

Development of Mathematics Teaching Modules Based on Differentiated Instruction to Stimulate Student Engagement

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Abstract. *Student engagement is one of the students' predictors for achieving more robust performance in mathematics, and it can be promoted by differentiated instruction. Therefore, this research aimed to develop a valid, practical, and effective mathematics module based on differentiated instruction to stimulate student engagement. Employing the ADDIE model, the research was conducted at one lower secondary school involving 22 eighth-grade students. We collected data through validity assessment sheets to test validity, teacher and student response questionnaires to test practicality, and student engagement observation sheets to test the practicality of teaching modules. The validity of the module was confirmed through V-Aiken's method, proving that the module satisfied the valid category. Findings demonstrate that modules are in the valid category and are very practical categories in the teacher response and the student response questionnaire. In addition, this module effectively stimulates student engagement in cognitive, behavioral, and emotional engagement logically, with the results of the observation sheet of student engagement in the engaged and very engaged categories. Thus, the mathematics teaching module based on differentiated instruction is declared valid, practical, and effective in stimulating student engagement.*

Keywords: *differentiated instruction, mathematics modules, student engagement*

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Introduction

Student engagement is paramount in creating a positive and effective environment for mathematics instruction. Students in math classrooms can share, discuss, and negotiate their ideas with their peers in constructing new mathematical knowledge (Durksen, Way, Bobis, Anderson, Skilling, & Martin, 2017; Jansen, Curtis, Mohammad, Cullicott, Smith, & Middleton, 2023). In addition, student engagement can be characterized by student activity in the task, such as attention, effort, verbal participation, persistence, voice, and positive emotions, which can contribute to their achievement in the learning process (Bobis, Way, Anderson, & Martin, 2016; Febrilia & Nissa, 2019; Patahuddin, Puteri, Lowrie, Logan, & Rika, 2018; Skilling, Bobis, Martin, Anderson, & Way, 2016). Student engagement includes behavioral engagement, such as seriousness in studying and completing assignments and following the rules; emotional engagement, such as a positive attitude, enthusiasm, and optimism in learning; and cognitive

engagement, such as the ability to use learning techniques well (Fredricks, Filsecker, & Lawson, 2016; Jansen et al., 2023). Student engagement in learning influences student learning outcomes significantly, so the Government of the Republic of Indonesia strives to improve the quality of learning in schools by implementing *Kurikulum Merdeka* (the independent curriculum).

The independent curriculum is an instruction guide emphasizing student-centered learning and has been implemented in Indonesia since 2022 (Hasanah, Suyatno, Maryani, Badar, Fitria, & Patmasari, 2022). An independent curriculum can foster learning recovery since the learning project aims to develop social skills and Pancasila character with the core of the material, one of which is basic numeracy and literacy skills, as well as teachers who are given the freedom to plan instruction according to the context or local content (Sadieda, Wahyudi, Kirana, Kamaliyyah, & Arsyavina, 2022). The independent curriculum also aims to increase student engagement in the learning process. One of the characteristics of an independent curriculum is differentiated instruction.

Differentiated instruction is a pedagogical model that aims to satisfy the individual students' needs in diverse-ability classrooms by establishing maximum learning and managing instruction about content, process, and product by student needs in terms of their readiness, interests, and learning profiles (Hackenberg, Creager, & Eker, 2021; Tomlinson, 2014). According to Tomlinson and Moon (2013), differentiated instruction can reach small groups of students using different learning strategies. It can be adjusted to the needs of each student so that students can obtain the best learning experience. This differentiated instruction is implemented in mobilizing schools, namely schools that encourage educational change and mobilize other educational units to implement an independent curriculum (Wijayanti, Herawati, Sari, Warniasih, & Jamilah, 2022). Hence, differentiated instruction is a pedagogical approach that enables teachers to proactively plan varied activities addressing what students need to learn, how they will learn, and how they show what they have learned.

Tomlinson (2017) found that the content aspect of a lesson determines the knowledge and skills students acquire, including their understanding and how they access this learning. In differentiated instruction, all students can engage with the same educational content through varied strategies, such as using different materials and examples, presenting content in multiple forms, and using diverse groupings (Herner-Patnode & Lee, 2021; Tomlinson, 2014). The process component focuses on the instructional methods and activities that help students understand and apply the concepts and skills taught. Differentiation in the process may involve varying levels of instructional support, different representations of concepts, manipulatives, and adjustments in the time allotted for activities (Tomlinson, 2014). Meanwhile, the product component involves creating assignments that allow various ways for students to apply what

they have learned and enable teachers to assess student progress. This includes tiered assignments, different modes of expressing learning, and tasks performed individually or in small groups (Tomlinson, 2014; Van den Kieboom & Groleau, 2022).

