



## Development of Discovery Learning-Based Teaching Modules to Facilitate Mathematical Connection Skills of Phase-F Students in Function Composition and Function Inverse Content

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### ABSTRACT

This research aims to produce a learning tool with a discovery learning model on function composition and inverse function content that meets valid and practical requirements to facilitate the mathematical connection abilities of F-phase students. This type of research is development research with a 4-D research design. The development that the researchers carried out consisted of four stages, namely: (1) define; (2) design; (3) develop; (4) disseminate. This research produced learning tools in the form of learning tools (Teaching Modules). The results of the research show that the learning tools met the criteria for validity and practicality. The validity of the development product is determined by expert validation with an average percentage of 97.22% in the very valid category. The practicality of the development product was determined by teachers with an average of 96.73%, and students with an average of 91.43% in the very practical category. Thus, the learning tools developed have met valid and practical requirements to facilitate students' mathematical connection abilities.

## 1. Introduction

In the Kurikulum Merdeka, mathematics learning aims to help students develop several skills. Based on the Decree of the Head of BSKAP, one of the skills that must be achieved is the ability to make mathematical connections. According to Sinaga et al. (2022), mathematics learning is largely based on the ability to think and build relationships in real life, which is essential for fostering connections and students' thinking skills so they can overcome problems in mathematics learning whose material tends to be abstract and students are also able to achieve mathematics learning objectives. This opinion is in line with Romli (2016), who stated that mathematical connection skills will help students in constructing

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mathematical models that also describe the relationship between concepts and data for a particular problem or situation. Therefore, the ability to make mathematical connections is an important skill for students to have.

According to Romli (2016) the indicators of mathematical connection ability are divided into two indicators, namely: (1) using the relationship between ideas in mathematics; and (2) applying mathematical ideas in contexts outside mathematics. Based on this indicator, researchers expect students to be able to connect mathematical ideas both in one content and in different content. The ability that is desired to be seen is how to use the relationship between facts, concepts, principles, and mathematical procedures in the problems provided. Furthermore, the ability expected from students is that students are able to identify facts, concepts, mathematical principles from everyday life or contexts outside mathematics and use the relationship between mathematics and concepts outside mathematics to solve problems in everyday life.

In contrast to expectations, students' mathematical connection skills are still relatively low. This can be seen from several previous research results. Research conducted by Ziliwu et al. (2022) on the mathematical connection skills of grade XI students in transformation material showed that students were unable to find relationships between transformation completion procedures and other mathematical content, and students were unable to apply mathematical concepts in everyday life or in other fields of science. Furthermore, research conducted by Dinata et al. (2023) on the analysis of students' mathematical connection skills in post-pandemic offline learning showed that students' mathematical connection skills were still relatively low, indicated by the achievement of mathematical connection skills for each indicator still not being achieved. Based on these facts, it can be concluded that students' mathematical connection skills are still relatively low. Therefore, teachers need to design teaching and learning activities in the classroom to be more innovative and use learning models that can facilitate students' mathematical connection skills.

According to Sinaga et al. (2022), the learning model that has a positive influence on mathematical connection skills is the discovery learning model. Sinaga stated that the characteristics of discovery learning have the potential to have a positive influence on mathematical connection skills. The characteristics of the discovery learning model include: (1) exploring and solving problems to form, combine, and announce knowledge; (2) focusing on students; and (3) there are activities combining new knowledge with pre-existing knowledge. These characteristics are reflected in the phases or syntax of discovery learning itself. The syntax of discovery learning includes (1) stimulation; (2) problem identification; (3) data collection; (4) data processing; (5) verification; and (6) generalization. Previous research also shows that the discovery learning model has a positive effect on students' mathematical connection skills, including research conducted by Istiqomah & Nurulhaq (2021), which compared students' abilities between discovery learning and expository learning models, and research by Kusuma et al. (2022), which examined the effect of the discovery learning model on students' mathematical connection skills. Therefore, an alternative learning method that

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enables students to develop good mathematical connection skills is to use the discovery learning model. Therefore, the discovery learning model needs to be packaged in the form of learning tools that can be used by teachers.

