

THE DEVELOPMENT OF WAYGROUND-ASSISTED DISCOVERY LEARNING WORKSHEET TO IMPROVE STUDENTS' MATHEMATICAL CONNECTION ABILITY AND LEARNING INDEPENDENCE ON JUNIOR HIGH SCHOOL

Dini Pujianingsih¹, Utari Sumarmo², Harry Dwi Putra³

¹IKIP Siliwangi, Jl. Terusan Jend. Sudirman, Cimahi, Indonesia.

dini.pujianingsih@gmail.com

²IKIP Siliwangi, Jl. Terusan Jend. Sudirman, Cimahi, Indonesia.

utarisumarmo@ikipsiliwangi.ac.id

³IKIP Siliwangi, Jl. Terusan Jend. Sudirman, Cimahi, Indonesia.

harrydp@ikipsiliwangi.ac.id

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ABSTRACT

Student worksheet (LKPD) is a teaching materials containing activities that guide students in understanding topic. However, several studies have shown that LKPD is simply practice questions and are not tailored to students' needs. This study aims to design and test the effectiveness of a student-based LKPD.discovery learning assisted by wayground in improving mathematical connection skills and learning independence of junior high school students. This research is a Research and Development (R&D) with the Borg & Gall model, which consists of preliminary studies, planning and drafting products, expert validation, limited trials, extensive trials and product tests. The subjects of the study were 10 students of class IXA for limited tests and 32 students of class IXB for extensive tests and the subjects of product tests were 32 students of class VIIID for the experimental class and 32 students of class VIIIE for the control class in one of the public junior high schools in Bandung Regency. The research instruments include: Mathematical Connection Test, Learning Independence Scale, LKPD Validation Scale and Learning Assessment Response Scale. The results of the study show feasibility with several criteria: Validity obtained from the results of validation by material experts is 89% and media experts 90%, both in the very valid category. Practicality of 83% obtained from the results of student responses is in the very practical category and Effectiveness is obtained from the results of the Ngain analysis 60%, is in the effective category. Thus, LKPD based on discovery learning assisted by wayground effectively improves students' mathematical connection skills and learning independence.

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Corresponding Author:

Dini Pujianingsih,
Department of Mathematics Education,
Institut Keguruan dan Ilmu Pendidikan Siliwangi,
Jl. Terusan Jend. Sudirman, Cimahi, Indonesia
Email: dini.pujianingsih@gmail.com

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INTRODUCTION

Mathematical connection skills are an important aspect of mathematics learning because they enable students to connect mathematical concepts with other knowledge and their application in everyday life (I. Mawaddah, 2025). With these skills, students can better understand concepts and make learning more meaningful. According to the National Council of Teachers of Mathematics (NCTM), instructional programs from prekindergarten through grade 12 should enable all students to recognize and use connections among mathematical ideas, understand how mathematical ideas interconnect and build on one another to produce a coherent whole, recognize and apply mathematics in contexts outside of mathematics (NCTM, 2000). Mathematical connection skills are the ability to recognize and use relationships between mathematical ideas, understand how mathematical ideas are interrelated, and recognize and apply mathematics beyond mathematical concepts. Mathematical connection is a cognitive process that requires effort to find a representation of concepts and procedures, understand interrelated topics, and apply these mathematical concepts in other fields or in everyday life (Fani & Effendi, 2021).

Learning mathematics is essentially about learning structured and interconnected concepts, requiring the ability to understand the connections or interrelationships between these concepts. Therefore, mathematical connection skills are crucial because they support students in understanding a concept in a substantial way and applying it in their daily lives. This aligns with the statement that mathematical connections are important because they support conceptual understanding and enhance students' understanding of other disciplines through the reciprocal relationships between mathematical concepts and those of other disciplines (Putri & Yosi Adiputra, 2022). Connection skills are also crucial because they are embedded in the school curriculum and are one of the standards for the mathematics learning process formulated by National Council of Teacher of Mathematics (NCTM)

Several studies have shown that students' mathematical connection skills are still low. This is based on the results of a study that found that 11th-grade students at SMK Negeri 1 Lahusa had low mathematical connection skills (Ziliwu H, Sarumaha R, 2022). Other research indicates that students' mathematical connection skills at the vocational high school level in Cianjur are relatively low (Putri & Yosi Adiputra, 2022). Another study conducted on fourth semester students found that students' ability to connect mathematical concepts and create mathematical models was still low (Yolanda & Wahyuni, 2020).

