

The Development of Interactive Learning Media Based on Discovery Learning Oriented to Students' Concept Understanding and Mathematical Disposition

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ABSTRACT

Interactive learning media that enhance active student participation are essential for optimizing mathematics learning and developing mathematical competencies. This research focused on designing interactive media based on discovery learning to improve students' conceptual understanding and mathematical disposition, ensuring their validity, practicality, and effectiveness. The study utilized the ADDIE development model, encompassing Analysis, Design, Development, Implementation, and Evaluation phases. The research involved 35 students from class XI SMA Negeri 4 Yogyakarta and assessed the media's validity, implementation practicality, and learning effectiveness. The interactive media were developed following discovery learning principles and made accessible via laptops and smartphones. Validation confirmed their effectiveness, achieving a 92.3% implementation rate. Wilcoxon and proportion tests revealed significant improvements in students' conceptual understanding and mathematical disposition. The average concept understanding test score exceeded the KKTP threshold (75), while the mathematical disposition questionnaire average surpassed the high criteria minimum (102). Furthermore, 88.5% of students reached the KKTP (75) threshold in conceptual understanding, and 94.2% met the high criteria (102) for mathematical disposition. The findings indicate that discovery learning-based interactive media significantly enhance students' conceptual understanding and disposition. The accessibility and engagement features align well with effective learning strategies for high school mathematics. Discovery learning-based interactive media are valid, practical, and effective tools for improving mathematical understanding and disposition in high school settings, supporting broader adoption in similar educational contexts.

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1. INTRODUCTION

The ability to understand concepts is a fundamental ability that can optimize and develop various mathematical abilities. Understanding mathematical concepts is a skill that needs to be

developed by every individual who learns mathematics and becomes a tool to develop other mathematical competencies and in solving problems in real life (Hendriana, Rohaeti, & Sumarmo, 2017; Nasution, Sinaga, & Mukhtar, 2019). Students can understand mathematics only if they understand concepts and the meaning or interpretation of a concept (NCTM, 1989). Understanding the concepts listed is one of the objectives of teaching mathematics in the Decree of the Head of BSKAP No. 8 of 2022 (Kemendikbudristek, 2022) and Graduate Competency Standards Number 5 of 2022 (Kemendikbudristek, 2022).

In addition to understanding concepts, one of the affective aspects that can support effective and is mathematical disposition. Disposition can encourage a person to engage in activities (Doig, Wiliams, Swanson, Ferri, & Drake, 2019). Disposition is One of the key objectives in education, apart from knowledge and skills (Pastor & Charalambous, 2023). Mathematical disposition is also a goal in mathematics learning as stated in the Decree of the Head of BSKAP No. 8 of 2022 (Kemendikbudristek, 2022). Mathematical disposition refers to an interest or pleasure in mathematics, as well as an appreciation for it. Mathematical disposition is not just an attitude, but includes the tendency to think and act positively when learning mathematics (Mentz, Beer, & Bailey, 2019; Minarti, Alghadari, & Hutajulu, 2020; NCTM, 1989).

The 2015 Trends in Mathematics and Science Study (TIMSS) revealed that Indonesia ranked 44th out of 49 countries in achievements related to geometric shapes and measurements, with a score of 394. This data highlights the need for greater emphasis on geometry in mathematics education. One specific area requiring improved conceptual understanding is the topic of circles (Damrau, 2023; New Sari & Armanto, 2022; Trianingsih et al., 2019). A key factor contributing to students' low comprehension of circle concepts is the lack of effective visualization and opportunities for concept discovery. Using appropriate learning media can enhance visualization and facilitate the discovery process, which supports student understanding. Therefore, developing innovative and suitable learning media tailored to this need is crucial.

This low mathematical disposition is caused by several factors, one of which is the lack of student involvement in the process of concept discovery (Trianingsih et al., 2019). Technology can be the best alternative to increase student involvement in the process of discovering concepts in learning. Mathematics learning using information and communication technology will be richer and a complex learning environment and potentially more active, effective, and productive mathematics learning (Moore, 2012; Smaldino, Russel, Heinich, & Molenda, 2002; Sutherland, 2007). One of the uses of technology in learning is the use of technology-based learning media.