One design of learning activities tailored to students' characteristics and needs is a mathematics teaching module based on differentiated instruction. Differentiated instruction modules are a student-centered learning strategy based on mapping characteristics and needs so students can learn more efficiently (Ndiung, Jediut, & Nendi, 2023). Furthermore, Suryani, Al Hadad, and Jamilah (2023) noted that a lesson plan with differentiated instruction provides many opportunities for students to develop their abilities. With these teaching modules, students can participate actively because learning activities and reading materials are adjusted to students' characteristics and needs.

Burhanudin, Pramesti, and Falasyifa (2023) pointed out that differentiated instruction as learning guides can create a quality, interactive, and challenging teaching and learning process for students to be actively involved in learning because it provides space for students to be independent and creative regarding their talents and not feel like they have failed. Additionally, Ekstam, Linnanmäki, Akademi, and Aunio (2017) explained that differentiated instruction can increase student interest, characterized by increased engagement, attention, and interest, as well as students' positive emotions. Hence, students learn according to their abilities or preferences.

Numerous researchers have documented differentiated mathematics instruction (Chamberlin, 2011; Hackenberg et al., 2021; Hubbard & Livy, 2021; Van den Kieboom & Groleau, 2022; Zerai, Eskelä-Haapanen, Posti-Ahokas, & Vehkakoski, 2023), but rare studies have examined how this pedagogical approach can promote student engagement. Hackenberg et al., (2021) found that inquiry into research-based knowledge and responsive inquiry into student thinking is at the core of differentiated mathematics instruction. In addition, students who receive differentiated instruction and are given assignments at a level appropriate to their abilities and needs will experience success since they are motivated and maintain their self-esteem (Bobis, Russo, Downton, Feng, Livy, McCormick, & Sullivan, 2021; Hackenberg et al., 2021). Meanwhile, research conducted by Van den Kieboom and Groleau (2022) only focused on prospective teachers who designed learning and had not carried out direct learning practices in the classroom. Furthermore, these studies have not focused on designs that contain specific mathematics learning activities. Therefore, it is essential to design teaching modules containing differentiated instruction on two-variable linear equation systems material to ensure the implementation of differentiated instruction practices. We selected this content since many students encountered difficulties in learning and solving two-variable linear equation systems (Fatio, Fatimah, & Rosjanuardi, 2020); specifically, students faced difficulties in understanding

algebraic expressions, applying arithmetic operations in numerical and algebraic expressions, understanding the different meanings of the equal sign, and understanding variables (Jupri, Drijvers, & van den Heuvel-Panhuizen, 2014).

Based on the problem description above, developing mathematics teaching modules based on differentiated instruction is essential to foster student engagement. Therefore, we proposed two research questions: (1) What are the processes and results of developing mathematics modules based on differentiated instruction that are valid, practical, and effective? and (2) Are differentiated instruction-based mathematics modules effective in stimulating student engagement?

Method

This type of research is research and development (R&D) aimed at producing differentiated mathematics instruction modules used utilizing the ADDIE development model, which consists of five stages: analysis, design, development, implementation, and evaluation. The teaching module contains the minimal components: (1) learning objectives and (2) learning steps or activities. Usually for one learning objective that is achieved in one or more meetings, (3) an assessment plan for the beginning of learning along with instruments and assessment methods, (4) an assessment plan at the end of learning to check the achievement of learning objectives along with instruments and assessment methods, (5) learning media used, including, for example, reading materials used, activity sheets, videos, or website links that students need to learn.

This research was carried out at one public lower secondary school that involved 22 eighth-grade students and mathematics teachers to examine the practicality and effectiveness of differentiated instruction-based mathematics teaching modules. We selected one of the public lower secondary schools in the Merauke District, Indonesia, as a participant in this study since this school implements an independent curriculum and differentiated instruction. The school utilizes mathematics textbooks published by the Indonesian Ministry of Education and Culture. However, the presentation and delivery of the material and discussion of sample questions in the book are less relevant if given to students with initial learning readiness. Based on direct observations during the mathematics learning process in class, some students are less involved in learning because they do not master prerequisite materials such as whole number calculation operations, which is indicated by students being unable to answer the teacher's questions or giving inaccurate solutions and writing multiplication tables in their books to serve as memorize. The mathematics teacher also confirmed this during a direct interview. The teacher stated that half of the students who had not mastered arithmetic operations were given exceptional guidance before class commenced. They were assigned to write and memorize the multiplication tables in their

books. Therefore, it is critical to design learning appropriate to these students' characteristics so that they can understand the material and be actively involved in learning.