Hard skills will develop optimally if supported by good soft skills. Hard skills are related to cognitive abilities and specific skills, while soft skills are behaviors needed to develop and optimize hard skills (Sumantika et al., 2021). One of the soft skills that supports mathematical connection skills is learning independence. According to Hendriana & Soemarmo, learning independence is characterized by a learning process where people feel responsible for the conception, implementation, and assessment of the process. Independent students can do anything to the best of their ability. (Novita & Medika, 2023). Learning independence is the ability to independently seek learning information from learning sources other than teachers. (Suhendri, 2014; Ali et al., 2022). Learning independence allows students to use various sources of information and media to learn topics without being influenced, forced, or assisted by others (Lestari et al., 2025). Thus, learning independence can make activities more effective and independent of teachers, train responsibility and discipline, increase internal motivation, which is one of the factors in improving student achievement.

The importance of independent learning remains a challenge. Several studies have shown low levels of student independence, including research in seventh-grade students at SMP Negeri 3 Pulau Punjung, Dharmasraya Regency, West Sumatra, where many students lack self-

confidence and rely on friends to complete their assignments (Novita & Medika, 2023). Another study at SDN 6 Dawuhan, Situbondo District, found that student independence in learning remains low. This is evident in the fact that during the learning process, some students do not pay attention, do not yet have the responsibility to learn independently, and do not complete assignments (Bramantha, 2019). Another study on independent learning found that the learning interest of eighth-grade students at SMPN 1 Sambit has begun to decline due to low levels of student independence. During the learning process, students appear dependent on the teacher, always waiting for direction from the teacher to find learning materials, and do not focus on the material being taught (Linassari & Arif, 2022).

In learning activities, besides being a teacher, teachers play an important role as facilitators, one of whose tasks is to develop teaching materials or media that are easy for students to use and also facilitate students' understanding of the concepts presented (Supriatin & Putra, 2023). The development of teaching materials must be systematically arranged, easy to understand and easy to access, and adapted to students' needs to become an alternative solution in overcoming various learning problems. Teaching materials that are often used are in the form of Student Worksheets (LKPD). LKPD are sheets containing materials, summaries, and assignments that must be completed by students (Anggraini et al., 2016; Lubis & Sukmawarti, 2022). LKPD contains a set of fundamental activities that must be carried out by students to maximize understanding of the formation of basic skills in accordance with the indicators of learning achievement that must be achieved (Costadena & Suniasih, 2022).

The development of information media and technology has significantly assisted in the development of student worksheets (LKPD), making visualizations clearer, more varied, and more engaging, as well as easier to access both online and offline. However, currently, the LKPDs used by teachers are not developed by the teachers themselves and are tailored to the characteristics of their students. Many teachers still lack the skills to use digital devices for learning. LKPDs also consist of practice questions and copying from the internet without adapting them to students' needs (Lubis & Sukmawarti, 2022).

One of the learning models that directs students to be active and trains students' learning independence is the model discovery learning. Furthermore discovery learning as a way for students to actively learn through the process of discovering and investigating on their own, so that the results obtained will last long in the memory, and will not be easily forgotten by students (Asriningsih, Sujana, & Sri Darmawati, 2021; Prasetyo & Abduh, 2021; Puspita et al., 2023) Discovery learning can be an alternative learning model that is suitable for students. In line with this opinion, discovery learning is an engaging learning model that facilitates students' active participation in building their understanding (Abdullah & Putra, 2024). A good understanding of concepts will be a supporting factor for their connection skills.