According to BSKAP (2022), learning tools and lesson plans are essential to assist teachers in directing the learning process to achieve learning objectives. In the independent curriculum, the learning tools used are teaching modules. These modules are intended to help educators teach more flexibly and contextually, without always relying on textbooks. A teaching module should at least contain objectives, steps, assessments, and learning media that can assist educators in implementing learning. One teaching module typically contains a learning plan for one or more learning objectives based on a predetermined learning objective flow.

Based on research conducted by Windayanti (2023) regarding the problems faced by teachers in implementing the independent learning curriculum, it states that the problems faced by teachers range from analyzing Learning Outcomes (CP) into Learning Objectives (TP), compiling Learning Objective Flows (ATP) and making them into teaching modules, difficulties in determining learning methods and strategies, and teachers' still limited ability to use technology. This is in line with what researchers found in observations and interviews at schools. Researchers obtained information that teachers do not 100% use teaching modules in classroom learning activities. This is because teachers feel that the available teaching modules are not appropriate for the conditions in the classroom. Related to mathematical connection skills, there are no teaching modules specifically to facilitate students' mathematical connection skills in schools.

Function composition and function inverse are materials in the elements of algebra and functions studied in high school. The material on function composition and function inverse is a prerequisite material for subsequent materials, for example, to find derivatives using function definitions, students must apply limits and function composition (Pipit Firmanti, 2023). This material is also related to everyday life and is also related to other fields of science, so it is very important for students to master this material. Based on the results of observations and interviews at SMAN 8 Pekanbaru, it was found that the material on function composition and function inverse is one of the materials considered difficult by students. This is because the material on function composition and function inverse contains abstract concepts and several variables that confuse students, students still have difficulty in connecting and understanding existing functions as function compositions or function inverses, as a result, in this material, most students' exam scores still do not reach the minimum completion criteria.

The problem in this study is whether the discovery learning-based teaching module on the content of function composition and function inverse to facilitate mathematical connection skills has been valid and practical for use by F-phase students. The objective achieved in this study is to produce a product in the form of a discovery learning-based teaching module on the content of function composition and function inverse to facilitate mathematical connection skills of F-phase students that meets the requirements of validity and practicality.

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## 2. Methodology

This research is a type of development research (Research and Development/R&D), which produces a valid and practical teaching module. The teaching module developed uses a discovery learning model on the content of function composition and function inverses to facilitate the mathematical connection abilities of F-phase students. The R&D model used in this study is in accordance with Thiagarajan's flow, namely 4-D (Four-D Models). The development model that will be used by researchers in this study is a 4-D model with a research flow of four stages, namely: (1) defining (define); (2) designing (design); (3) developing (develop); and (4) disseminating (Hikmah et al., 2023).

At the definition stage, initial-final analysis, student analysis, concept analysis, task analysis, and formulation of learning objectives are carried out. The results of this definition stage are problems found and potential solutions are selected for the problems found, namely the need for discovery learning-based teaching modules to facilitate students' abilities, at the design stage activities are carried out in the form of selecting teaching module formats, selecting media, designing teaching modules, and designing sheets to test practicality and practicality, at the design stage an initial draft of the teaching module is produced. Next, the development stage is carried out with validation activities and practicality tests as well as revisions based on suggestions and comments from experts, teachers, and students involved in the validation and practicality tests. The results are teaching modules that meet valid and practical criteria. Finally, the dissemination stage is carried out with seminar activities and the final product is a discovery learning-based teaching module to facilitate students' mathematical connection abilities. The research procedure for developing the 4-D model is presented in Figure 1 below.