The development procedures comprise five stages (analysis, design, development, implementation, and evaluation). At the analysis stage, student characteristics and needs are identified. Analysis of student characteristics is the stage of examining student characteristics based on their knowledge, skills, and development. The aim is to determine the level of student ability. Based on the learning readiness test related to Systems of Linear Equations in Two Variables (SLET) prerequisite knowledge, which includes Least Common Multiple (LCM), Algebraic Operations (Addition, Subtraction, and Multiplication), and Linear Equations in One Variable (LEOV), the data obtained is that 14 students do not understand whole number arithmetic operations, six students already understand integer calculation operations but do not yet understand the prerequisite knowledge. Two students already understand the prerequisite knowledge. The test results indicate that the learning readiness of students is still low. Therefore, it is essential to develop teaching materials appropriate to students' characteristics and needs, namely the development of teaching modules based on differentiated instruction to stimulate student engagement in mathematics learning. Needs analysis is the stage of identifying the basic problems faced in learning. Based on learning observations and interviews with mathematics teachers, we concluded that the school has implemented an independent curriculum for students and teachers guided by mathematics books from the Ministry of Education and Culture. However, the presentation of the material and discussion of example questions contained in the book are less relevant for use by students, whom students with low learning readiness dominate.

Subsequently, we developed teaching modules at the design stage. We analyzed the arrangement of teaching modules in learning by studying the components in the teaching modules of the independent curriculum. Lastly, we designed the arrangement of teaching and learning activities based on differentiated instruction.

The development stage of the ADDIE model includes designing learning device products with development steps, namely the activity of compiling teaching modules by considering the essential objectives needed to acquire the learning objectives. Next, validation was carried out by two mathematics education lecturers and one mathematics teacher to assess the feasibility of the differentiated mathematics instruction module that had been prepared. If the expert validation results are declared valid, it will proceed to the implementation stage. However, if the results from the validator are invalid, then a revision will be carried out.

The implementation stage is the stage for applying the teaching modules that have been developed. Teaching tools, in this case differentiated instruction modules, will be tested first to

examine their practicality. After the teaching module is declared practical, it will be implemented in learning activities in 8th grade.

The evaluation stage is the final step in the research and development of the ADDIE model. The evaluation was conducted to examine the effectiveness of the mathematics teaching module based on differentiated instruction through student engagement observation sheets.

The instruments used in this research were validation sheets given to expert validators to examine the validity of teacher and student response questionnaires to test practicality and student engagement observation sheets to investigate the effectiveness of differentiated mathematics instruction modules. We utilize an observation sheet since it allows us to capture student engagement in actual practice that can be indicated by teacher-student interactions, students' interaction with their peers, and students' interaction with mathematical content during learning in the classroom (Durksen et al., 2017; Kong, Wong, & Lam, 2003; Maulana, Smale-Jacobse, Helms-Lorenz, Chun, & Lee, 2020).

We analyzed data to determine the validity of differentiated instruction modules as follows.

Validity Analysis

The validity analysis was measured through an assessment sheet filled in by an expert validator to determine the level of validity or feasibility of the differentiated mathematics instruction module. The module was prepared and calculated using the Aiken Validity Index analysis with the following formula.

$$V = \frac{\sum s}{n(C - 1)}$$

Information:

V = Index Aiken

s = Score given by the validator minus the lowest score in the category

n = Number of Validators

C = Highest score in the category

Validity assessment criteria using the Aiken index are categorized in Table 1.

Table 1. Validity criteria

No.	Validity Criteria	Validity Level
1	0,61 - 1,00	Valid
2	0,00 - 0,60	Invalid

Practicality Analysis

A practical analysis of the response questionnaire filled out by mathematics teachers and class VII students uses the following formula (Meliana, Herlina, Suripah, & Dahlia, 2022).

$$\text{Percentage} = \frac{\text{Total Respondent Scores}}{\text{Maximum Score}} \times 100\%$$

The practicality criteria for differentiated mathematics instruction modules are described in Table 2.

Table 2. Practicality criteria

No.	Practicality Criteria	Practicality Level
1	80.01 % - 100 %	Very Practical
2	60,01 % – 80,00 %	Practical
3	40,01 % - 60,00 %	Less Practical
4	20,01 % - 40,00 %	Impractical
5	00,00 % - 20,00 %	Very Impractical

(Meliana et al., 2022)

Effectiveness Analysis

We utilized the observation sheet to examine students' engagement in the learning process, which comprises cognitive engagement, behavioral engagement, and emotional engagement, adapted from Wang, Fredricks, Hofkens, and Linn (2016). The indicator of student engagement is depicted in Table 3.

