



Technology-Assisted Inductive Learning: A Content Analysis of Prospective Mathematics Teachers' Lesson Plans

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Abstract

The shift in learning paradigm from passive to active requires prospective teachers to design meaningful learning experiences, one of which is through a technology-assisted inductive approach. This study aims to analyze the content of lesson plans developed by prospective mathematics teachers to implement technology-supported inductive learning. Using a qualitative content analysis method, this study involved 15 prospective mathematics teacher students from the State Islamic University of Salatiga who had taken courses related to lesson planning. The data sources for this study were lesson plan documents based on inductive learning, including Problem-Based Learning and Discovery Learning. Data were analyzed using thematic analysis to identify hidden patterns and themes. The results show that prospective teachers have integrated technology into each indicator of inductive learning, where the learning stages clearly begin from specific cases or problems to the generalization of concepts. This study contributes to providing an in-depth understanding of how prospective mathematics teachers translate inductive learning theory into lesson planning practices in the digital era, while also identifying aspects that need improvement in teacher training. Future research should investigate the relationship between the quality of lesson plan design and classroom teaching performance. Furthermore, comparative studies involving different technology platforms are needed to identify which tools best facilitate the conceptual discovery phase of inductive learning.

Keywords: inductive learning; innovation; lesson plan; prospective teachers; SDGs 4



INTRODUCTION

Mathematical knowledge needs to be actively constructed by students, rather than being transferred by teachers. Students in mathematics lessons should make progress in their learning by following the teacher's instructions and actively participating, using prior knowledge to understand new information, and transforming it into new knowledge (Emanet & Kezer, 2021). The role of teachers in this paradigm is becoming increasingly crucial, not merely as transmitters of information, but as facilitators who design meaningful learning experiences. In line with this shift, student-centered and inquiry-based learning approaches have become a key foundation in global curriculum reform (Hmelo-Silver et al., 2007).

One highly relevant pedagogical framework is inductive learning. Inductive learning is how people build up a great deal of knowledge (Birnbaum et al., 2013) which is the primary method humans use to acquire knowledge (Ge et al., 2021). Inductive learning is defined as an approach in which students start with specific examples, cases, or data and then discover principles, concepts, or generalizations independently (Richter et al., 2022; Zulkiply, 2013) in contrast to the deductive approach, which starts from general rules, its characteristics include starting from the specific to the general, being learner-centered, students building their understanding or formulating concepts from the results of exploration, involving active learning, connecting new knowledge with prior knowledge, and problem-solving-oriented assessment (Prince & Felder, 2006, 2007).

Numerous international studies have demonstrated that inductive learning offers several significant advantages. For example, (Iyanda & Sam-Kayode, 2024) confirms that inductive strategies are effective for introducing new mathematical concepts through real-world examples, enabling students to construct generalizations based on situational understanding. Inductive learning is effective in achieving student learning outcomes, increasing learning motivation, and supporting mastery of professional and metacognitive skills (Prince & Felder, 2006), and critical thinking skills (Arjunaidi & Azid, 2022).

Inductive learning encompasses several learning models, including problem-based, inquiry, case-based, project-based, just-in-time teaching, and discovery learning (Prince & Felder, 2006, 2007). These models emphasize student-centered learning, real-world problem solving, and active engagement in exploring concepts (Lutfi et al., 2025). The goal is to encourage students to discover and explore concepts rather than simply passively receiving information. Thus, the inductive learning model helps students develop a deeper understanding of the material.

Problem-Based Learning (PBL) requires students to develop their abilities actively (Argaw et al., 2017). According to Barrows, the features of PBL are: Learning is learner-centered, learning takes place in small learner groups, Teachers are facilitators and guides, Problems organize focus and apply knowledge, Problems are means for improving problem-solving skills, and new information is acquired by individual learning (Ari & Katrancı, 2014). PBL syntax includes orienting students to problems, organizing students to learn, guiding individual and group investigations, developing and presenting work results, and analyzing and evaluating the problem-solving process (Arends, 2012). PBL provides students with the broadest possible opportunity to develop their creativity in solving problems (Arzu & Katranc, 2014). The advantages of PBL include increasing mathematical literacy (Tabun et al., 2020), critical thinking skills (Putri & Siburian, 2021), mathematics learning achievement (Lusiana et al., 2021), and students' mathematical understanding (Yelvalinda et al., 2019).

According to Bateman (Prince, 2006), inquiry learning begins when students are faced with a problem to be solved, a series of observations to be explained, or a question to be answered (Prince & Felder, 2006). This model is designed to enable students to construct models, interpret data, or develop scientific explanations through a series of integrated activities that combine experiments, knowledge, and scientific reasoning (Diego Antonio Urdanivia et al., 2023). The inquiry method has proven to be most effective in facilitating students' discovery of the world by utilizing the knowledge and investigative skills they have mastered (Kamarudin et al., 2022). The stages of inquiry learning include starting the inquiry process, increasing dialogue with students, forming discussion groups, clarifying students' misunderstandings about scientific research procedures, attitudes, materials, and using students' experiences in order to form new knowledge (Odegaard et al., 2015).

In CBL, students are presented with specific cases that require them to apply their acquired knowledge (Loyens et al., 2008). Experts cite the following characteristics of CBL: students prepare the case beforehand, students apply their knowledge to solve or explain the case, the lecturer acts as a facilitator, and there is typically no post-session independent learning (Wijnia et al., 2024). Case studies create an active and meaningful learning environment that allows educators to develop students' critical thinking and analytical skills through the exploration of real-world situation (Emblen-Perry, 2022).

Project-based learning facilitates an active learning process in which students seek solutions, ask questions, discuss ideas, design plans, and interact socially (Choi et al., 2019). According to Krajcik and Shin (2014), Project-Based Learning is characterized by six key elements: the presence of driving questions, a focus on learning objectives, active involvement in educational activities, student collaboration, the use of scaffolding technology, and results in the form of concrete artifacts (Guo et al., 2020). According to Ayas and Zeniuk (2001), product creation in a project environment triggers opportunities for reflection, encourages students to take responsibility for their own decisions, and integrates multiple perspectives throughout the learning experience (Marnewick, 2023).

JiTT facilitates students in completing online assignments (such as reading or watching videos) and reporting difficulties, which then allows teachers to receive feedback, evaluate learning performance, and develop relevant learning plans (Zou & Xie, 2019). According to Novak (2007), Just-in-Time Teaching is an online pre-lesson activity that allows students to share knowledge with teachers and peers, so that instructors can utilize this prior knowledge to better prepare for class (López Cupita, 2016). According to Marrs and Novak, JiTT has the potential to increase good study habits and interactivity, while reducing attrition rates and increasing student satisfaction and cognitive achievement (Dominguez et al., 2018).

Arends (Andriyani et al., 2021) Explains that Discovery Learning (DL) is a student-centered learning approach that provides an active learning experience, where students discover and express their ideas related to the topic being studied. The DL method is considered promising because, unlike traditional learning, which is said only to transfer information, it encourages the active involvement of the learner to build a more organized foundation of knowledge (Aldalur & Perez, 2023). DL is executed through six syntaxes namely (1) stimulation in the form of teachers sparking curiosity with questions, pictures, or phenomena; (2) problem statement, namely students identify problems and formulate initial hypotheses; (3) data collection, namely students explore sources to obtain information; (4) data analysis, namely students organize and interpret findings; (5) verification, namely students check the truth of the hypothesis using evidence that has been processed, and (6) generalization, namely students draw conclusions/general concepts and communicate the results (Wulandari, 2021). DL can develop cognitive skills and processes (Fadlilah et al., 2020), students' mathematical reasoning skills, communication, and self-confidence (Siregar et al., 2020).