Learning media provide real experiences that are important in helping students understand abstract mathematical concepts (Smaldino et al., 2002). Firdha & Zulyusri (2022) Interactive learning tools are enjoyable resources that promote student engagement and active participation. Utilizing interactive learning tools can enhance students' conceptual understanding and promote their active participation. Ispring with powerpoint integrated widely used in the manufacture of media with geometric materials (Firdha & Zulyusri, 2022; Maryana, Suaedi, & Nurdin, 2019). The use of Geogebra in learning has a notable effect on enhancing students' mathematical skills (Baye, Ayele, & Wondimuneh, 2021; Yuliardi, Juandi, Maizora, & Mahpudin, 2021).

Discovery learning is learning that is designed so that learners can make the discovery of the concept in question for themselves (Hammer, 1997 ; Andelkovic & Maricic, 2023). Learning discovery learning have a positive impact on students' understanding of concepts (Gunawan, Kosim, & Lestari, 2020; Koto, 2020; Maifi, Anwar, & Ahmad, 2021; Swasti, Hutapea, & Suanto, 2022). Discovery learning can support learning media to focus more on facilitating understanding concepts and mathematical dispositions.

Although the potential of technology-enhanced discovery learning is acknowledged, there is a shortage of research dedicated to creating interactive learning tools specifically aimed at improving understanding of concepts and mathematical attitudes in high school circle geometry. This study seeks

to address this gap by developing and evaluating interactive learning media based on discovery learning, ensuring its validity, practicality, and effectiveness for high school geometry instruction.

2. METHODS

This research employs a Research and Development (R&D) approach, utilizing the ADDIE model (Analysis, Design, Development, Implementation, Evaluation) to systematically develop and assess interactive learning media. The ADDIE flowchart is described in figure 1.

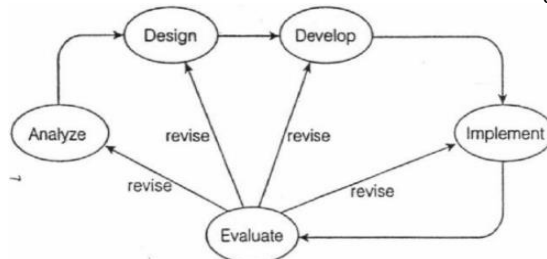


Figure 1. ADDIE Development Model

This research employed the ADDIE development model, which consists of the Analyze, Design, Development, Implementation, and Evaluation stages, ensuring a systematic approach to developing and evaluating educational media. Each stage was meticulously planned and executed to create an effective learning tool tailored to the needs of students.

The Analyze stage focused on a thorough examination of the educational landscape, including an assessment of curriculum requirements, student characteristics, and the school environment. This stage laid the foundation for the project by identifying specific needs and challenges, culminating in the creation of a detailed work plan to guide subsequent stages.

In the Design stage, interactive learning media were conceptualized to address the identified needs. The designs prioritized alignment with educational objectives and aimed to enhance students' conceptual understanding and mathematical disposition, integrating discovery learning principles.

The Development stage marked the creation and refinement of the learning media. Research instruments such as questionnaires and test sheets were developed alongside the media. Validation processes and small-scale trials were conducted to ensure the media met quality standards, allowing for iterative improvements based on feedback.

During the Implementation stage, the learning media were introduced to students in both initial and large-scale classroom trials. These trials assessed students' conceptual understanding and mathematical disposition. Additionally, feedback from teachers and students was collected to gauge the practicality and usability of the media. Post-implementation evaluations provided insights into the effectiveness of the tools.

The Evaluation stage analyzed data from various sources, including tests, observations, and questionnaires, to determine the validity, practicality, and effectiveness of the media. This study was conducted at SMA Negeri 4 Yogyakarta in the 2023/2024 academic year, involving 35 grade XI students. Instruments included questionnaires for validity, observation sheets and questionnaires for practicality, and mathematical disposition and conceptual understanding test sheets for effectiveness. The data analysis incorporated Widoyoko's (2017) categorization criteria, ensuring a robust evaluation framework. This comprehensive approach underscored the learning media's potential as a valuable educational resource.