One of the media used in learning is Quizizz, which has now been renamed Wayground with various additional features. Several previous studies have shown that the use of Wayground learning media has an effect on student learning outcomes in mathematics (A. W. Al Mawaddah et al., 2021). Research shows that students generally have a positive perception of Wayground in terms of ease, enjoyment, and practicality (Ridwan et al., 2025). With various interesting features such as interactive game-based quizzes and online and offline presentations, researchers provide an alternative learning solution by developing student worksheets (LKPD) assisted by Wayground. Unlike previous studies, where the Wayground application was used as an assessment medium in the form of an interactive quiz test, in this study, researchers used Wayground as a medium to design student worksheets containing material and interactive quizzes as assessments.

Discussion regarding the importance of mathematical connections and learning independence (self regulated learning) and existing conditions, became the reason for researchers to create a solution by developing LKPD based on discovery learning with wayground media and implementing it in learning circle material to improve mathematical connection skills and learning independence of junior high school students. The purpose of this study was to determine the development process, test the feasibility of the instruments used and test the effectiveness of using LKPD based on discovery learning assisted by wayground in improving students' mathematical connection skills and learning independence.

METHOD

This research is a study using the Research and Development (R&D) method which aims to design and implement LKPD which is packaged in Discovery Learning assisted by wayground to improve mathematical connection skills and Learning Independence of Junior High School students. The R&D method aims to produce products through the process of discovering potential problems, designing and developing a product as the best solution (Waruwu, 2024). The subjects of the study were grade VIII students at a junior high school in Bandung Regency, namely 10 grade IXA students for limited testing, 32 grade IXB students for extensive testing and for field testing, 2 classes were taken that had similar academic abilities with a total of 32 students each, with 1 class treatment for the control group using conventional learning and the experimental group with learning using LKPD based on discovery learning assisted by discovery learning. The Development Model of this research refers to the Borg & Gall model with the following steps:

1. Preliminary study: This activity is carried out by collecting data through interviews, literature studies, and needs analysis. The aim is to identify problems and determine an overview of the solutions that need to be developed.
2. Planning, in this stage specific objectives are formulated, user targets are determined, component or product feature designs are designed and resource estimates are made.
3. Making an initial product draft, the activity begins with making an initial design or prototype complete with supporting materials to produce a physical/digital form of the product that will be tested by experts.
4. Validation test, the finished product draft is validated by material experts and media experts to obtain assessments and suggestions for improvement. Then, necessary revisions are made.
5. Limited testing, at this stage the validated product is tested on a limited basis on 10 students with the aim of getting input regarding the readability and practicality of the product.
6. Revision, after conducting limited trials, the product was revised according to the suggestions received, including the addition of alternative answers to short answer questions to improve the product.
7. Extensive testing, the product was tested on a larger number of students, namely 32 students in different classes to obtain data related to the validity of the instruments used and to get more user respon.
8. Revision, after extensive testing, final revisions are carried out to improve the product. Extensive testing is carried out
9. Field testing. In this stage, the product is tested on two groups: a control class using conventional learning and an experimental class using the developed LKPD product.

In this study, the final steps, namely dissemination and implementation, were not carried out for time and cost efficiency. This development model has the advantage of being able to produce a product that has a high level of feasibility and validity as well as a continuous product, meaning that product innovation continues (Mata et al., 2017). The research instruments include: Mathematics Connection Test, Learning Independence Scale, Ahi Validation Scale and Learning Response Questionnaire. In the limited trial stage, the study found that all instruments have met the criteria of a good instrument (validity and reliability, for the scale and connection test and the level of difficulty and discrimination of the mathematical connection test items. In the limited trial stage, it was found that the LKPD packaged inDiscovery learningThe wayground-assisted test still needs to be revised, namely in improving the usage instructions and adding answer sheets for contextual essay questions.