Technology can strengthen the implementation of the inductive approach. Technology can replace traditional activities (Substitution) or add new functionality (Augmentation). For example, incorporating multimedia components into presentations (via tools like PowerPoint or Prezi) serves to engage students more fully than a traditional lecture would (Paulauskaite-Taraseviciene et al., 2022), changing the form of teaching assignments (Modification), to create activities that were previously impossible (Redefinition) (Blundell et al., 2022; Cáceres-Nakiche et al., 2024; Hilton, 2016; Kihzoza et al., 2016; Son, 2024). This means that technology can function as anything from an aid to a transformer in learning methods, and have an impact on student engagement (Attard & Holmes, 2019).

Digital tools are instrumental in creating interactive learning environments that accommodate diverse learning styles. For instance, a study by (Carriazo-Regino et al., 2024) concluded that tools like GeoGebra are effective in improving trigonometric competence by allowing students to visualize mathematical concepts dynamically. Furthermore, a blended approach, where digital platforms complement traditional learning, can facilitate mathematical understanding by enabling learning to occur anytime and anywhere (Attard & Holmes, 2019). Teacher education must effectively prepare student teachers to teach effectively with technology (Norhagen et al., 2024).

Based on a preliminary study conducted at the Mathematics Education Study Program at Salatiga State Islamic University from 2019 to early 2025, it was found that the majority of students as prospective mathematics teachers have not mastered inductive learning. This can be classified through

several conditions: 1) prospective mathematics teachers write inductive learning models in lesson plans but fill them with formula presentations at the beginning of the lesson, and 2) students have difficulty understanding the inductive learning paradigm (Wulandari et al., 2023).

Several studies have been conducted on the content analysis of lesson plans designed by prospective teachers. Findings indicate that pre-service science teachers demonstrate TPACK in their peer teaching and lesson plans, using technology (Bilici et al., 2016). Prospective physics teachers implement digital learning materials in their lesson plans, the most commonly used of which are learning videos, simulations, and videos equipped with several questions to develop student competencies (Thenetweeraphat, 2022). The prospective mathematics teacher's lesson plan demonstrates content knowledge and instruction (Sapkota & Hayes, 2024). These findings suggest that lesson plan analyses have primarily focused on TPACK and technology, but these studies were conducted with prospective science and physics teachers, rather than prospective mathematics teachers. Some research has been conducted on prospective mathematics teachers' lesson plans; however, it has not focused on the use of technology. Furthermore, in general, there is little research examining prospective mathematics teachers' ability to implement inductive learning in their lesson plans. However, the application of inductive learning is efficient for enhancing student learning outcomes. Therefore, more in-depth research is needed to explore how prospective teachers integrate technology-assisted inductive approaches into their instructional designs.

This study aims to analyze prospective mathematics teachers' lesson plans in depth to understand how they integrate and implement technology-assisted inductive learning. Thus, the study contributes to a comprehensive understanding of prospective teachers' lesson planning practices in the digital era, while also identifying aspects that can be improved in teacher training programs to enhance the quality of inductive learning implementation.

METHOD

Types of research

This research includes qualitative research with the type of content analysis, which is a systematic research method for analyzing textual data to identify patterns, themes, or hidden meanings in it (Hsieh & Shannon, 2005). Qualitative content analysis is specifically designed to extract in-depth information from documents, transcripts, or other texts (Krippendorff, 2019). This method is suitable for application in this research because it will help researchers understand how prospective mathematics teachers design technology-assisted inductive learning through their teaching modules.

Research Procedures

Content analysis of lesson plans prepared by prospective mathematics teachers was carried out according to research procedures (Krippendorff, 2019) as follows: 1) formulation of research questions, namely "How do prospective mathematics teachers implement technology-assisted inductive learning in their lesson plans?", 2) determination of data sources, namely lesson plans based on technology-assisted inductive learning prepared by prospective mathematics teachers, 3) determination of recording units based on seven characteristics of inductive learning, 4) development of categories based on descriptors of each characteristic of inductive learning, 5) data analysis using thematic analysis (Braun & Clarke, 2006; Nowell et al., 2017).

Research Subjects

The research subjects were prospective mathematics teachers, namely 15 undergraduate students of the Mathematics Education/Tadris Study Program at the State Islamic University of Salatiga who had taken courses related to mathematics learning theory, planning, implementation, and evaluation of mathematics learning, and had taken microteaching courses assisted by the Learning Management System in the form of Google Classroom at the address <https://classroom.google.com/u/2/c/NzYxMjc3NjMwMjgy> to facilitate learning that is not limited by space and time and supported by a learning community consisting of PMT members and lecturers who teach in the Mathematics Education study program. Participants were selected purposively based on the research objectives. A total of 45 students participated in the LMS-assisted microteaching course. Of these 45 students, 15 participants were selected who demonstrated data saturation through the discovery of similar patterns or conclusions. This research was conducted from February to July 2025 in the

Mathematics Education Study Program at Salatiga State Islamic University, located at Jalan Lingkar Salatiga, Km. 2, Pulutan, Sidorejo, Salatiga City, Central Java.

Instruments, Data Sources, and Data Analysis Techniques

The analysis instrument is in the form of a technology-assisted inductive learning checklist based on the characteristics of inductive learning, namely starting from the specific to the general, centered on the learner, students build their own understanding or formulate their own concepts from the results of exploration, involving active learning, connecting new knowledge with prior knowledge, and problem-solving oriented assessment (Prince & Felder, 2006, 2007). The data source originates from teaching modules developed by prospective teachers utilizing the PBL and Discovery Learning models. The data were analyzed using thematic analysis (Braun & Clarke, 2006; Nowell et al., 2017) includes 1) familiarizing with the data: this involved repeatedly reading the prospective mathematics teachers' lesson plans to gain a deep understanding of the content and noting initial analytical ideas, 2) creating initial codes: this involved regularly coding interesting features and segments of the data, specifically focusing on identifying and capturing the explicit and implicit characteristics of technology-assisted inductive learning contained in the lesson plans, 3) searching for themes: the resulting codes were aggregated into broader potential themes that represented patterns of meaning within the data set, 4) reviewing themes: potential themes were rigorously examined against code extracts and the entire data set to ensure they accurately reflected the data and were distinct from one another, 5) defining and naming themes: this involves defining the specific content of each theme, resulting in a clear and concise definition and final theme name, and 6) producing reports: selecting clear and compelling quotes from the lesson plans to illustrate each theme, conducting a final interpretive analysis, and linking the findings back to the research question and relevant literature.

RESULTS

The research results are described based on the characteristics of inductive learning, including starting from the specific to the general, being learner-centered, students building their own understanding or formulating concepts from the results of exploration, involving active learning, connecting new knowledge with prior knowledge, and problem-solving-oriented assessment (Prince & Felder, 2006, 2007). The research results are described based on the characteristics of inductive learning, including starting from the specific to the general, being learner-centered, students building their own understanding or formulating concepts from the results of exploration, involving active learning, connecting new knowledge with prior knowledge, and problem-solving-oriented assessment.

