and characteristics of students.

Media expert validation results

Media expert validation includes aspects of display, interactivity, navigation, and technical quality of learning media.

Table 3. Media Expert Validation Results

Assessment aspects	Percentage	Categories
Media display	93%	Very valid
Interactivity	95%	Very valid
Navigation	90%	Very valid
Technical quality	92%	Very valid
Average	92,5%	Very valid

The results of the validation of media experts show that learning media has excellent display quality and interactivity so that it is suitable for use in the learning process.

Implementation stage

The implementation stage was carried out through a limited trial on grade XI students of SMA Negeri 2

Padang Panjang. The trial was conducted to determine the level of practicality and effectiveness of the learning media developed.

Results of teacher practicality

Teacher practicality is measured through a questionnaire of teachers' responses to the use of learning media in the mathematics learning process.

Table 4. Results of teacher practicality

Assessment aspects	Percentage (%)	Categories
Ease of use	94	Very practical
Material suitability	92	Very practical
Benefits	96	Very practical
Learning efficiency	93	Very practical
Average	93.75	Very practical

These results show that learning media is easy to use and helps teachers in delivering learning materials more effectively.

Results of student practicality

Student practicality was measured through a student response questionnaire after using learning media.

Table 5. Results of student practicality

Assessment aspects	Percentage %	Categories
Ease of use	89	Very practical
Attractiveness of the look	93	Very practical
Interactivity	91	Very practical
Learning motivation	90	Very practical
Average	90.75	Very practical

Based on the results of the questionnaire, students gave a positive response to the learning media developed. Students feel more interested and more active in participating in mathematics learning.

Results of the effectiveness of learning media

The effectiveness of learning media is measured through students' pretest and posttest results. The results of the analysis showed an increase in student learning outcomes after using discovery learning-based interactive learning media.

Table 6. Pretest and posttest results

Remarks	Result
Average pretest	67,4
Average posttest	88,6
N-Gain	0,73
Category	High

The result of the N-Gain calculation of 0.73 shows that the learning media developed is in the high category

and is declared effective in improving student learning outcomes in matrix materials.

Evaluation Stage

The evaluation stage is carried out thoroughly on the process and results of the development of learning media. The evaluation was carried out based on the results of the validation, practicality, and effectiveness of the learning media. Based on the results of the evaluation, it was found that the discovery learning-based interactive learning media met the criteria of valid, practical, and effective so that it was suitable for use in mathematics learning in high school.

Discussion

The results of the study show that the interactive learning media based on discovery learning developed has a very high level of validity. The high validation score shows that the learning media is in accordance with learning competencies, student characteristics, and interactive learning principles. The use of animations, simulations, and interactive exercises helps visualize matrix concepts that were previously considered abstract by students. These findings are in line with Saharani's research and (Mahardinata et al., 2024) which states that interactive learning media based on discovery learning is able to improve students' understanding of mathematical concepts because the presentation of the material becomes more visual, systematic, and interesting. In addition, the research Kusumastuti & Ghufro (2025) shows that Scratch-based interactive math learning media can help students understand math concepts more concretely and increase student engagement in learning.

The results of the study also show that learning media has a very good level of practicality based on the responses of teachers and students. Teachers stated that learning media helps the process of delivering material to be more effective and efficient, while students feel more interested, active, and motivated in participating in learning. This condition shows that the use of interactive media is able to create a more enjoyable and student-centered learning atmosphere. Research Astuti et al., (2024) also showed that Desmos-assisted interactive learning media can increase learning motivation and provide positive responses from students and teachers in mathematics learning.

The effectiveness results showed an increase in student learning outcomes with an N-Gain value of 0.73 in the high category. This improvement shows that the integration of interactive learning media with the discovery learning approach can help students understand the concept of the matrix more deeply. Through the stages of finding concepts independently, students become more active in exploring, analyzing,

and concluding mathematical concepts. These findings are in line with research (Potu & Poluakan, 2020) which shows that the application of the discovery learning model assisted by interactive media has a significant influence on improving students' mathematical critical thinking skills based on the results of the N-Gain analysis. Research (Yani & Santoso, 2024) It also shows that discovery learning-based learning with the help of interactive media effectively improves student learning outcomes and critical thinking skills.

The results of this study also support Bruner's theory that learning through discovery can improve students' understanding of concepts and thinking skills. In the learning process, students not only receive information passively, but are directly involved in discovering concepts through exploration and problem-solving activities. Research (Bimayu et al., 2025) It shows that the interactive worksheet-based discovery learning approach is able to improve students' critical thinking skills because students are encouraged to actively search, process, and infer information independently. In addition, the research (Wantoro et al., 2025) It also states that guided discovery-based learning is effective in improving students' problem-solving skills and learning independence. In addition, the use of interactive learning media in this study has been proven to be able to increase students' learning motivation. This can be seen from the enthusiasm of the students during the learning process and the positive response to the interesting.

Thus, the interactive learning media based on discovery learning developed can be an alternative to mathematics learning innovations that are relevant to the demands of 21st century learning. This learning media not only helps improve student learning outcomes, but also supports the development of students' critical thinking, creativity, communication, and independent learning skills. Based on the results of the research and support from previous research, the learning media developed is considered feasible to be used as one of the solutions to improve the quality of mathematics learning in high school.

Conclusion

Based on the results of the research and development that has been carried out, it can be concluded that the interactive learning media based on discovery learning in the Matrix material has been successfully developed using the ADDIE model and meets the valid, practical, and effective criteria for use in mathematics learning in high school. The results of the validation of material experts and media experts showed that the category was very valid, while the results of the practicality test of teachers and students showed that the

category was very practical. In addition, the effectiveness results showed an increase in student learning outcomes with an N-Gain value of 0.73 in the high category. Thus, discovery-based interactive learning media is able to increase motivation, engagement, concept understanding, and student learning outcomes in the Matrix material so that it is suitable for use as a mathematics learning innovation in accordance with the demands of 21st century learning.

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Author Contributions

"Conceptualization, D.F.W and F.Y.; methodology, D.F.W.; software, D.F.W.; validation, D, R.P. and R.; formal analysis, D.F.W.; investigation, D.F.W; resources, D.F.W; data curation, D.F.W; writing—original draft preparation, D.F.W; writing—review and editing, F.Y.; visualization, D.F.W.; supervision, F.Y. All authors have read and agreed to the published version of the manuscript."

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Conflicts of Interest

The authors declare no conflict of interest.

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