To evaluate the effectiveness of the developed LKPD, a control group and an experimental group design were used. Both groups were given a pretest to measure students' initial mathematical connection skills. The experimental group was then given learning using LKPD-baseddiscovery learningintegrated with the Wayground application, while the control group was taught using conventional teaching methods. The learning intervention was implemented over six sessions, followed by a posttest for both groups to measure learning outcomes and the scale of learning independence.

In the broader trial stage, it was found that the characteristics of the mathematical connection test had good test characteristics (validity of readability by students 0.830, validity of test items 0.626, reliability 0.602, discrimination power 0.546, difficulty level 0.579); the results of the scale trial obtained a scale reliability of 0.820; With these findings, LKPD, mathematical connection test and learning independence scale are suitable for use in product testing.

RESULTS AND DISCUSSION

Results

LKPD Development Process discovery learning based on wayground assistance

- a. The preliminary study began with classroom observations and interviews with subject teachers regarding the material and learning process to identify potential areas and emerging challenges. This information served as a reference for planning and drafting the product to be developed.
- b. Planning and drafting of the product, in this stage the researcher designs and plans the product to be used based on the results of the preliminary study referring to student characteristics, aspects of material adequacy and the applicable curriculum. The design plan includes the application used, the concept and material of the teaching material to be delivered. The research plan includes outputs and target achievements, objectives and problem formulation, research subjects and implementation stages.
- c. Validation Test of teaching materials: This stage is conducted to determine the feasibility of the discovery learning-based student worksheet (LKPD) with the assistance of waygrounds on the topic of circles. The validation test is conducted after the initial product development is complete. This validation activity involves two material experts and one practitioner. The material experts are lecturers in the master's program who assess the LKPD by providing input for improving the product and the instruments used, resulting in a LKPD that is suitable for the trial implementation. The results of the expert validation can be seen in Table 1 and Table 2 below.

Table 1. Material Expert Validation Results

Indicator	First Testing	%	Category	Second Testing	%	Category
LKPD Design	20,3	81,3%	Very Valid	23	92%	Very Valid
Completeness of content and suitability with material	20	80%	Valid	22,3	89,3%	Very Valid
Language proficiency used	13	84%	Valid	13,3	89%	Very Valid
Compatibility with learning model	12	80%	Valid	13	87%	Very Valid

Based on Table 1 above, it can be analyzed that the validation results for the LKPD used are very valid, as seen from the scores for each indicator, namely for the LKPD display getting 92%, Completeness of content and suitability of material 89.3%, Language suitability 89% and suitability with the model used 87%. The validation results above are the average of the validation results from the 3 validators involved.

Table 2. Media Expert Validation Results

Indicator	First Testing	%	Category	Second Testing	%	Category
Layout Design	7	70%	Valid	9	90%	Very Valid
Image Quality	11	73%	Valid	13	87%	Very Valid
Navigation Facilities	11	73%	Valid	14	93%	Very Valid
Appropriate font size and type	8	80%	Valid	9	90%	Very Valid

Based on table 2 above, the results of the media expert validation can be analyzed, which explains that the LKPD is very valid for use, as seen from the scores for each indicator as follows: for LKPD layout design 90%, Image quality 87%, Ease of navigation 93%, Suitability of size and font type 90%.

Table 3. Results of Student Response Questionnaire Assesment of Teaching Materials