Table 1. Validity Category of Material Experts

Score Interval	Validity Category
$67.2 \leq V < 80$	Very Valid
$54.4 \leq V < 67.2$	Valid
$41.6 \leq V < 54.4$	Quite Valid
$28.8 \leq V < 41.6$	Less Valid
$16 \leq V < 28.8$	Invalid

The category of media validation by media experts is explained in table 2.

Table 2. Validity Category of Media Experts

Score Interval	Validity Category
$71.4 \leq V < 85$	Very Valid
$57.8 \leq V < 71.4$	Valid
$44.2 \leq V < 57.8$	Quite Valid
$30.6 \leq V < 44.2$	Less Valid
$17 \leq V < 30.6$	Invalid

Media is declared valid if it reaches the valid or very valid category. Categories of media practicality assessment by teachers are in Table 3.

Table 3. Categories of Practicality by Teachers

Score Interval	Categories Practicality
$84 \leq V < 100$	Very Practical
$68 \leq V < 84$	Practical
$52 \leq V < 68$	Quite Practical
$36 \leq V < 52$	Less Practical
$20 \leq V < 36$	Impractical

The category of media practicality assessment by students is in table 4.

Table 4. Categories of Practicality by Students

Score Interval	Categories Practicality
$71.4 \leq P < 85$	Very Practical
$57.8 \leq P < 71.4$	Practical
$44.2 \leq P < 57.8$	Quite Practical
$30.6 \leq P < 44.2$	Less Practical
$17 \leq P < 30.6$	Impractical

The media is considered practical if it falls into the practical or highly practical category. This implementation analysis sheet has two answer options, namely "yes" and "no". Calculation of the percentage of observations, here is the formula used:

$$\text{Value}(\%) = \frac{\text{Score}}{\text{Maximum Score}} \times 100\%$$

The effectiveness analysis technique was carried out with media criteria to facilitate the understanding of concepts and mathematical dispositions if they met the effectiveness criteria, namely: (1) The average concept understanding test of students achieved the Learning Goal Achievement Criteria (KKTP) in the school, which was 75 and the mathematical disposition achieved a minimum score on the high criteria (102), (2) the percentage of many students who obtained a score of KKTP (75)

$\geq 75\%$ and mathematical disposition (102) $\geq 75\%$, and (3) there was an increase in the average ability to understand concepts and mathematical dispositions after learning employing interactive educational tools. Discovery learning is applied with learning principles that provide students with the opportunity to explore and make discoveries from experiments carried out as well as processing the results of experiments and discussions.

3. FINDINGS AND DISCUSSION

The outcomes of developing interactive learning media using the ADDIE model are outlined as follows.

3.1 Analyze Stage

The analysis stage served as the foundation for designing media that align with the specific conditions, needs, curriculum, school environment, and student characteristics. Observations and interviews, along with questionnaire results, highlighted that students' conceptual understanding and mathematical disposition remain low. Current learning approaches have not adequately provided opportunities for student-centered discovery, nor have they integrated interactive learning media directly accessible to students in mathematics classes.

While students have access to technology such as mobile phones, these tools have not been effectively utilized to optimize learning in mathematics. The schools involved in the study implement the independent curriculum, which emphasizes personalized and active learning. However, findings from the characteristic analysis reveal that most students struggle with understanding mathematical concepts, particularly in the domain of geometry and measurement.

Given these challenges, the media were specifically developed to address geometry concepts, focusing on circular material. The available school facilities offer potential for optimization through the use of interactive learning tools, enabling students to actively engage with the material. These tools are designed to support discovery-based learning, fostering a deeper understanding of concepts and improving mathematical disposition. The analysis underscores the critical need for discovery learning-based interactive media as an essential component for enhancing students' learning outcomes in mathematics.