Table 3. Indicators of students' engagement

Students' Engagement Component	Engaged	Disengaged
Cognitive Engagement	1. Student accomplishes mathematical tasks in the classroom and ensures the solution is accurate.	6. Students prefer to be told the answer than have to do the work.
	2. The student thinks of multiple approaches to solving the problems.	7. When work is hard, students only learn the easy parts.
	3. Student tries to connect the current material with their prior knowledge.	8. Students only do the assignments given and don't like to do more than assigned.
	4. Students are aware/of their mistakes and misconceptions and strive to revise them.	
	5. Students did not face difficulty in accomplishing assignments in the classroom.	
Behavior Engagement	9. The student stays focused.	14. The student does not participate in class.
	10. The student puts effort into learning mathematics.	15. The student does other things when He/She is supposed to pay attention.
	11. The student keeps trying even if something is hard.	16. If a student does not understand, He/She gives up immediately.
	12. Students complete their homework on time.	
	13. Student talks about mathematics outside of class.	
Emotional Engagement	17. The student looks forward to mathematics class.	21. The student often feels frustrated and down in mathematics class.
	18. The student enjoys learning new things about mathematics.	22. The student thinks that mathematics class is boring.
	19. The student wants to understand what is being learned in mathematics class.	23. The student does not want to be in mathematics class.
	20. The student feels good when he/she is in mathematics class.	24. The student does not care about learning mathematics.
		25. The student gets worried when he/she learns new things about mathematics.

A student engagement observation sheet was used to measure the effectiveness of differentiated mathematics instruction modules in stimulating student engagement. Three observers (two observed seven students, and one dealt with eight students) investigated student engagement. Subsequently, we analyzed this data using the formula (Centaury, 2015).

$$A = \frac{F}{N} \times 100\%$$

Information:

A: Percentage

F: Number of students engaged

N: Number of students present

The criteria for the percentage of student engagement are demonstrated in Table 4 (Wibowo, 2016).

Table 4. Criteria for student engagement

No.	Engagement Criteria	Engagement Category
1	80 % - 100 %	Very Engaged
2	60 % – 79 %	Engaged
3	40 % - 59 %	Less Engaged
4	20% - 39 %	Disengaged
5	0 % - 19 %	Very Disengaged

The mathematics teaching module based on differentiated instruction is effective if student engagement is between 60% and 100%.

Results and Discussion

At the analysis stage, student characteristics and needs were identified through interviews with mathematics teachers, direct observation, and student learning readiness tests. The analysis demonstrated that students' learning readiness was low, such as not understanding arithmetic operations and not understanding the prerequisites for the material. This also causes the textbooks, which are used as guidelines in learning, to be less relevant for students, so a mathematics teaching module based on differentiated instruction is developed.

Design Stage

A mathematics teaching module based on differentiated instruction is designed at the design stage, considering students' characteristics and needs based on the analysis results. At this stage, the researchers created a draft mathematics teaching module based on differentiated instruction by paying attention to the steps in developing the teaching module and the components of the teaching module. After that, the researchers searched for and collected various reference materials, images, and learning videos to develop teaching modules, organize learning activities, and prepare assessment instruments to assess the development of teaching modules consisting of assessment sheets for the validity of teaching modules, teacher and student response

questionnaires to evaluate the practicality of the teaching module, as well as student engagement observation sheets to determine the effectiveness of the mathematics teaching module.

Development stage

At the development stage, a mathematics teaching module based on differentiated instruction is prepared, developed, and designed completely and attractively and then consulted with the mathematics teacher educators. The results of creating a mathematics teaching module based on differentiated instruction are as follows.

a. Teaching Module Cover

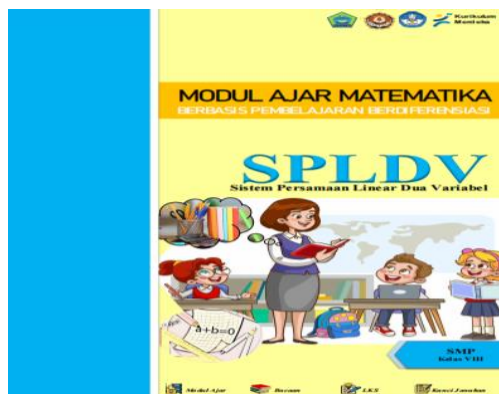


Figure 1. Cover of the mathematics teaching module

b. Identity and General Information

The identity and general information include the module author, institution of origin, year of preparation, semester, class, time allocation, initial competencies or prerequisite knowledge, Pancasila student profile, facilities and infrastructure, target students, and learning model.

c. Core Components

The core components include learning objectives, meaningful understanding, trigger questions, learning activities, and teacher and student reflection. Table 5 depicts the core components of developing differentiated mathematics instruction modules.