From Specific to General

This characteristic is characterized by the presence of an opening activity that presents a contextual problem, a mathematical case study, or data/phenomena that trigger exploration. All PMTs were able to translate this characteristic from specific to general in the teaching modules they created. The following are elements of the teaching modules developed by prospective mathematics teachers, in this case, PMT and RRA, which show these characteristics, as shown in Table 1:

Table 1. The lesson plan section of the RRA subject shows the characteristics starting from specific to general

Problem-Based Learning Syntax	Teacher Activities	Student Activities
Orienting students to the problem	1. The teacher provides thought-provoking questions about sets, relations, and functions.	1. Students answer the questions given by the teacher.
	2. The teacher gives questions that stimulate students to understand problems related to relations, functions, and their connections.	2. Students listen to and understand the problems presented and delivered by the teacher.
	3. The teacher allows students to ask about the problems that have been discussed previously.	3. Students are allowed to ask questions if they encounter difficulties in understanding the content of the problem presentation that has been discussed.

RRA prepared a teaching module for eighth-grade junior high school mathematics learning on the topic of relations and functions, with the learning objective that students can identify and state everyday problems or situations that are relational and functional. The learning model used is Problem-Based Learning (PBL). Based on Figure 1, it is known that in the first syntax of PBL, RRA includes activities to provide questions that stimulate students to understand problems related to relations, functions, and their relationships in everyday life, such as the relationship between the number of items purchased and the total price of an item and the relationship between a vehicle license plate and a vehicle. This indicates that RRA has presented initial learning activities in the teaching module that are in accordance with the presence of an opening activity section that presents contextual problems, mathematical case studies, or data/phenomena that trigger exploration. RRA presents contextual problems in the form of situations regarding the relationship between the number of items purchased and the total price of an item, as well as the relationship between a vehicle license plate and a vehicle. Students will then solve this contextual problem through investigation activities through syntaxes 2 to 5.

The characteristics starting from specific to general are also in line with the student worksheet compiled by RRA, as shown in Figure 1 below:



Translation:

Student Worksheet

Syntax 1: Orienting Students to the Problem

At Pelita Bangsa Middle School, a special class is offered each month for additional extracurricular activities. In this special class, there are only four children, namely Andi, Budi, Citra, and Doni. The available extracurricular activities are the Youth Scientific Group (KIR), dance, music, and futsal. Each month, there are rules that each child must follow, adjusted to the amount of time and the number of supervisors in each of these extracurricular activities.

Alpha Package

In the first four months (January to April), no rules were applied. They were free to choose the extracurricular activities they wanted. In January, Andi chose dance, Budi chose Youth Scientific Group (KIR), Citra chose futsal, and Doni chose music. In February, Andi chose KIR, dance, music, and futsal, but Budi, Citra, and Doni did not make a choice. In March, Budi chose the Youth Scientific Group (KIR), but Andi, Citra, and Doni did not. In April, Andi chose KIR, Budi chose dance, Citra chose music, and Doni did not make a choice.

Beta Package

In May, a rule had to be followed, which required each child to choose an extracurricular activity and could only choose one. Andi chose Youth Scientific Group (KIR), Budi chose dance, Citra chose music, and Doni chose futsal. In June, the rules remained unchanged from March. Andi chose KIR, Budi chose dance, and Citra and Doni chose music.

Note: KIR means Youth Scientific Group

Figure 1. The student worksheets section of the RRA subject shows characteristics ranging from specific to general

Figure 1 shows that RRA presents a contextual problem in the form of a student's extracurricular choice situation with specific rules. These rules lead to the concepts of relations, functions, and non-functions. These problems will be explored in the following syntax. CSP demonstrates the use of technology in the first characteristic by presenting contextual problems through the YouTube platform, as shown in Table 2.

Table 2. Sections of the CSP lesson plan that show characteristics of moving from specific to general with the help of technology.


Syntax	Teacher Activities	Student Activities
Student orientation to problems	1. The teacher shows a YouTube video in front of the class using a projector about examples of algebraic form problems. Link: https://www.youtube.com/watch?v=9XJrcSSluSw 	1. Students are asked to watch and observe https://classroom.google.com/u/2 allowed to ask questions if they have difficulty understanding the content of the material presentation.

Table 2 shows the use of links to instructional videos uploaded to the YouTube platform. CSP intends the videos to present contextual problems related to the topic of algebraic forms.

Learner-Centered

These characteristics are characterized by descriptions of activities in lesson plans that tend to involve students analyzing, solving, and formulating, with teachers facilitating, guiding, or asking stimulating questions. All PMTs have successfully translated these characteristics into the teaching modules they created. The following are elements of a teaching module developed by one PMT, RRA, which demonstrate these characteristics, as shown in Table 3:

Table 3. The lesson plan section of the RRA subject shows student-centered characteristics

Syntax	Teacher Activities	Student Activities
Organizing students for learning.	1. The teacher asks students to form groups of 3-4 people based on the results of the cognitive diagnostic test from the previous day (divided into two groups: students with a moderate and high understanding of relation and function material). 2. The teacher distributes student worksheets (LKPD) according to the groups (moderate and high), which contain tasks to be completed through group discussion. 3. The teacher allows all groups to understand the problem and plan the steps to be taken to solve it.	1. Students gather in their respective groups. 2. Students understand the provided student worksheet. 3. Students understand the problem and plan the steps to be taken to solve it.
Guiding individual and group investigation.	1. The teacher asks students to investigate by collecting information about problems related to relations and functions. 2. The teacher circulates to guide and monitor students' activities in solving problems related to relations and functions. For the moderate group, more emphasis and assistance are given. 3. The teacher also directs that at the end, there will be learning resources (barcodes) to help conclude.	1. Students investigate by gathering information to solve problems related to relations and functions. 2. Students open learning resources in order to formulate a conclusion.
Developing and presenting the work.	1. The teacher instructs students to develop their investigation results regarding problems related to relations and functions information about problems related to relations and functions. 2. The teacher asks one or two group representatives to present the results of their discussion, then asks other groups to respond.	1. Students develop their investigation results. 2. Representatives from each group present the results of their discussion, then other groups provide feedback on the other group's presentation.
Analyzing and	1. The teacher facilitates students to analyze the problem-solving.	1. Students work on the given questions.

evaluating the problem-solving process.

2. The teacher helps students to reflect and evaluate the problem-solving process.

2. Students make improvements by summarizing or making conclusions in accordance with additional input from the teacher.

3. The teacher evaluates the students' learning outcomes.

Table 3 shows that the RRA includes activities such as teachers asking students to conduct investigations by gathering information on problems related to relations and functions, and teachers facilitating students in analyzing and solving problems. This is also supported by the student worksheet prepared by the RRA, as shown in Figure 2:



Translation:

Syntax 1: Student Orientation to the Problem

At Pelita Bangsa Middle School, a special extracurricular class is offered every month. In this special class, there are only four children: Andi, Budi, Citra, and Doni. The available extracurricular activities are KIR, dance, music, and futsal. Every month, there are rules that each child must follow, which are adjusted according to the duration and supervision for each extracurricular activity.

