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Interactive Digital Teaching Module Based on Differentiated Instruction and Its Impact on Students' Problem-Solving Skills

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Abstract: Differentiated Instruction (DI) is a solution offered in the Merdeka Belajar curriculum, where students study chemistry material according to their abilities, what they like, and their individual needs so that they are not frustrated and feel like they have failed in their learning experience. This study aims to develop interactive digital teaching modules based on Differentiated Instruction (DI) that meet valid, practical, and effective criteria for problem-solving abilities. This research is development research based on the ADDIE model with stages: analysis, design, development, implementation, and evaluation. The trial sample was class X students of SMAN 1 Latambaga. The results showed validity with a value of 2.59, Practical with a value of 3.31 on teacher activity and a weight of 3.41 on student activity. Effective with good student response 74%. Problem-solving ability increases with a test score gain of 0.32 in the medium category. It is concluded that the interactive digital teaching module based on Differentiated Instruction (DI) can be used in the learning process because it begins with a diagnostic assessment so that learning is by students' abilities and learning styles.

Keywords: DI; Interactive Digital Module; Problem-Solving

Introduction

One of the policies of the Ministry of Education and Culture, namely the application of independent learning as an effort to create high-quality education. Merdeka Learning believes that later, students will have the freedom, individually or in groups, to think to develop students who are creative, critical, innovative, and superior in the future. In addition, Merdeka learning is an idea in response to the needs of students in the era of the industrial revolution 4.0 (Aan et al., 2021; Arung et al., 2023; Paus et al., 2023). Merdeka Belajar curriculum is essentially an implementation of the 2013 curriculum, where students are also directed to have the ability to ask questions, reason, and be able to convey all forms of knowledge that have been obtained in the learning process (Rahayu et al., 2020). A differentiated approach or Differentiated Instruction (DI) is a new paradigm in which the abilities or talents of students apply learning activities. Differentiation learning focuses more on meeting students' learning needs with independent learning strategies. In its application, students obtain information by managing ideas that are carried out so that when students interact with the material, they have the right to choose a learning style according to their wishes (Wahyuni, 2022; Lavania & Nor, 2021; Ojong, 2023). The differentiated approach can be applied in all subjects at school, including chemistry lessons.

Chemistry is the study of natural sciences, matter, the properties of objects or changes in compounds that combine to form new compounds. Chemistry reviews related to the movement of atoms in individuals intend for knowledge to be at the macroscopic level, in the sense of studying the embodiment of a molecule so that later we can understand all phenomena that occur. Chemistry also provides students with insight into thinking scientifically, namely having an attitude towards science that can be formed through the environment and personal factors from the environment, behavior, cognitive processes, and consistency (Rahayu, 2021).

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However, based on observations of Chemistry learning activities at SMA Negeri 1 Latambaga, the student learning outcomes were relatively low. The results of interviews with chemistry teachers at SMA Negeri 1 Latambaga that the complexity of chemistry material makes students overwhelmed in solving problems, and the lack of supporting teaching materials results in students having low learning motivation and problem-solving abilities. In line with the results of student interviews, most said that chemistry material was challenging to understand. So that this becomes a problem that needs to be addressed so that the learning process can take place effectively so to achieve the goal.

Problem-solving is one of the abilities at high levels in the cognitive domain. In addition, problem-solving skills are efforts to achieve the desired goals by finding new answers through plans or strategies as a solution to action (Hadi et al., 2023; Ojong, 2023; Rahayu & Adistana, 2018). Problem-solving abilities can lead to active interaction and cooperation between students in learning activities so that they are by the learning expected by the 21st century (Adeoye & Jimoh, 2023; Maemunah et al., 2019). Students who are active and skilled in learning activities make them independent in improving their thinking skills and overcoming the problems they face (Hasan et al., 2019; Jayadiningrat & Ati, 2018). Problem-solving abilities can be supported, one of which is through applied teaching materials.