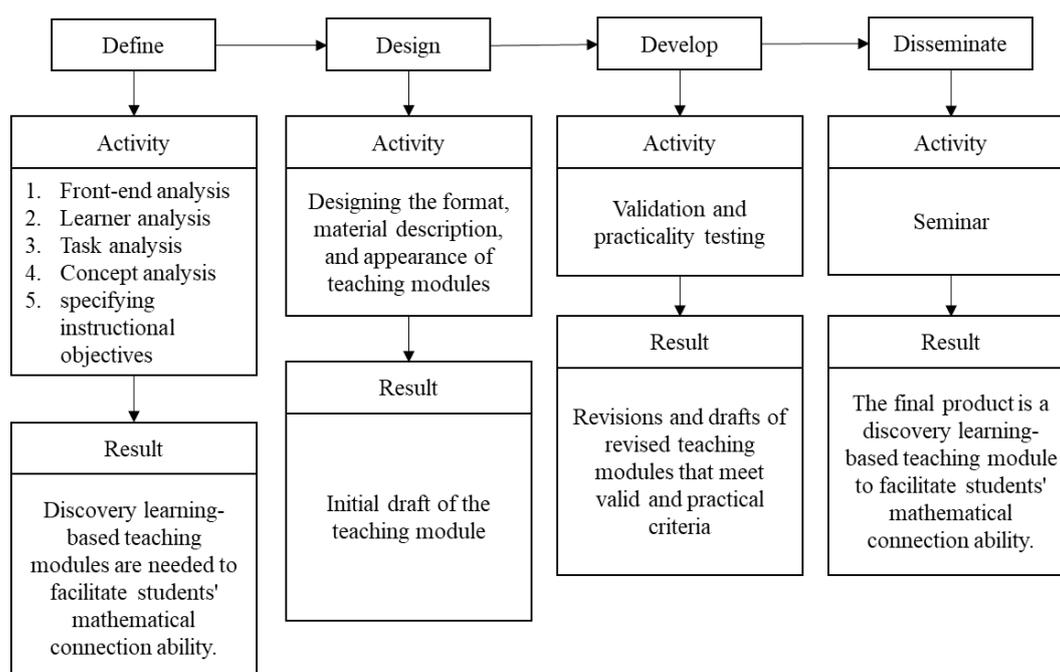


Figure 1. Development Procedure

The types of data in this study include qualitative and quantitative data. The data collection instruments used were the teaching module validation sheet, a readability test questionnaire, a teacher response questionnaire, and a student response questionnaire. The qualitative data in this study were obtained from input from validators or expert lecturers, as well as teachers and students regarding the discovery learning-based teaching module on function composition and function inverses for grade XI SMA/MA Mathematics Phase F students. This qualitative data served as a guideline for revising the developed product. Quantitative data in this study were obtained from the validator's assessment scores on the validation sheet, the teacher response questionnaire scores, and the student response questionnaire scores to assess the discovery learning-based teaching module and worksheet on function composition and function inverses for grade XI SMA/MA Mathematics Phase F students.

The data analysis techniques used in this study included validity and practicality analysis. The teaching module validation sheet was created using the Guttman scale, with assessment categories ranging from 0 (No) to 1 (Yes), and the Likert scale with assessment categories as shown in Table 1 below:

Table 1. Assessment Categories for the Teaching Module Validation Sheet

Category	Score
Totally inconsistent with the statement given	1
Not in accordance with the statement given	2
In accordance with the statement given	3
Very much in accordance with the statement given	4

Source: Adapted from (Nuri & Marsigit, 2019)

The validity value is calculated by adding the scores obtained, dividing by the highest score, and then multiplying by 100%. The average analysis criteria used in the validity analysis can be seen in Table 2 below:

Table 2. Validation Score Criteria

Score Range	Classification
89,01% – 100,00%	Very valid
79,01% – 89,00%	Valid
59,01% – 79,00 %	Less valid
0,00% – 59,00%	Not valid

Teacher and student response questionnaires were used to analyze the practicality of the teaching module. The teacher and student response questionnaires were assessed using a four-point Likert scale: 1, 2, 3, and 4, indicating "very inappropriate," "not appropriate," "appropriate," and "very appropriate." The student response questionnaire was used to determine the practicality of the Student Worksheet (LKPD) as an attachment component of the teaching module, while the teacher response questionnaire was used to determine the practicality of the teaching module as a whole. The criteria for the teacher and student response questionnaires regarding the practicality of the teaching module and the Student Worksheet are presented in Table 3 below.