Paket Alfa

For the first 4 months (January to April), no rules were applied. They were free to choose the extracurricular activity they wanted. In January, Andi chose dance, Budi chose KIR, Citra chose futsal, and Doni chose music. In February, Andi chose KIR, dance, music, and futsal, but Budi, Citra, and Doni did not make a choice. In March, Budi chose KIR, but Andi, Citra, and Doni did not choose. In April, Andi chose KIR, Budi chose dance, Citra chose music, and Doni did not make a choice.

Paket Beta

In May, a rule had to be met: every child had to choose one extracurricular activity, and only one activity could be chosen. Andi chose KIR, Budi chose dance, Citra chose music, and Doni chose futsal. In June, the rule remained unchanged from March. Andi chose KIR, Budi chose dance, and Citra and Doni chose music.

Note:

KIR means Youth Scientific Group


Figure 2. The student worksheet section of the RRA subject shows student-centered characteristics

Figure 2 illustrates that RRA designed a student worksheet that encourages students to actively engage in discussions to understand the problem, identify known information, formulate questions, and plan the steps necessary to solve it. This aligns with student-centered characteristics. The use of technology that supports these characteristics is shown by LKA as shown in Figure 3 below:

3) Membimbing Penyelidikan Secara Individu & Kelompok

Langkah Kegiatan :

1. Scan barcode di bawah ini



2. Lihat video sampai selesai untuk mengisi tabel di bawah ini

Lingkaran	Diameter Lingkaran (cm)	Keliling Lingkaran (cm)	Perbandingan <i>Keliling Lingkaran</i> <i>Diameter Lingkaran</i>
1			
2			
3			

Translation:

3) Guiding Individual & Group Investigations

Activity Steps:

1. Scan the barcode below
2. Watch the video completely to fill in the table below

Circle	Diameter (cm)	Circumference (cm)	Ratio <i>circumference</i> <i>diameter</i>
1			
2			
3			

Figure 3. Utilization of technology in LKA teaching modules on student-centered characteristics

Figure 3 illustrates that LKA utilizes a barcode that directs users to the YouTube platform. This platform provides an overview of activities designed to empirically determine the ratio between the circumference and diameter of a circle. Figure 3 illustrates that the LKA utilizes a barcode that directs users to the YouTube platform. The platform provides an overview of activities designed to empirically determine the ratio between the circumference and diameter of a circle. By watching the video, it is hoped that students will be able to conduct investigations to empirically discover the relationship between circumference and diameter.

Students Build Understanding, Formulate Their Own Concepts from the Results of Exploration

These characteristics are characterized by activity descriptions in lesson plans that include steps in which students are expected to construct their own understanding or formulate concepts based on their explorations. There are sessions for confirmation or refinement of concepts by the teacher after students have attempted to build their understanding. Technological assistance is evident in the prospective mathematics teacher's lesson plans, specifically in the use of barcodes to aid in drawing conclusions. All PMTs have successfully translated these characteristics into the teaching modules they created. The following are elements of a teaching module compiled by one PMT, RRA, which demonstrate these characteristics, as shown in Table 4:

Table 4. The lesson plan section for the RRA subject illustrates the characteristics of students building understanding and formulating their own concepts based on the results of exploration.

Syntax	Teacher Activities	Student Activities
Organizing for students learning.	<ol style="list-style-type: none"> 1. The teacher asks students to form groups of 3-4 people based on the results of the cognitive diagnostic test from the previous day (divided into 2 groups: students with a moderate and high understanding of relation and function material). 2. The teacher distributes student worksheets (LKPD) according to the groups (moderate and high), which contain tasks to be completed through group discussion. 3. The teacher allows all groups to understand the problem and plan the steps to be taken to solve it. 	<ol style="list-style-type: none"> 1. Students gather in their respective groups. 2. Students understand the provided student worksheet. 3. Students understand the problem and plan the steps to be taken to solve it.
Guiding individual and	<ol style="list-style-type: none"> 1. The teacher asks students to investigate by collecting information about problems related to relations and functions. 	<ol style="list-style-type: none"> 1. Students investigate by gathering information to

Syntax	Teacher Activities	Student Activities
group investigation.	<ol style="list-style-type: none"> The teacher circulates to guide and monitor students' activities in solving problems related to relations and functions. For the moderate group, more emphasis and assistance are given. The teacher also directs that at the end, there will be learning resources (barcodes) to help conclude. 	<ol style="list-style-type: none"> solve problems related to relations and functions. Students open learning resources to formulate a conclusion.
Developing and presenting the work.	<ol style="list-style-type: none"> The teacher instructs students to develop their investigation results regarding problems related to relations and functions information about problems related to relations and functions. The teacher asks one or two group representatives to present the results of their discussion, then asks other groups to respond. 	<ol style="list-style-type: none"> Students develop their investigation results. Representatives from each group present the results of their discussion, then other groups provide feedback on the other group's presentation.
Analyzing and evaluating the problem-solving process.	<ol style="list-style-type: none"> The teacher facilitates students to analyze the problem-solving. The teacher helps students to reflect, and evaluate the problem-solving process. The teacher evaluates the students' learning outcomes. 	<ol style="list-style-type: none"> Students work on the given questions. Students make improvements by summarizing or making conclusions by additional input from the teacher.

Table 4 shows that RRA includes activities that direct students to build understanding by providing opportunities for all groups to understand the problem, planning steps to be taken to solve the problem, asking students to conduct investigations by collecting information about problems related to relations and functions, the teacher walks around to guide and monitor students' activities in solving the problem, directing that at the end there will be a learning resource (barcode) to help answer the conclusion, asking one or two people as group representatives to present the results of their discussion, then asking other groups to respond to it. This is also supported by the student worksheet that has been prepared by RRA as figure 4 follows:

Figure 4 shows that RRA designed a student worksheet that facilitates students in identifying the differences between relations, relations that are functions, and relations that are not functions through a situation where extracurricular activities are chosen with specific rules. Next, students are asked to work in groups to formulate in their own words the definitions of relations, functions, and the differences between the two. Figure 4 also demonstrates the use of technology, in the form of barcodes, to assist students in formulating the concepts of relations and functions.



STUDENT WORKSHEET

From the table of differences for packages Alpha, Beta, and Gamma that you have completed, answer the following conclusion questions!

a) What are the characteristics of package Beta?

.....

b) What distinguishes the characteristics of package Beta from the other packages?

.....

c) From the table that has been completed, package Alpha is a, package Beta is a, and package Gamma is a relation that is not a function. (To make it easier to fill in the blanks in question (c), you can scan the barcode below.)



Syntax 4: Developing and Presenting the Work

Based on the activity just now, please answer the following questions with your group members.