Table 5 Core components of modules

Learning Activities	
Initial activities (10 minutes)	
1.	Learners perform the prayer before learning (the teacher enquires a learner to lead the prayer)
2.	The teacher checks the learners' attendance and asks them to prepare their stationery.
3.	Learners obtain information about the learning that will be carried out with material connected with the prior material.
4.	Learners receive information about the competencies, material scope, objectives, learning steps, and assessment methods that will be carried out.
5.	The teacher poses questions about the Least Common Multiple (LCM) and algebraic form (AF) that learners learned in previous meetings, and learners answer the questions.
6.	The teacher associates LCM and AF with the material that is being taught.
Core activities (55 minutes)	
Clarify the problem	
1.	The teacher groups learners based on their learning readiness.

Learning Activities

2. The teacher provides varied learning resources to explain the SLETV material and its solution using various learning media.

Content Differentiation:

- a. Learners who do not understand arithmetic operations are given learning media, such as reading materials and straws, as tools in arithmetic operations.
- b. Learners who already understand arithmetic operations but do not yet understand the prerequisite knowledge are only given learning media in the form of reading materials.
- c. Learners who already understand the prerequisite knowledge but slightly make errors in the calculation are given learning media through reading materials or watching videos.

Process Differentiation:

- a. The teacher explains the prerequisite knowledge in detail and utilizes straws as a medium to assist learners who do not comprehend algebraic operations.
- b. The teacher organizes learners who have understood the prerequisite knowledge but made slight errors in algebraic operations to sit in groups to read the material or watch the learning video.
3. The teacher distributes the worksheet as a group assignment, and each group provides solutions according to the media used.
 - a. Learners who do not understand arithmetic operations are given worksheet A, which has work instructions and utilizes straws as a medium to assist learners in accomplishing problems in the worksheet.
 - b. Learners who already understand arithmetic operations are given worksheet A, which has work instructions but does not utilize straws to accomplish the worksheet.
 - c. Learners who already understand the prerequisite knowledge are assigned worksheet B.
4. The teacher encourages the group members to write down and pose problems on the worksheet that they have not understood.
5. Learners discuss in their groups to accomplish the problem in the worksheet.

Information and data collection

6. Learners in each group discuss the steps to solve the problem in the worksheet.
7. The teacher observes learners in groups and asks about their difficulties, providing opportunities for students to pose questions that have not been understood.

Process differentiation:

If there are learners who have difficulty, the teacher will re-explain the concept.

8. The teacher provides scaffolding to groups of learners for problems that they encounter difficult through the media they have used.

Sharing Information and Discussing to Solve the Problem

9. Learners discuss and accomplish the tasks in the worksheet.
10. Group learners compile a report on the results of their discussion in accomplishing the problems in the worksheet.

Presentations of Problem-Solving Discussion

11. Each group presents their work based on worksheet instructions.

Product Differentiation:

- a. Learners who do not understand arithmetic operations use straws as a medium to explain their discussion results clearly.
- b. Learners who already understand arithmetic operations explain their discussion results in detail without using straws.
- c. Learners with prerequisite knowledge can fluently explain the solution to the problem in the worksheet.
12. A learner from another group responds to the presenting group. After all groups have presented, the teacher provides feedback.

Reflection

13. Learners and the teacher reflect, summarize, and draw conclusions about the content that has been learned.
14. The teacher gives appreciation (praise and applause) for the participation of all learners.

Final activities (15 minutes)

1. The teacher assigns individual homework as a form of enrichment for learners who already understand the material and remedial for learners who struggle to understand the material.
 2. The teacher provides information about the material for the next meeting and gives assignments to find references to the material learned, either through books in the library or by searching the internet.
-

We highlighted the differentiation based on students' learning readiness in Table 5. For instance, this lesson plan allows students to learn systems of two-variable linear equations regarding their prior knowledge (differentiation of content). Additionally, this module provides a pedagogical approach that enables teachers to differentiate explanations in their practice. For example, the teacher can re-explain content and employ small-group discussions when students encounter difficulty (differentiation of process). Lastly, this module differentiated students in selecting how to do assignments based on their previous knowledge (differentiation of product).

Appendix

The teaching module attachments in developing differentiated mathematics instruction modules consist of reading materials with learning videos, student worksheets, enrichment, and remedial materials, answer keys, learning criteria, and assessment sheets.

Reading material

The presentation of the material contained in the Independent Curriculum Package used at the school is less relevant to the characteristics and needs of students, so the researchers have prepared student reading material in more straightforward language, completed steps in detailed example questions, and have learning videos to help students if they still do not understand the reading material, as in Figure 2.

Bahan Bacaan

Metode 1 Menyelesaikan SPLDV

Permasalahan Linear Dua Variabel (SPLDV)
 SPLDV adalah persamaan linear yang mempunyai dua variabel berpangkat satu.