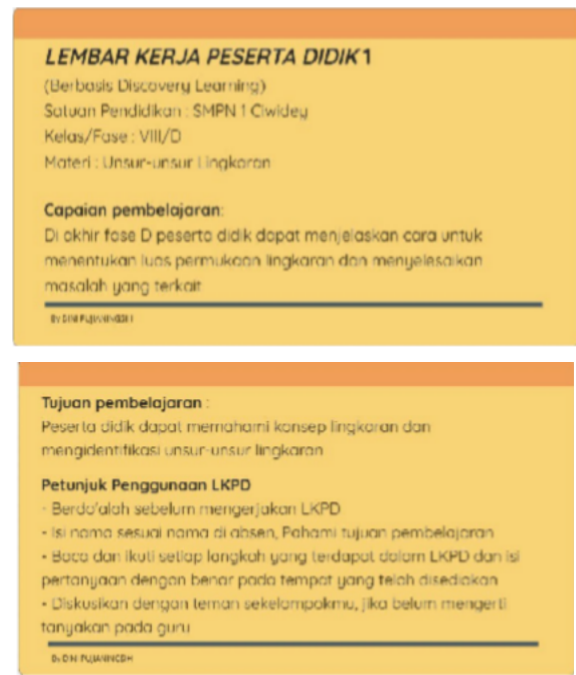
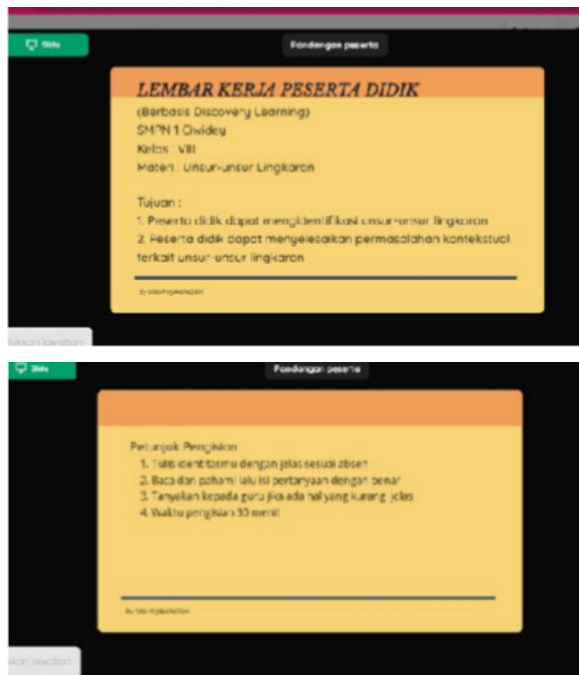
No.	Indicator	N Item	R	SMI	Number of SMI	Total Score	Percentage of Response
1	Usefulness	4	10	5	200	166	83,33%
2	Accessibility	6		5	300	250	80,28%
3	Dependency	4		5	200	168	84,17%
4	Attraction	6		5	360	305	854,7%
Average Percentage							83%

Based on Table 3 above, it can be analyzed that the questionnaire responses to the LKPD are in the very good category. This can be seen from the scores for each aspect assessed: usefulness (83.3%), ease (80.3%), helpfulness (84.2%), and attractiveness (84.7%). The teaching materials used in the above trial have been revised as follows:

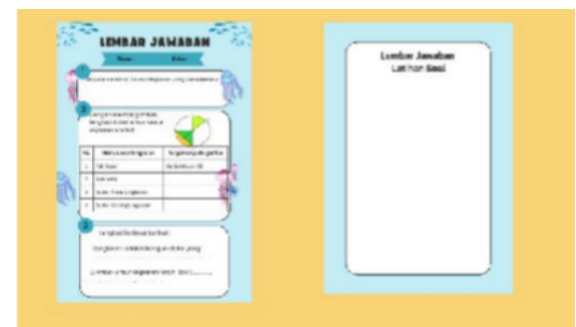
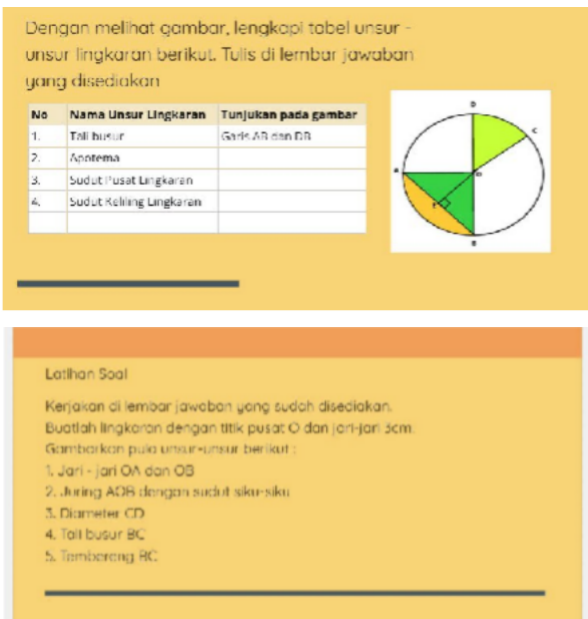
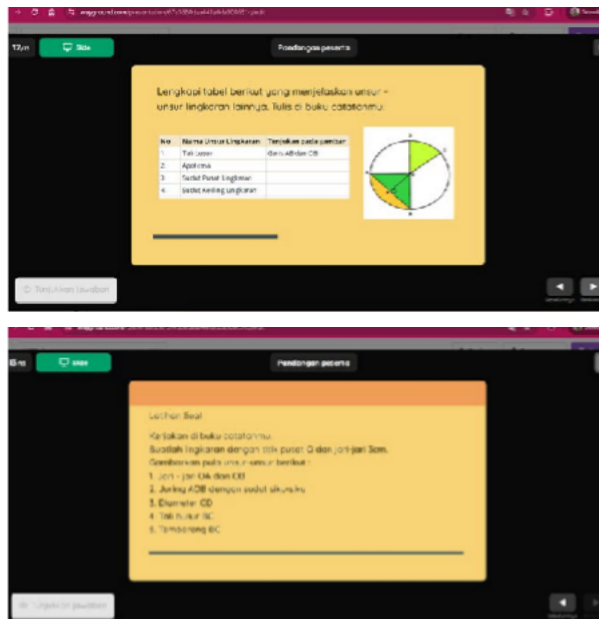
Product Before Revision

Product After Revision

- Improvements to the layout of LKPD: slides 1 and 2, improvements to the instructions for use.



- Revision of LKPD: Slides 12-13, namely the addition of an answer sheet for essay questions



Feasibility of Mathematical Connection Ability Test Instrument, Learning Independence Scale

1. Mathematical Connection Ability Test

The connection ability test instrument was created using connection ability indicators, namely recognizing equivalent representations of the same concept, recognizing relationships between mathematical procedures or processes, using and assessing connections between topics, using and assessing connections between mathematical topics with other disciplines and everyday life. This stage was carried out after the product was validated and revised based on input from expert validators. The instrument trial was carried out to measure the instrument's feasibility, namely in terms of validity, reliability, difficulty index, and discriminatory power. The results of the instrument test can be seen in Table 4 below:

Table 4. Results of Mathematical Connection Ability Trial Test

No	Validity	Reliability	Index Difficulty	Distinguish Power	Note
1	High	Reliable	Moderate	Good	Used
2	Moderate		Moderate	Good	Used
3	Moderate		Moderate	Good	Used
4	Moderate		Moderate	Good	Used
5	Moderate		Moderate	Good	Used

Based on Table 4 above, the validity score of each item can be analyzed above the R table, which means it is valid. The reliability score also reached 0.602, which means it is above the R table, so the item is reliable. The Difficulty Index score is in the moderate range, namely between 0.30 and 0.70, and the discrimination score for all questions is in the good range, namely in the range of 0.4 to 0.7. Thus, the mathematical connection ability test instrument is suitable for use.

2. Learning Independence Scale

The Learning Independence Scale instrument was compiled by referring to the independence indicators according to Mudjiman (2011: 9) which consist of: 1. Self-confidence 2. Active in learning 3. Discipline in learning 4. Responsibility in learning (Ali et al., 2022). The learning independence scale consists of 26 statements with details of the Self-confidence indicator 4 statements, Active in learning 10 statements, Discipline in learning 8 statements and Responsibility in learning 4 statements. The following table shows the validation results of the learning independence scale.