1. A relation is
2. A function is
3. The difference between a relation and a function is

Figure 4. Section of the RRA subject student worksheet that shows the characteristics of students building understanding, formulating their own concepts from the results of exploration

The use of technology to support students in building understanding and formulating their own concepts from the results of exploration is also demonstrated by the use of a platform to confirm students' conceptual understanding achieved through investigation. This is done by MCN as shown in Figure 5 below:

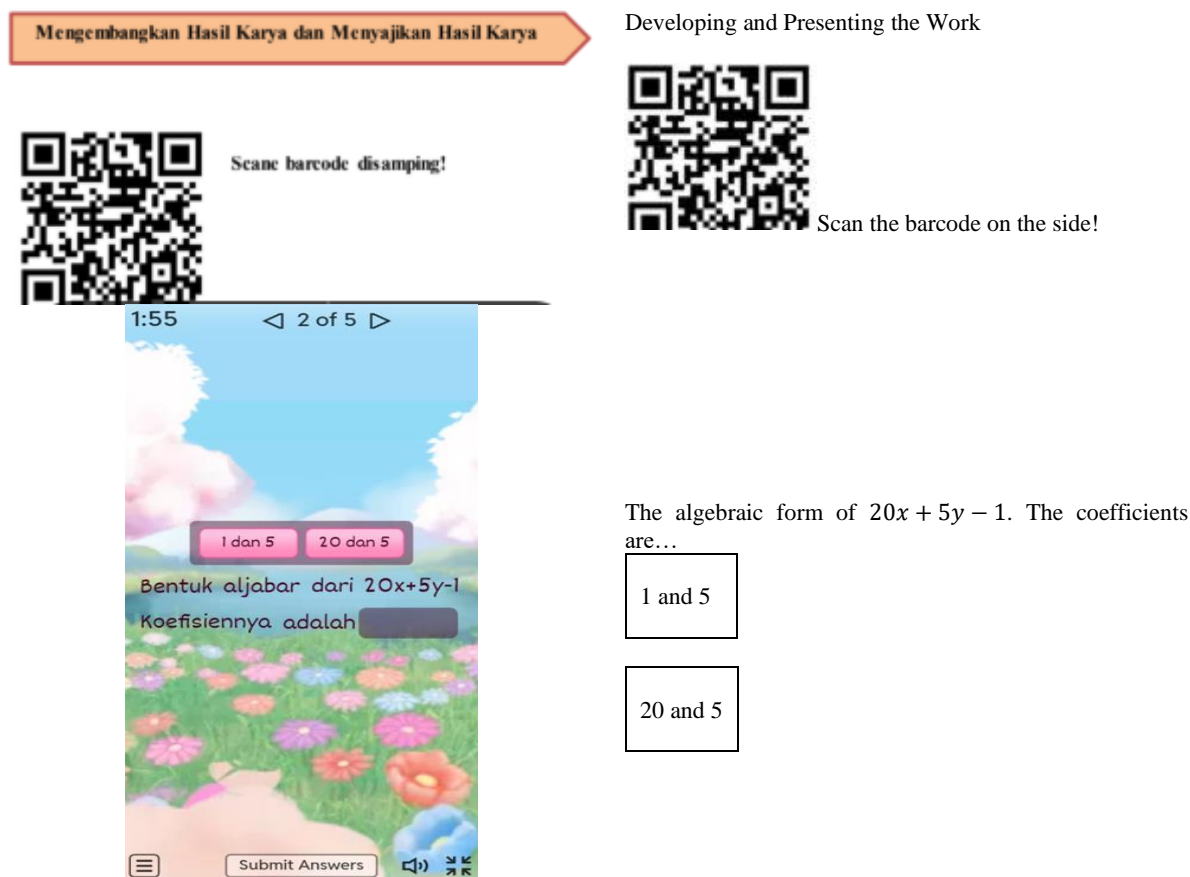


Figure 5. Utilization of technology in student worksheets: MCN on student-centered characteristics

Figure 5 shows a barcode that leads to a Canva-assisted media containing research activities related to the concept of algebraic forms. In this media, MCN also presents mathematical problems using a word wall platform, as shown in Figure 9, which is intended to implement the fifth syntax of PBL, namely, analyzing and evaluating problem-solving. The learning objective to be achieved is for students to identify and express everyday problems or situations in algebraic forms involving variables, constants, terms, coefficients of terms, like terms, and unlike terms through problem-based learning.

Engaging Active Learning

These characteristics are characterized by a variety of activities in the lesson plan that require students to move, discuss, manipulate objects/data, or interact cognitively, all within an adequate time allocation. All PMTs have successfully translated these characteristics into the teaching modules they created. The following are elements of a teaching module developed by one PMT, RRA, which demonstrate these characteristics, as shown in Table 6:

Table 6. The lesson plan section of the RRA shows characteristics involving active learning

Translation:

Syntax	Teacher Activities	Student Activities
Guiding individual and group investigation.	<ol style="list-style-type: none"> 1. The teacher asks students to investigate by collecting information about problems related to relations and functions. 2. The teacher circulates to guide and monitor students' activities in solving problems related to relations and functions. For the moderate group, more emphasis and assistance are given. 3. The teacher also directs that at the end, there will be learning resources (barcodes) to help conclude. 	<ol style="list-style-type: none"> 1. Students investigate by gathering information to solve problems related to relations and functions. 2. Students open learning resources in order to formulate a conclusion.

Developing and presenting the work.	<ol style="list-style-type: none"> 1. The teacher instructs students to develop their investigation results regarding problems related to relations and functions, and provide information about issues related to relations and functions. 2. The teacher asks one or two group representatives to present the results of their discussion, then asks other groups to respond. 	<ol style="list-style-type: none"> 1. Students develop their investigation results. 2. Representatives from each group present the results of their discussion, then other groups provide feedback on the other group's presentation.
Analyzing and evaluating the problem-solving process.	<ol style="list-style-type: none"> 1. The teacher facilitates students to analyze the problem-solving. 2. The teacher helps students to reflect and evaluate the problem-solving process. 3. The teacher evaluates the students' learning outcomes. 	<ol style="list-style-type: none"> 1. Students work on the given questions. 2. Students make improvements by summarizing or making conclusions in accordance with additional input from the teacher.

Table 6 shows that the RRA includes activities that direct students to actively discuss with their group mates, conduct presentations, and respond to presentations from other groups. These activities receive the largest allocation of time, at 100 minutes out of a total of 120 minutes, indicating sufficient time for students to engage in learning actively. MS utilizes technology to engage active learning. This is illustrated in Table 7 below:

Table 7. The lesson plan section of the RRA demonstrates the use of technology in the characteristics, involving active learning.

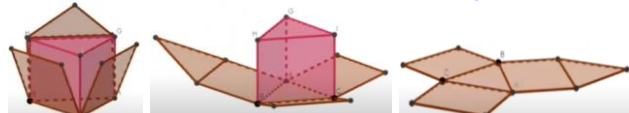
Syntax	Teacher Activities	Student Activities
Problem Statement (Problem Identification)	The teacher asks students to read and understand the problem presented in the student worksheet.	Students identify what they already know and what is being asked in the problem.
	<p>Visual The teacher shows an illustration or video related to the surface area of a prism. Video link: https://www.youtube.com/watch?v=iEEdGFKG2ng</p>	<p>Group: Students pay attention to the illustration or video given by the teacher.</p>
		<p>Students discuss the problem-solving strategies in their respective groups.</p>
	<p>Source: Celsy Yulia Sari's YouTube Channel The teacher asks students to illustrate the given problem in the form of a prism and draw the net of the prism.</p>	
	<p>Auditory The teacher rereads the presented problem, then asks students to illustrate the problem into a prism shape and draw the prism's net.</p>	<p>Group:</p>
	<p>Kinesthetic The teacher asks students to illustrate the given problem into a prism shape, cut it out, and then arrange the flat shape pieces into a prism net.</p>	<p>Group:</p>

Table 7 shows that MS utilizes the YouTube platform to present illustrations related to the concept of prisms. These illustrations consist of everyday examples that can serve as models for prisms. In these illustrations, MS displays visualizations of prism models, their elements, and the process of forming prism nets.