Bentuk umum SPLDV:
 $ax + by = c$

Keterangan:
 x dan y disebut variabel
 c disebut konstanta
 a disebut koefisien x
 b disebut koefisien y
 a dan b tidak boleh nol (0)

Sistem Persamaan Linear Dua Variabel (SPLDV)
 SPLDV adalah kumpulan persamaan linear dua variabel yang saling berkaitan.

Bentuk SPLDV:
 $\begin{cases} ax + by = c & \dots (1) \\ dx + ey = f & \dots (2) \end{cases}$

Contoh
 Diketahui Sistem Persamaan Linear berikut.
 $\begin{cases} 2x + y = 9 \\ 3x + 2y = 15 \end{cases}$
 Tentukan penyelesaian SPLDV tersebut dengan metode Substitusi, Metode Eliminasi, dan Metode Gabungan (Eliminasi-Substitusi)

Video SPLDV
 Untuk menambah pemahaman tentang penyelesaian SPLDV, simaklah video berikut ini:
<https://youtu.be/000000000000>
<https://youtu.be/000000000000>

Penyelesaian

Metode Substitusi

Diketahui SPLDV sebagai berikut.

$$\begin{aligned} 2x + y &= 9 & \dots \text{Pers. 1} \\ 3x + 2y &= 15 & \dots \text{Pers. 2} \end{aligned}$$

Ubah persamaan 1 menjadi $y = \dots$
 $2x + y = 9 \rightarrow 2x - 2x + y = 9 - 2x$ (Kedua ruas dikurangi $2x (-2x)$)
 $y = 9 - 2x$... Pers. 1

$3x + 2y = 15$... Pers. 2

Substitusi $y = 9 - 2x$ ke persamaan 2

$$\begin{aligned} 3x + 2y &= 15 \\ 3x + 2(9 - 2x) &= 15 \\ 3x + 2(9) - 2(2x) &= 15 \\ 3x + 18 - 4x &= 15 \\ 3x - 4x + 18 &= 15 \\ -x + 18 &= 15 \\ -x + 18 - 18 &= 15 - 18 & \text{(Kedua ruas dikurangi 18 (-18))} \\ -x \cdot (-1) &= -3 \cdot (-1) & \text{(Kedua ruas dikali -1)} \\ x &= 3 \end{aligned}$$

Substitusi $x = 3$ ke persamaan 1

$$\begin{aligned} 2x + y &= 9 \\ 2(3) + y &= 9 \\ 6 + y &= 9 \\ 6 - 6 + y &= 9 - 6 & \text{(Kedua ruas dikurangi 6 (-6))} \\ y &= 3 \end{aligned}$$

Jadi, Nilai $x = 3$ dan $y = 3$

Figure 2. Reading material

Student worksheet

Student worksheets based on student readiness are shown in Figure 3. In Figure 3, students at the initial learning readiness level solve the problem in worksheet A. Meanwhile, advanced students deal with problems in worksheet B. This differentiation enables each student to engage actively in terms of their cognitive abilities.

A

Diketahui Sistem Persamaan Linear Dua Variabel sebagai berikut.

$$\begin{cases} 2x + 4y = 28 \\ 3x + 2y = 26 \end{cases}$$

Tentukanlah penyelesaian dari SPLDV di atas menggunakan metode gabungan (Eliminasi-Substitusi)!

Penyelesaian

Diketahui:

$$\begin{array}{ll} 2x + 4y = 28 & \dots \text{Pers. 1} \\ 3x + 2y = 26 & \dots \text{Pers. 2} \end{array}$$

✚ Eliminasi x dari persamaan 1 dan 2

✚ Substitusi nilai y = ... ke persamaan 2

Jadi, nilai x = ... dan y = ...

B

Diketahui Sistem Persamaan Linear Dua Variabel sebagai berikut.

$$\begin{cases} 2x + 4y = 28 \\ 3x + 2y = 26 \end{cases}$$

Tentukanlah penyelesaian dari SPLDV di atas menggunakan metode gabungan (Eliminasi-Substitusi)!

Penyelesaian

Figure 3. Student worksheet

Enrichment and Remedial

Enrichment is given to be done independently without guidance by students who already understand the material. In contrast, remedial is done by students and given re-explanation on parts that are not yet understood. An example of enrichment and remedial tasks is in Figure 4.

Enrichment Task

A parking attendant gets Rp. 25,000.00 from 3 cars and 5 motorbikes, while from 4 cars and 2 motorbikes he gets Rp. 24,000.00. How much parking money will he get if there are 10 cars and 20 motorbikes?

Remedial Task

David and Joseph went fishing at a river. David got mujair fish and 3 goldfish, which were sold for IDR 70,000, while Joseph got 4 mujair fish and 4 goldfish, which were sold for IDR 72,000. How much do 1 mujair fish and 1 goldfish cost?