Table 3. Practicality Score Criteria

Score Range	Classification
89,01% – 100,00%	Very practical
79,01% – 89,00%	Practical
59,01% – 79,00 %	Less practical
0,00% – 59,00%	Not Practical

### 3. Results and Discussion

In the define stage, the researcher identified the basic problems faced, necessitating solutions. The researcher collected data through observations and interviews at two schools, namely SMAN 2 Tambang and SMAN 8 Pekanbaru. The results showed that both schools had implemented the Merdeka Curriculum in grades 10 and 11. Teachers also had teaching modules in accordance with the Merdeka Curriculum but did not implement them 100% in the learning process. This was because the teachers believed that the available teaching modules did not match the available time allocation. This indicated that there were problems for teachers in developing teaching modules and implementing the Merdeka Curriculum. This is in line with the results of research by Zulaiha et al. (2022) that the problems faced by teachers in implementing the Merdeka Curriculum lie in planning, implementation, and learning assessment. The problems faced range from analyzing learning outcomes (CP) into learning objectives (TP), compiling a flow of learning objectives (ATP) and making it into a teaching module, difficulties in determining appropriate learning methods and strategies, and the teachers' still minimal ability to use technology.

In addition, based on the results of observations and interviews, students experience difficulties in connecting existing concepts to solve a given problem or question, this can be seen from the results of previous assessments on the content of function composition and function inverses, most students obtained scores below the minimum completion criteria. Difficulties in using mathematical concepts with concepts outside mathematics, including daily life problems, are related to mathematical connection abilities. For this reason, researchers gave a mathematical connection ability test with the content of function composition and function inverses to 32 students, the results obtained were that students' mathematical connection abilities were classified as low. These results are in line with research from Ziliwu's (2022) study, which found that 20 students had low mathematical connection skills, with findings that students did not understand mathematical concepts, students did not understand the relationship between mathematical concepts and other mathematical topics, students were unable to find the relationship between mathematical problem-solving procedures and other mathematical procedures, and students were unable to apply mathematical concepts in everyday life or in other fields of science.

One alternative in learning that allows students to have good mathematical connection skills is through the discovery learning model. Based on research by Istiqomah & Nurulhaq (2021) who examined the comparison of students'

mathematical connection skills between discovery learning and expository learning models, it was found that the Discovery Learning learning model was better than students who received expository learning. This is in line with research by Kusuma et al., (2022) whose research results showed that the mathematical connection skills of students who were given the guided discovery learning model were better than students who were given conventional learning. Research conducted by Saputra et al. (2022) found that learning devices with the discovery learning model met the valid and practical requirements for facilitating students' mathematical connection abilities.

In the analysis of students, it was found that the students who were the subjects in this study were grade XI high school students with an average age of 17 years. According to Piaget's concept, the intellectual abilities of 17-year-olds have reached the formal operational phase where students are generally able to think abstractly, are able to use their reasoning, are able to construct their own knowledge, and are able to develop deductive hypotheses about how to solve problems and reach conclusions systematically (Ardiningtyas et al., 2023). However, because all students have different abilities, the learning module developed is a learning module that can be used by regular students with high, medium, and low abilities.

The researcher conducted a concept analysis by identifying the concepts to be developed and systematically arranging them related to the content of function composition and function inverse. In this content, 8 sub-contents were obtained, namely the conditions and rules for two functions to be composed, determining the composition of two functions, the relationship between commutative and associative properties with function composition, problems related to function composition with other mathematical ideas and everyday life, conditions for a function to have a function inverse (bijective function), determining the inverse of a function, the relationship between function composition and function inverse, and problems related to the concept of inverse function with other mathematical concepts and everyday life. Next, the researcher conducted a task analysis by formulating ATP from the F-phase learning outcomes referring to BSKAP 2022. Then the researcher conducted an analysis of learning objectives by analyzing the competencies and scope of content in the F-phase learning outcomes. Learning objectives are used as a reference in developing teaching modules.