3.2 Design Stage

Based on the findings from the analysis, the product and learning design stages were initiated. These stages involved creating product content and instructional strategies guided by discovery learning principles, with a focus on enhancing conceptual understanding and fostering positive mathematical dispositions. During this phase, interactive learning media were carefully designed alongside teaching modules, research instruments, and validation sheets. Each element was developed to align with the educational goals and ensure that the tools effectively support discovery-based learning and actively engage students in the learning process.

3.3 Development stage

The development stage, develop products in accordance with the learning design, compile instruments, learning tools and also carry out a validation process and limited trials. Interactive learning media is developed using microsoft PowerPoint software, ispring suite 10, and geogebra. The first component of the developed learning media is the opening page as shown in figure 2.



Figure 2. Opening Page View

The opening page contains the title of the application, namely the interactive learning media circle, the exit/exit button, the hint button and the start button that leads to the main menu. The main menu page contains features that can be accessed in the media, namely, competencies, receptions, concept maps, materials, videos, examples, quizzes, and developer profiles as shown in this figure .



Figure 3. Main Menu Display

The apperception page contains buttons and an interactive display equipped with an interactive circle animation regarding the elements in the circle as shown in figure 4.

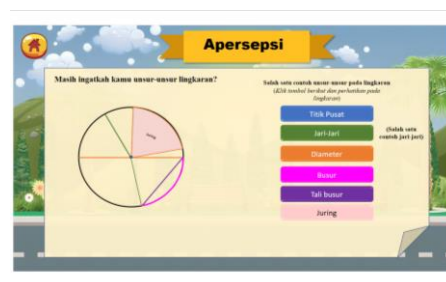


Figure 4. A perceptual Display

In the material, there is a series of learning activities that are arranged based on the steps and principles of discovery learning as well as indicators of understanding concepts and mathematical dispositions as shown in figure 5.

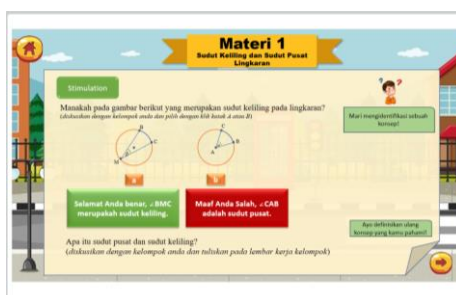


Figure 5. Material Display

In the material, there are interactive buttons and also activities to conduct experiments using geogebra and video as shown in figure 6.



Figure 6. Geogebra Display

The media is also equipped with sample questions and interactive quizzes where students can find out the results of the quiz and send it to the teacher's email.



Figure 7. Video Components

This media is also equipped with learning videos regarding the proof of the theorems being studied.

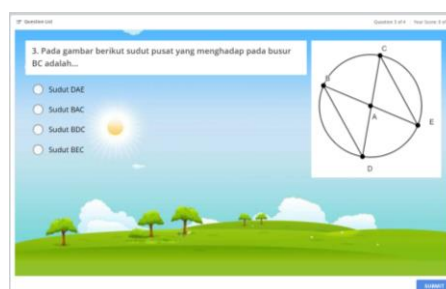


Figure 8. Interactive Quiz View

This media is also equipped with interactive quizzes that students can work on and the results are directly connected to the teacher's email. After creating the media, validation is carried out. The validation results revealed that the developed learning media products, concept comprehension test questions, mathematical disposition questionnaires, teaching modules, observation sheets, teacher and student practicality questionnaires, readability questionnaires and LKPD obtained valid or very valid categories, therefore the media and instruments were declared valid so that they were suitable for use in this research.

Limited or small-scale trials are conducted to assess the readability and practicality of learning media before broader classroom testing. This trial involved 6 students from class XI. The results of the limited trial are shown in Table 5.

Table 5. Limited trial results

Aspects	Acquisition	Maximum score	Category
Implementation of Learning Implementation	88%	100%	Practical
Practical assessment by teachers	95	100	Very Practical
Assessment of practicality by students	72	85	Very Practical
Readability Assessment	61.33	70	Very Practical

The results of the limited trial indicated that the media was deemed practical and suitable for implementation in large-scale classroom trials.