Table 5. Expert Validation Results

Aspect	SMI	V1	V2	Category
Construct	24	23	22	Very valid
Language	24	22	23	Very valid
Construction	20	20	19	Very valid

Based on the table above, validators 1 and 2 gave very valid scores in all aspects assessed, so it can be concluded that all statements are valid and can be used in the learning independence scale instrument.

3. Effectiveness of Wayground-Assisted Discovery Learning LKPD

Mathematical connection skills were analyzed by administering a pretest and a posttest to students in the control and experimental classes. The control class used conventional learning methods, while the experimental class used student worksheets (LKPD) with a discovery learning model assisted by wayground. The pretest aimed to determine students' initial abilities before being given treatment, while the posttest aimed to observe improvements in mathematical connection skills after the learning process.

The results of the pretest data processing of mathematical connection abilities are presented in the following table 6:

Table 6. Normality Test Results for PreTest Data

Class	Sig value	Information
Control	0,01	Abnormally distributed
Experiment	0,034	Abnormally distributed

Based on the results of the normality test shown in the table above, it can be seen that the pretest data for the control and experimental classes are not normally distributed. The control class has a significance value of 0.01, and the experimental class has a significance value of

0.034. Both values are less than 0.05, so it can be concluded that the pretest data for the control and experimental classes are not normally distributed.

To determine the initial level of mathematical connection ability of the control class and the experimental class, the next data analysis was a non-parametric test (Mann Whitney test).

The next step is hypothesis testing. Based on the non-normal distribution of the data, a non-parametric test, the Mann-Whitney test, was used. In the context of this study, the Mann-Whitney test was conducted to determine whether there was a difference in the initial mathematical connection abilities of the control and experimental classes. The statistical hypothesis for the pretest data is formulated as follows:

- $H_0: m_1 = m_2$ There is no difference in initial mathematical connection abilities between students who use conventional learning and students who use LKPD based on discovery learning assisted by wayground.
- $H_1: m_1 \neq m_2$ there is a difference in the initial mathematical connection ability between students who use conventional learning and students who use LKPD based on discovery learning assisted by wayground.

The results of processing the pre-test hypothesis test data can be seen in the table 7 below.

Table 7. Non Parametric Results for PreTest Data

	Score
Mann-Whitney U	398.500
Wilcoxon W	926.500
WITH	-1.578
Asymptotic Sig.(2tailed)	.115

Based on the table above, the 2-tailed asymptotic value of 0.115 is greater than the significance value of 0.05, so it can be concluded that there is no difference in the initial mathematical connection ability between the control class and the experimental class.

The results of the post-test data processing of mathematical connection skills are presented in the following table 8:

Table 8. Normality Test Results for PostTest Data

	Sig value	Information
Control	0,10	Not normally distributed
Experiment	0,406	Normally distributed

Based on the results of the normality test shown in the table above, it can be seen that the control class posttest data has a significance value of 0.01 which is smaller than 0.05, so it can be concluded that the control class posttest data is not normally distributed, while the experimental class has a significance value of 0.406 which is greater than 0.05, so it can be concluded that the experimental class posttest data is normally distributed.

Because one of the data is not normally distributed, to determine the final level of mathematical connection ability of the control class and the experimental class, the next data analysis is a non-parametric test (Mann Whitney test).

Table 9. Non Parametric Results for PostTest Data

Mann-Whitney U	42.000
Wilcoxon W	570.000
WITH	-6.358
Asymp. Sig. (2-tailed)	.000

Based on the Mann Whitney test results table above, the 2-tailed asymptotic value of 0.000 is smaller than the significance value of 0.05, so it can be concluded that there is a difference in the final mathematical connection ability between the control class and the experimental class.