Figure 4. Enrichment and remedial task

Reflection

Reflection is carried out to determine the strengths and weaknesses of the learning that has been implemented. A reflection of the differentiated mathematics instruction module is shown in Figure 5.

Teacher Reflection	1. How effective is this differentiated instruction implemented to learners? 2. How does implementing this differentiated instruction stimulate student engagement during the learning process?
Learners' Reflection	1. How do you feel when learning with the differentiated instruction approach? 2. What interesting parts did you experience when learning with this learning approach? 3. Has today's learning been in accordance with what you want?

Figure 5. Teacher and student reflections

Bibliography

The bibliography contains various reference sources for the primary material, images, and learning videos. The mathematics teaching module based on differentiated instruction, which has been completely prepared, was validated by two mathematics education lecturers and one mathematics teacher to test the validity of the mathematics teaching module before being implemented in the learning process.

At this validation stage, two experts in mathematics education validated the differentiated mathematics instruction module and calculated it using the V-Aiken formula. The V-Aiken validity criterion is more than or equal to 0.61. From the validation results, statement items are less than 0.61 (invalid), so the teaching module is unsuitable for use and needs to be revised according to the validator's suggestions. Validator 1 gave suggestions to carry out a diagnostic assessment first because the teaching modules being developed were not in accordance with the needs and characteristics of students. Meanwhile, validator 2 suggested that the development of mathematics teaching modules focus on one form of differentiation: differentiation based on learning readiness or learning style. Expert validators then revalidated the revised teaching module. The results of the expert validator assessment showed that the V-Aiken score obtained for all statement items is > 0.60 . This means that the mathematics teaching module based on differentiated instruction is valid and feasible for implementation in learning activities.

Implementation Stage

The mathematics teaching module based on differentiated instruction, validated and declared suitable for use, was tested on 22 eighth-grade students as a limited participant to examine the practicality of the teaching module. The results of the practicality of the teaching module through teacher response questionnaires and student response questionnaires after the differentiated mathematics instruction module was tested on a limited basis show that the mathematics teaching module based on differentiated instruction is in the very practical category. Meanwhile, the percentage of student responses in the practical and very practical categories. Thus, the mathematics teaching module based on differentiated instruction is stated to be practical for learning.

After the mathematics teaching module based on differentiated instruction was declared practically valid, implementation was then carried out to test the effectiveness of the teaching module through an observation sheet on student engagement when the teaching module was implemented in learning, which consisted of 3 meetings, namely on 21, 26 September 2023, and 03 October 2023 with prerequisite knowledge material or initial competency which includes least common multiple (LCM), Algebraic Operations (AO), and linear equations in one variable

(LEOV) at the first meeting, material for solving systems of linear equations at the second meeting, and material for solving applications of systems of linear equations in two variables at the meeting third.

Evaluation Stage

The differentiated mathematics instruction module implemented in learning is tested for its effectiveness through student engagement observation sheets. The percentage results of these sheets show that the percentage of student engagement in the cognitive aspect was obtained in the range of 64% - 100% at meeting 1, 79% - 100% at meeting 2, and 72% - 100% at meeting 3. Meanwhile, the percentage obtained for behavioral engagement ranged from 82% - 95% at meeting 1, 89% - 100% at meeting 2, and 89% - 100% at meeting 3. Furthermore, we obtained data in the emotional engagement domain with a range of 77% - 100% at meeting 1, 79% - 100% at meeting 2, and 89% - 100% at meeting 3. Thus, the differentiated mathematics instruction module effectively stimulates student engagement.

The mathematics teaching module based on differentiated instruction was developed based on the analysis results so that the teaching module is in accordance with the needs and characteristics of students. As Van den Kieboom and Groleau (2022), student characteristics and needs are analyzed to determine appropriate and accurate steps for learning activities according to student needs. In addition, Smale-Jacobse, Meijer, Helms-Lorenz, and Maulana (2019) asserted that student needs analysis aims to optimize the development of student potential in order to achieve learning goals.

We validated the teaching module involving an expert validator to produce a mathematics teaching module based on differentiated instruction that is of good quality and suitable for use. In the first validation stage, the teaching module's validation results were invalid in content suitability and suitability for differentiated instruction, so revisions were made according to the validator's suggestions and comments. Invalid validation results must be revised until declared valid (Rahayu, Mayasari, & Pagiling, 2021). Expert validators revalidated the revised differentiated mathematics instruction module as phase II validation. The results of phase II validation for all aspects of the assessment are in the valid category, with Aiken validity results above 0.61. Marsigit, Retnawati, Apino, Santoso, Arlinwibowo, Santoso, and Rasmuin (2020) explained that validation results with V-Aiken results of more than 0.61 were declared valid. Thus, a mathematics teaching module based on differentiated instruction is suitable for implementation in the teaching and learning process.