The next stage is design. In the format selection, the format of the teaching module was obtained which was developed in accordance with the provisions of the teaching module based on BSKAP (2022). The media selection for the developed teaching module was in the form of print media. The initial design of the teaching module product includes the design of the teaching module for 4 meetings. Meeting-1 contains the composition content of the time allocation function of  $3 \times 45$  minutes, meeting-2 contains the composition content of the time allocation function of  $3 \times 45$  minutes, meeting-3 contains the inverse content of the time allocation function of  $3 \times 45$  minutes, and meeting-4 contains the inverse content of the time allocation function of  $3 \times 45$  minutes. Furthermore, in the design stage, the researcher also designed a validation sheet, a readability questionnaire, a teacher response questionnaire, and a student response questionnaire. The teaching module

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and LKPD sheets were assessed based on content and construct aspects. This is in line with Amalia's (2024) research but differs in the aspects of model suitability and ability. The readability questionnaire was designed by assessing the readability of the LKPD in terms of LKPD display, LKPD content/material, and language. This is in line with research conducted by Siti Masruroh (2023) but differs in terms of content, model, and ability. The student response questionnaire was designed by assessing the LKPD display, LKPD content/material, and ease of use. This is in line with research conducted by Siti Masruroh (2023) but differs in terms of content, learning model, and ability. The teacher response questionnaire was developed by assessing aspects of teaching module suitability, LKPD suitability, and learning implementation. This is in line with research conducted by Kamaluddin & Rusgianto (2019) but differs in terms of content, learning model, and ability.

In the development stage, activities were carried out to develop the initial design of the teaching module with the validation and product trial stages. The results obtained were a discovery learning-based teaching module to facilitate the mathematical connection skills of phase-F students that met the requirements of validity and practicality. The results of the validation of the teaching module with an average value given by the validator with aspects of construct, content, face, and language. The average value obtained was 92.81% which met the criteria of very valid. Validation of the LKPD components was carried out separately. The results of the questionnaire and validation test analysis obtained an average validity of LKPD 1 of 89.87% with a very good category, the validity of LKPD 2 had an average of 90.69% with a very good category, the validity of LKPD 3 had an average of 90.67% with a very good category, and LKPD 4 had an average of 90.14% with a very good category, and the average validity of the developed LKPD was 90.34% with a very valid category. This is in line with the results of research by Saputra et al. (2022) who obtained a very valid category with an average percentage of 94.25%. Based on these validation results, it was concluded that the teaching module met the valid requirements.

The three validators also concluded that the developed teaching module was worthy of being tested with revisions. The validator's comments on the developed teaching module were found on the cover of the developed teaching module which was less attractive because the color was too pale. Furthermore, there were comments on the core components of the teaching module, specifically in the remedial and enrichment sections, which lacked a sequence of learning activities. The validator's comments also concerned the typography in the teaching module and suggestions for adding names and sources for images in the teaching module and worksheets. Comments and suggestions on the worksheets focused primarily on expanding the student answer space. The teaching module was then revised based on the validator's suggestions and comments, which became the revised draft from the validation stage. Changes in the appearance of the cover before and after revision can be seen in figure 2 and figure 3.

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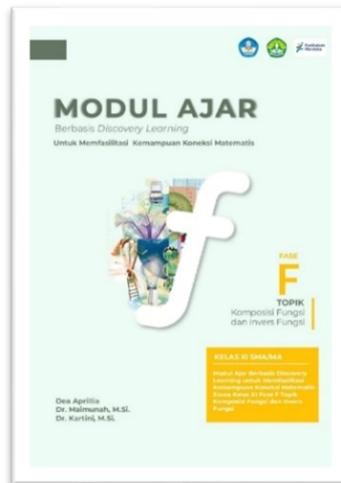


Figure 2. Cover view of teaching module before revision



Figure 3. Cover view of teaching module after revision

The results of the teaching module validation are presented in Table 4 below.

Table 4. Teaching Module Validation Results

Aspect	The average value of the three validators in the teaching module at the th meeting (%)				Average (%)	Category
	1	2	3	4		
Content	94,95	94,96	95,51	94,40	94,96	Very Valid
Construct	90,45	89,81	90,12	92,28	90,66	Very Valid
	Average (%)				92,81	Very Valid

The results of the LKPD validation test as a component of the teaching module attachment are presented in Table 5 below.