One type of teaching material is the teaching module. Through teaching modules, learning activities will be easier to do because they include all forms of material arranged systematically to accommodate students in achieving competence (Andriani et al., 2019; Magdalena et al., 2021; Rizki & Linuhung, 2017). Digital module is media that can be accessed using digital devices. This digital media can be in the form of websites, social media, digital images and videos, digital audio and others (Abdulrahaman et al., 2020; Basar et al., 2021; Indariani et al., 2018). Various studies have shown that interactive digital teaching modules are valid and feasible to use in the learning process with an outstanding category that can improve learning outcomes and problem solving skills (Aisyah et al., 2021; Herawati & Muhtadi, 2018; Panggabean & Purba, 2021). So based on the description above, this research is essential for the purpose develop interactive digital teaching modules based on DI (Different Instruction) on chemistry problem-solving abilities as a form of independent learning.

Method

The design for developing interactive digital teaching media based on DI (Different Instruction) follows the ADDIE development model in Figure 1.

Figure 1. ADDIE Development Model Design

First, the analysis phase is carried out with a diagnostic assessment. Second is the design stage, namely the stage of making learning plans and organizing students according to the results of the diagnostic assessment and curriculum analysis, which includes content, process, product and learning environment differentiation. Third, the Development stage, namely developing interactive digital teaching modules. Fourth is the implementation stage, namely, implementing interactive digital teaching modules in the learning process to determine the level of efficiency, effectiveness, and problem-solving skills of students. The last stage is the Evaluation stage, where a final product revision is carried out based on suggestions and input during the implementation stage.

The measurement instruments used are validation sheets, observation sheets, questionnaires, and written tests consisting of diagnostic assessments and tests to obtain students' problem-solving abilities. The aspects assessed in the validation sheet are adjusted by the experts involved to obtain data on the validity, practicality and practicality of the interactive digital teaching modules being developed. The scale used in the validation, observation and questionnaire sheets is 4 = perfect, 3 = good, 2 = poor and 1 = very poor, which adopts the Likert scale. Next, determine qualitative criteria by referring to guidelines.

The state of the diagnostic assessment test used refers to the Three Tier Test model, namely a diagnostic question with three levels. The first tier is about the answers, the second is about the reasons for the answers, and the third is about the beliefs about answering questions and explanations. After getting the categories for each answer, the percentage of solutions can be calculated. The answers rate is calculated from the majority of answers given by students for each item.

Data analysis of problem-solving skills was carried out using a written test in the form of a description test. Tests are prepared based on problem-solving indicators, namely understanding the problem, developing a settlement plan, carrying out the settlement plan, and re-examining the settlement results. Furthermore, the scoring process data is converted into a value and then analyzed by determining the percentage of problem-solving abilities.

Result and Discussion

The results of developing differentiated instruction-based interactive teaching modules will be detailed according to the stages of ADDIE development.

Analysis Stage

The analysis phase is carried out to identify and clarify the problems faced by students. Based on differentiation learning, the learning process starts from the diagnostic assessment stage. A diagnostic assessment is an assessment that is carried out to identify the basic abilities and conditions of students so that educators can determine the parts that must be repaired and improved. So, through the diagnostic assessment carried out, information can be obtained regarding students' strengths, weaknesses, knowledge, skills, readiness, interests and learning profiles (Agniya et al., 2023; Iskak et al., 2023).

Figure 2. Implementation of the Cognitive and Noncognitive Diagnostic Assessment Tests

The diagnostic assessment carried out on SMA Negeri 1 Latambaga students consisted of cognitive and non-cognitive diagnostic assessments. Cognitive diagnostics is done by giving questions to measure students' understanding before entering the atomic structure material related to literacy and numeracy abilities. The cognitive questions used are multiple choice questions of the Three Tier Test model or questions with three levels. Meanwhile, non-cognitive diagnostics are carried out to identify students' learning environments and learning styles. The process of carrying out a diagnostic assessment can be seen in Figure 2.

Based on the results of cognitive diagnostics, it was found that 5.4% of students had good mastery of literacy and numeracy competencies. 33.6% of students need a better knowledge of literacy and numeracy competencies. 61% of students have mastery of literacy and numeracy competencies that need clarification. At the same time, the results of the noncognitive diagnostic assessment stated that 67.8% of students had a visual learning style. The results obtained are in accordance with previous research, which stated that the use of three-tier tests in chemistry lessons was able to have a positive impact on the analysis of students' initial conceptual understanding. Through the test results, teachers can find out the initial steps taken in the learning process, including determining learning methods and media that suit students' learning styles (Khairunnisa & Prodjosantoso, 2020; Mellyzar, 2021).