Developing New Knowledge and Initial Knowledge

These characteristics are characterized by instructions or questions that guide students in connecting new concepts to what they already know. All PMTs were able to translate these characteristics into the teaching modules they created. The following are elements of a teaching module developed by one PMT, RRA, that demonstrate these characteristics, as shown in Table 8:

Table 8. The lesson plan section of the RRA subject shows the characteristics of developing new knowledge and prior knowledge.

Syntax	Teacher Activities	Student Activities
Students' Orientation to the Problem	<ol style="list-style-type: none"> 1. The teacher gives stimulus questions regarding sets, relations, and functions 2. The teacher asks questions that stimulate students to understand problems related to relations, functions, and their connections. 	<ol style="list-style-type: none"> 1. Students answer the questions given by the teacher. 2. Students listen to and understand the problems presented and explained by the teacher. 3. Students are allowed to ask questions if needed.

Table 8 shows that the RRA includes activities such as providing prompting questions about sets. The concept of sets is a prerequisite for material related to relations and functions. Mastery of the concept of sets enables students to present representations of relations and functions, as well as identify domains and codomains. The use of technology is presented by IRL through the use of the GeoGebra platform so that students can visualize and simulate the shape of a prism, as shown in Figure 6 below:

Membimbing Penyelidikan

Gunakan bantuan Web Geogebra untuk memvisualisasikan bentuk prisma:
<https://www.geogebra.org/m/ksrvv2xy>

A. Volume prisma segi empat.

1. Gambarlah tempat pensil berbentuk prisma persegi panjang.
2. Misalnya ukuran alas 6 cm × 4 cm, dan tinggi 15 cm.
3. Apakah kamu mengenal bentuk ini sebelumnya?
4. Bagaimana cara mencari volumenya?

Jawab:

Translation:

Guiding the Investigation

Use the GeoGebra website to visualize the shape of a prism:

<https://www.geogebra.org/m/ksrvv2xy>

A. Volume of a Rectangular Prism

1. Draw a pencil case shaped like a rectangular prism.
2. Suppose the base measures 6 cm × 4 cm, and the height is 15 cm.
3. Have you seen this shape before?
4. How do you find its volume?

Answer:

.....

.....

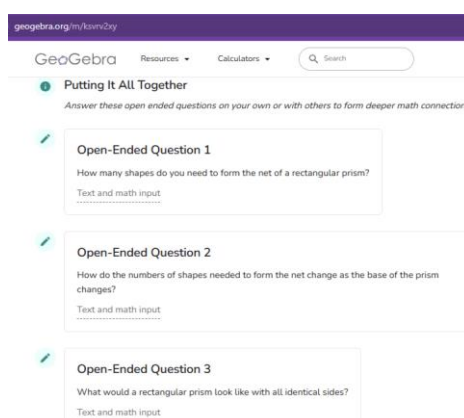
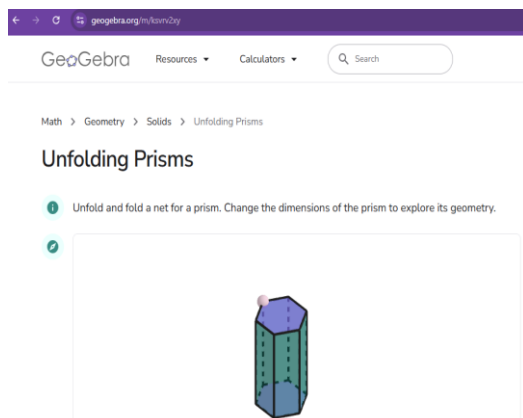


Figure 6. The student worksheet section of IRL's work shows the characteristics of developing new knowledge and prior knowledge

Figure 6 shows part of a student worksheet prepared by IRL to implement discovery learning in 7th-grade junior high school students regarding the volume of prisms. GeoGebra was used because it serves as a medium for visualizing mathematical objects, including geometric ones.

Problem-Solving Oriented Assessment

The presence of contextual assessment instruments characterizes these characteristics, the absence of a single, straightforward procedure, the need for more than one mathematical operation, and the testing of analysis and reasoning. All PMTs have successfully translated these characteristics into the teaching modules they have created. The following is an assessment instrument developed by RRA, one PMT that demonstrates these characteristics, as shown in Figure 9:

<p>Translation: Mrs. Sastro has four children, namely Amar, Budi, Cika, and Desta. Each child has a different favorite food. On Sunday, they went for a walk to the town square to buy their favorite food. At the town square, there were many food vendors, such as meatball soup (<i>bakso</i>), satay (<i>sate</i>), fried rice (<i>nasi goreng</i>), fried noodles (<i>mie goreng</i>), chicken noodle soup (<i>mie ayam</i>), and <i>soto</i>. The following is the list of foods ordered by each child:</p> <ul style="list-style-type: none">• Amar ordered <i>bakso</i> (meatball soup).• Budi ordered satay.• Cika ordered fried rice.• Desta ordered fried noodles.• Erma ordered fried noodles. <p>Based on the story above, answer the following questions: a) What are the domain and codomain? b) Represent this relationship using an arrow diagram. Then, does this problem represent a relation? What do you know about relations? c) Does the relation in this story represent a function? Explain!</p> <p>Answer:</p>
--

Figure 9. RRA's assessment instrument that demonstrates a problem-solving-oriented assessment

Figure 9 shows that the instrument, in the form of questions developed by RRA, is contextual, representing a situation involving food orders by several children. These questions can be solved using arrow diagrams, paired sets, or other representations. These questions also require more than one mathematical operation to find a solution. The questions also test analysis and reasoning by asking students to explain whether the situation in the question is a function.

The use of technology is demonstrated by the use of Google Forms as an alternative technique for collecting student answers. Through Google Forms, RRA can digitally document student answers. Google Forms also allows RRA to design questions as quizzes and assign answer keys, enabling automatic scoring. The use of this technology can be found at the following link: https://docs.google.com/forms/d/e/1FAIpQLSfLpqi1NchKGpAEzQo9s2iBnMuHLCR-FxTqLfoaCeOwzqZ_kw/viewform?pli=1.

In addition to designing student learning outcome assessments, RRA also designs diagnostic assessments that utilize technology, as shown in Figure 10:

Link: <https://wordwall.net/play/90464/166/410>



Translation:

Link:

<https://wordwall.net/play/90464/166/410>

Wordwall

Cognitive Diagnostic on Relations and Functions – Rizqi

Enter your name

Remember me?

Login

If $B = \{1, 3, 5, 7, \dots\}$ is a set that represents...