Table 5. LKPD Validation Results

Aspect	Average validity value of LKPD (%)				Average	Category
	1	2	3	4		
Content	90,18%	90,96%	90,29%	90,29%	90,43%	Very Valid
Construct	89,56%	90,41%	91,05%	89,99%	90,25%	Very Valid
Average	89,87%	90,69%	90,67%	90,14%	90,34%	Very Valid

The results of the teacher response questionnaire regarding the practicality of learning devices were 96.73%. The teaching module aspect was 96.43% with a very practical category, the LKPD aspect was 97.92% with a very practical category, and the learning implementation aspect was 95.83% with a very practical category. These results are in line with the results of Kamaluddin & Rusgianto's (2019) research which obtained results with a very practical category for LKPD with an average percentage of 91.20%. Furthermore, for the student response questionnaire, the results were 91.43% with a very practical category. This result is in line with the research results of Kamaluddin & Rusgianto (2019) who obtained results with a very practical category for LKPD with an average percentage of 91.20%. Furthermore, for the student response questionnaire, the results were 91.43% with a very practical category. In all aspects, the average for LKPD 1 was 91.68% with a very practical category, LKPD 2 was 91.88% with a very practical category, LKPD 3 was 91.70% with a very practical category, and LKPD 4 was 91.78% with a very practical category. In the overall LKPD, the appearance aspect had an average of 89.73% with a very practical category, the content/material aspect had an average of 89.87% with a very practical category, the ease of use aspect had an average of 90.98% with a very practical category. This is in line with the results of research conducted by Amalia (2024) who obtained results in the very practical category for LKPD with an average percentage of 91%. The results of the teacher response questionnaire regarding the practicality of the teaching module as a whole are presented in table 7 below,

Table 7. Results of the Teacher Response Questionnaire on the Practicality of the Teaching Module

Aspect	Practicality Value	Category
Teaching Modules	96,43%	Very Practical
LKPD	97,92%	Very Practical
Implementation of Learning	95,83%	Very Practical
Average	96,73%	Very Practical

The results of the student response questionnaire regarding the LKPD components in the large group trial are presented in table 8 below,

Table 8. Results of the Student Response Questionnaire for the Large Group Trial

Aspect	Average practicality value of LKPD (%)				Practical Value	Category
	1	2	3	4		
Appearance	90,18%	90,96%	90,29%	90,29%	89,73%	Very Practical

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Content/ Material	89,56%	90,41%	91,05%	89,99%	89,87%	Very Practical
Ease of Use	95,31%	94,27%	93,75%	95,05%	90,98%	Very Practical
Average	91,68%	91,88%	91,70%	91,78%	91,43%	Very Practical

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At the dissemination stage, the researcher packaged the product in the form of a book and held a seminar on the development of the developed teaching module and. Based on the explanation above, the teaching module developed based on discovery learning to facilitate the mathematical connection skills of phase-F students meets the valid and practical requirements so that it can be used as a reference or used in the mathematics learning process. However, this development research has not yet reached the stage of measuring effectiveness. This research also has another weakness, namely that in the implementation of large group trials it was not carried out in the appropriate time allocation and has not been able to facilitate the overall mathematical connection skills. Thus, further research can carry out research up to the effectiveness stage by paying attention to mathematical connection capabilities.

#### 4. Conclusion

This development research produced a product in the form of a teaching module which is a learning tool that refers to the independent curriculum based on discovery learning on the content of function composition and function investment for phase F students of grade XI of high school/Islamic high school that can help facilitate mathematical connection skills. This teaching module has met the requirements of validity and practicality after being validated by three validators, three students in one-to-one testing, six students in small group trials, one teacher and 32 students in large group trials.

However, this developmental research has not yet reached the stage of measuring effectiveness. Another weakness of this study is that the large-group trial was not conducted within the stipulated time allocation and did not facilitate the overall development of mathematical connection skills. Therefore, further research can be conducted to the effectiveness stage by considering mathematical connection skills.

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