3.4 Implementation Stage

Interactive learning media based on discovery learning was tested on a large scale in class XI F5 SMA Negeri 4 Yogyakarta, consisting of 35 students. Large-scale trials were carried out as many as seven meetings. Two meetings were held for pre-test and post-test and 5 meetings were held for learning. The teacher did the opening activity, and then proceeded to the core activity. In the core activity, Learning is conducted by utilizing media based on discovery learning. Students carry out discovery activities and experiments with geogebra. After conducting the experiment, students process data and discuss it with friends to be able to find the concept in question. After discussing with the group, verification activities are carried out with students watching a video and writing proof.

3.5 Evaluation stage

Evaluation activities consist of evaluation activities on the practicality and effectiveness of media or products. According to the evaluation results obtained the percentage of learning implementation using media with the most significant results at the 2nd meeting, namely 95.12%. The average implementation is 92.3% with the category "Very Practical". According to the results, Effective learning media is utilized in instruction. The practicality assessment by the teacher obtained a score of 94 out of a possible form 100 with the category "Very Practical". The assessment of practicality by students result an average score of 65.6 out of the maximum score in the "practical" category. According to these results, the media achieved the practical and very practical categories, it was concluded that the media that had been used was declared practical.

Based on Hotelling's T^2_{test} , the value and significance value of $T^2 = 76.93$ $p\text{-value} = 2.2e-16$ were obtained. Therefore it is obtained $T^2 = 76.93 > \frac{(n-1)p}{(n-p)} F_{p,(n-p)} = 6.75$ and $p\text{-value} = 2.2e-16 < 0.05$ then it is rejected. Thus, it can be concluded that the average concept understanding and mathematical disposition are not the same as the criteria set, namely KKTP concept understanding 75 and mathematical disposition 102. Further tests will be carried out. The capacity to grasp the idea was carried out based wilcoxon signed rank test. According to the outcomes of the Wilcoxon test mentioned earlier, it is evident that $p\text{-value} = 0.0001534 < 0.05$. Based on this, it H_0 rejected so that the average result of the student's concept understanding test was greater than 75 (KKTP). Considering these results, learning with the application of educational media developed is effective from to understand concepts. Meanwhile, considering these results of the concept comprehension proportion test, a score of $H_0 Z = 1.861 > Z_\alpha = 1,65$. was obtained Therefore, H_0 was rejected so that it can be concluded that the proportion of student concept comprehension test results that reached KKTP (75) is more than 75%. Based on the results of the wilcoxon test on the pretest and posttest, the result of $p\text{-value} = 2.535e-07 = 0.0002535 < 0.05$ was obtained. Based on this, it was rejected, indicating a difference in the average conceptual understanding before and after learning using interactive learning media. There is an improvement in conceptual understanding following the use of interactive learning media.

3.6 Statistical Analysis

The descriptive statistical results for the conceptual understanding and mathematical disposition questionnaire are shown in Table 6 below.

Table 6. Descriptive statistics of conceptual understanding and mathematical disposition

Description	Conceptual understanding	Mathematical disposition
Highest Scores	95.83	130
Percentage of students who complete	88.5%	94.2%
Grade Point Average	81.667	111,8

The results show a fairly high percentage of completion and average. These results suggest that the media are effective in enhancing students' understanding of mathematical concepts and dispositions. Based on the findings of the *one sample t-test* above, $t_{hitung} = 23,89 < t_{tabel} = 1.690$ and $p\text{-value} = 2.2\text{e-}16 < 0.05$. Based on this, it was rejected so that the students' average score mathematical disposition questionnaire was greater than 102 (the minimum score in the high category). Considering these results, learning with the application of learning media developed is effectively reviewed from mathematical disposition. Considering these results of the calculation above with a significance of 0.05, a value of $H_0 Z = 2.626 > Z_\alpha = 1.65$. H_0 was rejected, so it can be concluded that the proportion of the results from the mathematical disposition questionnaire of students who reached a score of 102 was more than 75%. Based on the results of the *pair sample t-test* above, it is known that $p\text{-value} = 8.571\text{e-}08 = 0.00008571 < 0.05$. Based on this, it was rejected so that there was a variation in the average mathematical disposition before and after using interactive learning media.