The implementation of the mathematics teaching module based on differentiated instruction was carried out through limited trials and field trials through direct learning in 3

meetings with the main material, namely SPETV prerequisite knowledge, which consists of Least Common Multiple (LCM), Algebraic Operations (AO), and One Variable Linear Equations (OVLE) at the first meeting, Completion of Systems of Linear Equations in Two Variables (SLETV) at the second meeting and Completion of Applications of Systems of Linear Equations in Two Variables at the third meeting. Limited trials were conducted to test the practicality of differentiated mathematics instruction modules through teacher and student response questionnaires. The results of teacher and student responses were in the practical and very practical categories for aspects of convenience and attractiveness. This means that the mathematics teaching module based on differentiated instruction is useful and easy to use so students can learn independently. These findings corroborate previous research regarding the ease of teaching modules (Kartika, Sanapiah, & Juliangkary, 2017; Nesri & Kristanto, 2020), which help facilitate students' independent learning and provide the same access to every student in constructing their understanding. Meanwhile, field trials were carried out after the differentiated mathematics instruction module was declared practical.

Furthermore, to prove the effectiveness of the differentiated mathematics instruction module in stimulating student engagement, an assessment was carried out through observation sheets of student engagement when the teaching module was applied to learning. The student engagement observation sheet results show that the differentiated mathematics instruction module developed based on student learning readiness can stimulate student engagement cognitively, behaviorally, and emotionally. Furthermore, Hasanah et al. (2022) and Suprayogi, Valcke, and Godwin (2017) stated that differentiated instruction based on student abilities can encourage student engagement in learning.

Student engagement in learning is classified based on aspects of cognitive engagement, behavioral engagement, and emotional engagement. The form of student engagement in the cognitive aspect is that students are cognitive throughout the meeting. For instance, students do mathematics assignments in class and ensure correct solutions. Students do not have difficulty doing class assignments; they do it themselves rather than being told the answer. Meanwhile, the form of student engagement in the aspect of behavioral engagement, students try to learn mathematics even though some are difficult, students complete assignments on time, students participate in class, and students do not give up if they do not understand the material, and pay attention to the teacher's explanation and do not do things that are difficult to understand.

Furthermore, the form of student engagement in the aspect of emotional engagement is that students look forward to mathematics class, students want to understand what is being studied in mathematics lessons, students feel comfortable and happy when learning mathematics, students care and want to learn mathematics in class during mathematics lessons, do not feel worried when

learning mathematics, and students enjoy learning new things about mathematics. These findings corroborate prior research (Burhanudin et al., 2023), which states that differentiated teaching modules can create a quality, interactive teaching and learning process and challenge students to participate in learning actively.

Research findings in the development of differentiated mathematics instruction modules that stimulate student engagement in learning, namely the presentation of material and discussion of example questions arranged in detail in simple language according to students' characteristics and needs, as well as the use of plastic straws in the teacher's explanation of the material and explanation of steps-steps to solve example questions. These findings align with prior studies regarding the use of manipulatives, such as attractive plastic straws, which can enhance interest and motivation and help students understand the mathematics content (Hinojosa & Bonner, 2023; Lee & Lee, 2019; Wilkie & Roche, 2022).

Thus, the mathematics teaching module based on differentiated instruction, developed based on the analysis of characteristics and student needs, is declared valid, practical, and effective in stimulating student engagement. These findings support Gusteti and Neviyarni (2022), Suprayogi et al. (2017), and Van den Kieboom and Groleau's (2022) research on differentiated instruction is very interesting and suitable for mathematics learning since it adapts to students' learning needs. This study has several limitations; first, the development of mathematics teaching modules is limited to differentiated instruction based on students' learning readiness; second, this teaching module is only implemented in one class; future studies can examine in other contexts at several mathematics classes in order to provide valuable lens how differentiated instruction can foster student engagement.

Conclusion

This research describes the process and results of developing a mathematics teaching module based on differentiated instruction that is valid, practical, and effective. Development is carried out based on an analysis of student characteristics and needs by paying attention to the components and steps in preparing teaching modules. The development results were valid, practical, and effective teaching modules for stimulating student engagement. This study recommends that teachers analyze students' characteristics and needs before designing learning activities and utilize various learning resources and media in the teaching and learning process tailored to students' needs and characteristics to achieve maximum learning outcomes. Meanwhile, future researchers can develop teaching modules or learning tools based on differentiated instruction in other materials so that each student is well-facilitated and gets the best learning results. These are developed based on the characteristics and needs of students that

meet valid, practical, and effective criteria to stimulate student engagement so that the mathematics teaching module is well used and developed in learning.

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