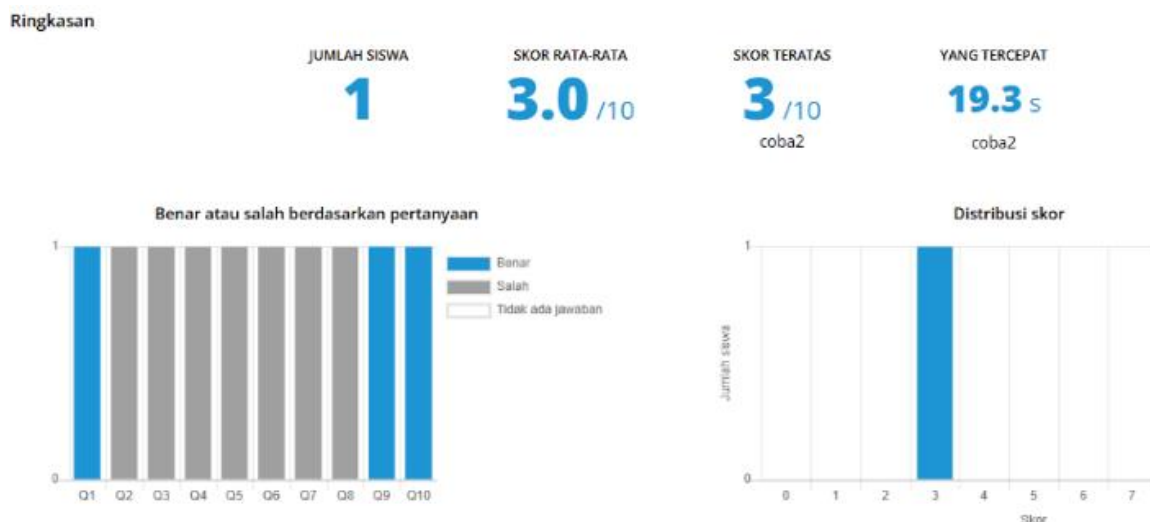
- A set of natural numbers
- A set of odd numbers
- A set of even numbers
- A set of positive numbers

Which of the following is a set?

- A set of beautiful students in class 7M
- A set of bright students in class 7M
- A set of 7M students whose houses are in Taman subdistrict
- A set of 7M students who own a bag

Figure 10. Section of the RRA subject's lesson plan showing technology-assisted assessment.

The diagnostic assessment instrument design created by RRA, as shown in Figure 16, utilizes the Wordwall platform. Wordwall is a website-based application that allows users to create and display quizzes, as well as compile analysis results from the responses to those quizzes. The analysis results on the Wordwall are displayed in Figure 11 below:



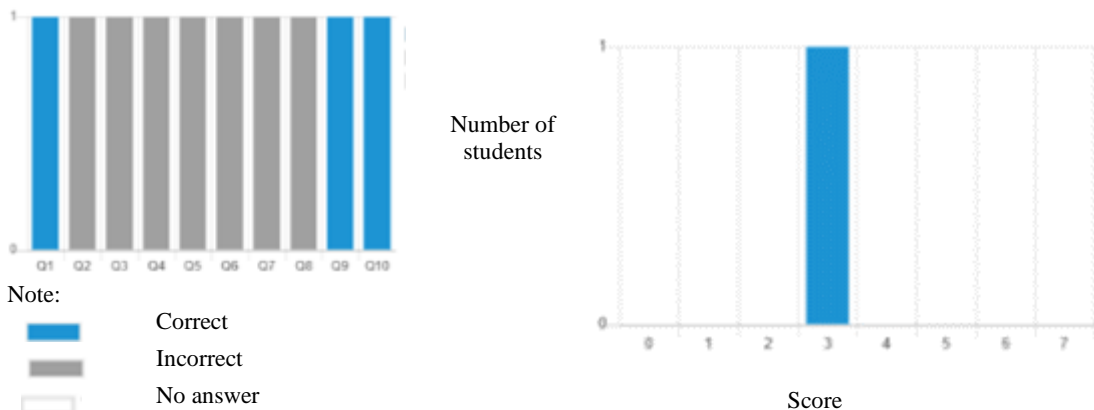
Translation:

Score distribution:

Summary

- Number of Students: 1
- Average Score: 3.0 /10
- Highest Score: 3 /10
- Fastest Time: 19.3 S

Correct or incorrect based on the questions



Papan Peringkat

Peringkat	Nama	Skor	Waktu
ke1	coba2	3	57.9
ke2	-	-	-
ke3	-	-	-

Hasil berdasarkan siswa

URUTKAN MENURUT Pengajuan Nama Benar + Waktu

Siswa	Telah dikirimkan	Benar	Salah	Waktu
coba2	7:00 - 15 Apr 2025	3	7	57.9

Hasil berdasarkan pertanyaan

URUTKAN MENURUT Nomor Benar Salah

Pertanyaan	Benar	Salah
1▶ Jika $B = \{1, 3, 5, 7, \dots\}$ adalah himpunan yang menyatakan...	1	0
2▶ Manakah yang termasuk himpunan?	0	1
3▶ Bagaimana relasi disebut sebagai fungsi?	0	1
4▶ Himpunan dari makanan yang dijual di kantin SMP Negeri 2 Taman dapat dinyatakan dengan...	0	1
5▶ Diketahui $A = \{\text{Surabaya, Bandung, Semarang, Makassar}\}$, himpunan $N = \{\text{Jawa Timur, Jawa Barat, Jawa Tengah, Sulawesi Selatan}\}$. Nyatakanlah himpunan tersebut dengan mendaftarkan anggotanya!	0	1
6▶ Diketahui himpunan $M = \{\text{Surabaya, Bandung, Semarang, Makassar}\}$, himpunan $N = \{\text{Jawa Timur, Jawa Barat, Jawa Tengah, Sulawesi Selatan}\}$. Relasi yang memenuhi kedua himpunan tersebut adalah...	0	1
7▶ Relasi "setengah dari" himpunan $A = \{1,2,3,4,5\}$ ke himpunan $B = \{2,4,6,8\}$ dapat dinyatakan dengan himpunan pasangan berurutan....	0	1
8▶ Perhatikan diagram panah berikut. Relasi yang mungkin dari himpunan C ke himpunan D adalah...	0	1
9▶ Perhatikan diagram panah berikut. Relasi yang mungkin dari himpunan K ke himpunan L adalah...	1	0
10▶ Dari gambar, apakah merupakan sebuah fungsi?	1	0

Translation:

Leaderboard

Rank	Name	Score	Time
1st	coba2	3	57.9
2nd	-	-	-
3rd	-	-	-

Results by Student

Student	Submitted	Correct	Incorrect	Time
coba2	7:00 - 15 Apr 2025	3	7	57.9

Results by Question

No	Question (translated)	Correct	Incorrect
1	If $B = \{1, 3, 5, 7, \dots\}$, then B is a set that states...	1	0
2	Which of the following is a set?	0	1
3	How is a relation defined as a function?	0	1
4	The set of students in Grade 2 SMP Negeri 2 Taman can be represented by...	0	1
5	Given $A = \{\text{natural numbers less than 5}\}$. Write the set by listing its members!	0	1

6	Given $M = \{\text{Surabaya, Bandung, Semarang, Makassar}\}$, $N = \{\text{East Java, West Java, Central Java, South Sulawesi}\}$. The relation that satisfies both sets is...	0	1
7	The "half of" relation from set $A = \{1,2,3,4,5\}$ to set $B = \{2,4,6,8\}$ can be expressed as ordered pairs...	0	1
8	Observe the diagram below. Possible relations from set C to set D are...	0	1
9	Observe the diagram below. Possible relations from set K to set I are...	1	0
10	From the diagram below, is it a function?	1	0

Figure 11. The lesson plan section of the RRA subject shows the analysis of the results of the technology-assisted assessment

Figure 11 illustrates that the Wordwall platform enables RRA to present assessment analysis results in the form of student numbers, average scores, top scores, and fastest scores. Another subject, ASR, utilizes technology to facilitate diagnostic assessments of learning style types using a learning style survey provider website, as shown in Figure 12 below:

<p>8. ASESMEN Asesmen Diagnostik : https://akupintar.id/mp/tes-gaya-belajar Asesmen Formatif : <i>Terlampir</i> Asesmen Sumatif : <i>Terlampir</i></p>	<p>Translasi: 8. ASSESSMENT Diagnostic Assessment : https://akupintar.id/mp/tes-gaya-belajar Formative Assessment : Attached Summative Assessment: Attached</p>
---	---

Figure 12. The Wordwall Platform Helps RRA Present Assessment Analysis Results

Each table and figure should have a sentence that refers to it. Tables or figures should not be duplicated or overlap. For example, if data is presented in table or figure form, you should choose one. The discussion focuses on the relationship between the data and analysis results, the research problem or objectives, and the broader theoretical context. The discussion can also include answers to questions about why the facts are found in the data.