Discussion

Considering these results of the research, the developed interactive learning media satisfies the three criteria of effectiveness in facilitating understanding of mathematical concepts and dispositions. Interactive learning media meets the validity criteria based on the results of validation of media, research instruments, and learning tools. Suggestions and inputs to the media, tools, and research instruments are highly regarded and improved. According to Nieveen (1999), a product is said to be valid if it is relevant to the theory and has a framework and components that are compatible with each other. According to Sugiyono (2012), if it is theoretically correct, the measurement results using a measuring device guided by it will be considered valid.

Based on the evaluation of the practicality of interactive learning media by teachers, the assessment by students, and the percentage of learning implementation using the media, it is deemed practical for use. In line with Firdha & Zulyusri (2022) which reveals that interactive learning media is an instructional medium that can be fun and can foster active participation of learners in the learning process. In addition, according to Sutherland (2007), Mathematics learning using technology will be richer and a complex learning environment and potentially more productive mathematics learning. According to Santoso et al. (2022), Interactive learning media is an engaging tool designed for enjoyable and effective learning so that learning goals are achieved.

Considering these results and the final product review, the developed interactive learning media meets the criteria of effectiveness in facilitating students' ability to understand concepts and mathematical dispositions. Understanding of mathematical concepts can be improved by using technology such as learning media. According to Moore (2012) which reveals that the effectiveness and quality of teaching can be greatly improved through the use of technology. Learning media creates active learning conditions and supports the development of students' conceptual understanding abilities. Other opinions according to Widodo & Wahyudin (2018), one of the roles of learning media is as a means that helps to produce effective learning conditions, connections between learning components so that the expected learning situation is created, helps understand something abstract so as to reduce verbalism and increase students' understanding.

The research results demonstrate that the use of learning media effectively enhances students' ability to understand mathematical concepts. Firdha and Zulyusri (2022) emphasize that learning media serve as tools for communicating or delivering instructional messages efficiently and effectively, aiding students in comprehending learning materials. The media developed in this study adhere to the

principles of discovery learning, which play a critical role in their effectiveness. As noted by Smaldino et al. (2008), discovery learning fosters deeper content understanding by engaging students actively in the learning process.

The integration of Geogebra in the learning media further supports students in visualizing and understanding circle concepts. Juandi et al. (2021) found that incorporating Geogebra into mathematics instruction significantly improves students' mathematical abilities. This research aligns with those findings, confirming that the developed interactive learning media are valid, practical, and effective for teaching circle-related mathematics. These media can be utilized in high schools to enhance both conceptual understanding and mathematical dispositions.

The learning media fulfill three critical criteria—validity, practicality, and effectiveness—by aligning with specific ability indicators. Features such as discovery-based activities, interactive quizzes that reinforce conceptual understanding, and other supportive elements ensure the media's effectiveness in achieving learning objectives.

4. CONCLUSION

This study concluded that circle-based interactive learning media, oriented toward discovery learning, effectively enhances high school students' conceptual understanding and mathematical dispositions. The media incorporate discovery learning principles through stages such as stimulation, problem statement, data collection, data processing, verification, and generalization. Accessible online via computers, laptops, or smartphones, the media include features such as competencies, perceptions, concept maps, materials, videos, sample problems, and interactive quizzes. The media met validity criteria based on expert validation, practicality criteria with teacher and student scores averaging above 85%, and a "Very Practical" rating based on a 92.35% implementation score. Additionally, the effectiveness criteria were achieved through improved student performance on concept comprehension tests and mathematical disposition questionnaires.

For future research, it is recommended that similar media be developed for topics beyond circle geometry to broaden their impact on mathematics learning. Infrastructure, such as internet availability and compatible devices, must be addressed to ensure successful implementation. Future designs should focus on providing realistic problems, functional media elements, and tasks aligned with specific learning indicators. Dissemination of the media through schools and educational websites is encouraged for wider adoption. This study's limitations, including small sample size, technology access, and network conditions, highlight areas for improvement in subsequent research to enhance the applicability and scalability of interactive learning tools.

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