The statistical hypothesis of N gain data is formulated as follows:

- $H_0: m_1 = m_2$ The increase in mathematical connection skills between students who use LKPD based on discovery learning assisted by wayground is not better or the same as students who use conventional learning.
- $H_1: m_1 \neq m_2$ The increase in mathematical connection skills between students who use LKPD based on discovery learning assisted by wayground is better than students who use conventional learning.

The next step to test the above hypothesis is the Mann Whitney test in the table 10.

Table 10. Hypothesis Test

Mann-Whitney U	46.000
Wilcoxon W	574.000
WITH	-6.263
Asymptotic Sig.(2-tailed)	.000

Based on the table above, the Assymp Sig 2 tailed value is 0.000 which means it is less than 0.05, so H_0 is rejected, so it is concluded that the increase in students' mathematical connection abilities using LKPD based on discovery learning assisted by wayground is better than students who use conventional learning.

Discussions

This study shows that the development of teaching materials in the form of LKPD based on Discovery learning Packaged in a valid, practical, and effective wayground application to improve students' mathematical connection skills and independent learning on the topic of circles. To strengthen the discussion, five previous relevant studies are attached below:

First article, the effectiveness of learning models Discovery Learning This study supports the findings of Mawaddah (2025) who stated that there was a significant influence of the use of learning models discovery learning on students' mathematical connection skills. Through a hands-on and contextual discovery process, students are encouraged to actively develop deeper understanding and see the relationships between various mathematical concepts holistically.

Second article, the effectiveness of using the model discovery learning in increasing learning independence in line with the findings of Ihwono (2023) who emphasized the steps of the learning model discovery learning In learning, it can make students more active in exploring knowledge and make them more independent in the teaching and learning process. This learning independence is seen in the form of being responsible and proactive in the learning process, being able to find information sources to meet their needs,

The third article, the use of digital media to explore mathematical connection skills is included in the valid and feasible category (Khoerunnisa et al., 2021). The use of digital media has been proven to provide very significant results in improving mathematical connection skills.

The fourth article, in this study explains that the use of IT-based media in the form of wayground applications can increase student independence, this is reinforced by previous research, namely the results of a study of 20 articles in the period 2017 to 2022 found that IT-based learning media is very useful in increasing student learning independence (Lillihata et al., n.d.)

The fifth article, independent learning significantly influences mathematical connection skills. With independent learning, students can discover connections between various mathematical concepts and their application in contextual problems. This is reinforced by previous research by Septian and Soeleman, who explained a significant association between independent learning and students' mathematical connection skills (2022).

CONCLUSION

This development study produces teaching materials in the form of student worksheets based on Discovery Learning (DL) assisted by interactive web wayground on circle material is valid, practical, and effective. The validation results of material experts reached 89.25% (very valid) and ICT expert validation reached 90% (very valid), while the practicality test reached 83.5% (very practical). The effectiveness test also proved that the implementation of DL assisted by interactive digital media significantly improved mathematical connection skills. Students in the experimental class achieved a higher average score in mathematical connection (70) compared to the control class (52), with an N-Gain of 0.61 (moderate) versus 0.40 (moderate). Statistical testing of Learning Independence confirmed a significant difference between the two groups (sign value <0.05), indicating that there is a difference in learning independence between the control and experimental classes. The use of LKPD based on DL assisted by wayground gave a positive response to students' learning independence. Based on these findings, LKPD learning

material based on DL assisted by wayground on circle material can be an alternative solution to support the development of students' connection skills and learning independence. Schools are also advised to provide adequate technological infrastructure and ongoing professional development for teachers in utilizing interactive digital learning media. For future research, it is recommended to expand the scope of the study by involving a larger sample size and a longer implementation period to test the long-term impact of the developed learning materials. Further studies should also explore other important variables such as critical thinking skills, creativity, and problem-solving abilities. Furthermore, future developments could integrate these learning materials with other digital learning platforms to build a more comprehensive and adaptive digital learning ecosystem.

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