DISCUSSION

This study shows that prospective mathematics teachers (PMT) have successfully integrated technology-assisted inductive learning into their lesson plan designs. This integration aligns with the main characteristics of inductive learning identified by (Prince & Felder, 2006, 2007). This achievement is evident at every stage, from the presentation of specific problems to the formulation of general concepts.

In the characteristic of moving from the specific to the general, PMTs such as RRA and CSP effectively use contextual problems and YouTube videos to stimulate exploration, demonstrating the adaptability of these concepts to the digital environment. These findings support the literature emphasizing the importance of relevant and engaging early learning experiences for building conceptual understanding, in line with the principle that students learn best when they actively (Putri & Siburian, 2021) discover principles from examples rather than passively receiving information (Prince & Felder, 2006).

Furthermore, learner-centered characteristics are consistently demonstrated through activity designs that encourage students to analyze, problem-solve, and conceptualize, with the teacher acting as a facilitator and guide. The use of structured worksheets to guide group discussions and explorations, as in RRA, and the use of barcodes to facilitate individual investigations by LKA, indicate that PMT is capable of implementing a student-centered approach in a digital context. This is consistent with the argument that technology can enhance inductive learning by providing an interactive and adaptive environment that supports student autonomy in learning (Son, 2024). This design also strengthens the role of teachers as facilitators of knowledge, not just as transmitters of information, which is at the heart of student-centered curriculum reform (Hmelo-Silver et al., 2007).

The characteristic of students constructing their own understanding and formulating their own concepts from exploration is also well reflected in the lesson plan. PMT designs activities that allow students to construct their own understanding before it is confirmed by the teacher, such as the use of

barcodes to help students formulate conclusions about the concepts of relations and functions (RRA) or algebraic forms (MCN). The integration of technology in this phase highlights how digital tools can serve as catalysts for active learning and knowledge construction. As the SAMR model suggests, technology can modify teaching tasks (Modification) or even create activities that were previously impossible (Redefinition) (Son, 2024), such as providing instant access to concept confirmation resources via QR codes. This represents a significant advancement beyond mere technology substitution or augmentation.

Active learning engagement is reflected in the dominant time allocation for discussion, presentation, and cognitive interaction, as illustrated in the RRA design. MS's use of YouTube videos to present illustrations of prisms and their nets also supports active learning by providing dynamic visualizations that encourage students to manipulate objects and data cognitively. This is in line with previous research showing that digital tools, such as GeoGebra, are effective in improving trigonometry competency by enabling students to visualize mathematical concepts dynamically (Carriazo-Regino et al., 2024). The use of technology in this context not only replaces traditional methods but also improves the quality of student engagement.

Furthermore, the characteristic of connecting new knowledge with prior knowledge is also reflected, as PMT designs activities that activate prerequisite concepts, such as sets, before moving on to relations and functions. The use of technology in this context not only replaces traditional methods but also enhances the quality of student engagement in exploring prior knowledge as a foundation for developing new knowledge.

Finally, the problem-solving-oriented assessment characteristic is implemented through contextual assessment instruments that require multidimensional analysis and reasoning. PMT, like RRA, uses Google Forms for learning outcome assessments and Wordwall for learning style diagnostic assessments. The use of these digital platforms not only facilitates efficient collection and analysis of assessment data (as demonstrated by the results analysis feature in Wordwall) but also enables assessment adaptation to support various learning styles, a crucial aspect of modern learning. The integration of technology in this assessment aligns with findings that emphasize the importance of teachers' digital competencies for effectively integrating technology into their curricula (Meaney et al., 2023). However, there is still a need for improvement in developing truly non-routine questions that require a high level of creativity.

Overall, these findings suggest that prospective mathematics teachers (PMTs) are not only capable of integrating technology into their learning but also of utilizing it to enhance and refine the core characteristics of inductive learning. Starting with simple integration (substitution and augmentation), the PMTs in this study successfully reached the level of modification and even redefinition (Son, 2024), as seen in the use of QR codes to confirm concepts and interactive videos that encourage independent exploration. This signals a significant shift from traditional approaches to a more dynamic, student-centered approach, where technology acts as a catalyst, not just a tool.

The implications of these findings are significant. First, they confirm that teacher education programs have successfully equipped prospective educators with the digital competencies necessary to design relevant learning experiences in the modern era (Meaney et al., 2023). Second, this study provides empirical evidence that technology-supported inductive learning not only enables students to construct their own knowledge but also enables teachers to act as effective facilitators. This underscores the importance of teacher education curricula focused on pedagogical technology integration (Norhagen et al., 2024) As a foundation for educational reform.

However, there is room for improvement, particularly in the development of assessment questions that require a high level of creativity and non-routine thinking. Future research could explore how PMTs can be encouraged to design activities that better focus on the ultimate goal of inductive learning, namely, developing critical thinking and complex problem-solving skills, beyond simply formulating basic concepts.

CONCLUSION

This study concludes that prospective mathematics teachers (PMTs) have consistently integrated technology-assisted inductive learning into their lesson plans, in accordance with the main characteristics of inductive learning. The findings indicate that each characteristic, starting from the specific to the general, is learner-centered, students construct their own understanding or formulate concepts from exploration results, involves active learning, connects new knowledge with prior knowledge, and problem-solving-oriented assessments can be facilitated through the use of various digital tools such as YouTube, GeoGebra, barcode/QR codes, Google Forms, and Wordwall. This integration not only strengthens the student-centered learning orientation but also increases interactivity, motivation, and depth of understanding of mathematical concepts. However, the results of this study also emphasize the need to strengthen the professional competence of prospective teachers, especially in designing non-routine assessments and high-level problem solving, so that the implementation of technology-assisted inductive learning is more optimal in supporting the goals of 21st-century education. The study suggests that future research should explore the relationship between lesson plan quality and classroom teaching performance. Furthermore, comparative studies involving various technology platforms could be conducted to identify which tools best facilitate the conceptual discovery phase of inductive learning.

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DECLARATIONS

- Author Contribution : Author 1: Conceptualization, Writing - Original Draft, Editing, and Visualization; Author 2: Formal Analysis and Methodology; Author 3: Conceptualization and Visualization
Author 3: Validation and Supervision
(<https://www.elsevier.com/authors/policies-and-guidelines/credit-author-statement>)
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- Additional Information : Additional information is available for this paper.

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