Design Stage

This stage aims to design learning based on the results of cognitive diagnostic assessments and non-cognitive diagnostic assessments. According to Melesse & Belay (2022), differentiated learning design must include 4 things, namely differentiation of content, process, product and learning environment.

First, differentiation of the content, determine the material, namely the atomic structure, and next, analyze Learning Achievement (CP) among them. Students can observe, investigate and explain phenomena according to scientific work principles in explaining chemical concepts in everyday life; applying chemical concepts in environmental management, including explaining global warming; writing down chemical reactions and using basic chemical laws; and understanding atomic structure and its applications in nanotechnology. Form the Learning Achievement (CP) reduced to Flow of Learning Objectives (ATP) among them Explains the development of atomic theory along with the discovery of the particles that make up atoms, determines protons, electrons and neutrons (symbols of elements) and writes electron configurations and determines valence electrons and the value of quantum numbers.

Second, differentiation of the process, namely determining the learning model according to the learning environment and learning styles of students. The learning model is the direct instruction model because students need the formation of initial concepts because they have an understanding of misconceptions, so educators must provide straightforward explanations using interactive media in the form of animated pictures of atomic models and interactive videos of discoveries of atomic particle constituents. The learning approach uses a scientific learning approach, which includes observing, asking, associating, collecting data, and communicating activities. Learning methods are lectures, discussions, questions and answers and assignments.

Third, product differentiation, namely determining the ability of the final learning outcomes, namely in the form of students' collaboration abilities increasing in discussion activities, student learning outcomes increasing and problem-solving skills increasing. The last is the differentiation of the learning environment, namely determining the composition of groups heterogeneously because, based on the results of non-cognitive diagnostic assessment analysis, it shows that most students have a visual learning style.

Development Stage

The third stage is to develop the design that has been made. Several things were prepared, namely,

editing teaching modules using the Canva application and collecting materials used such as videos, animations, images, etc. Next, is realizing the designs that have been made before. At this stage, coordination and consultation were carried out with expert animators, programmers, and video editors. The results of the development that has been carried out are in Figure 3 and Figure 4.

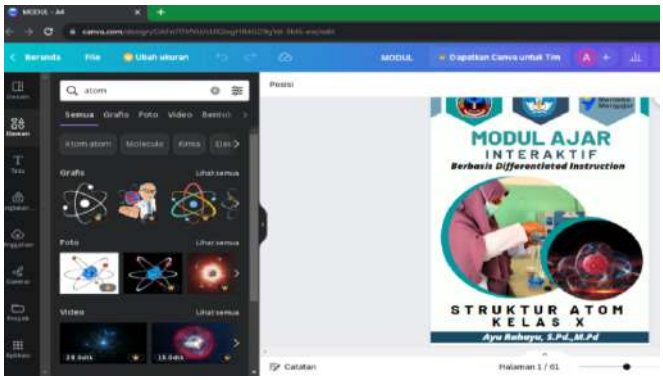

Figure 3. Creating Teaching Modules Using the Canva Application

Previous research believes that Canva is an exciting application for designing teaching materials because it offers a variety of graphic design options. It has been proven that Canva-based teaching materials developed on chemistry material meet valid criteria that can increase students' understanding of concepts and learning motivation (Holisoh et al., 2023; Wahyuni et al., 2022; Yunita et al., 2023). Meanwhile, the Flip PDF Corporate Editor application in creating digital modules has also been carried out specifically for chemistry material, which shows that the E-module meets the valid criteria or is suitable for use in the learning process (Elvinawati et al., 2022; Fitri et al., 2022).

Figure 4. Creating Teaching Modules Using the Flip PDF Corporate Editor Application 2.4.10.2

After the editing process uses the Flip PDF application, the publication is online, accessed at flipbuilder.com, as shown in Figure 5.

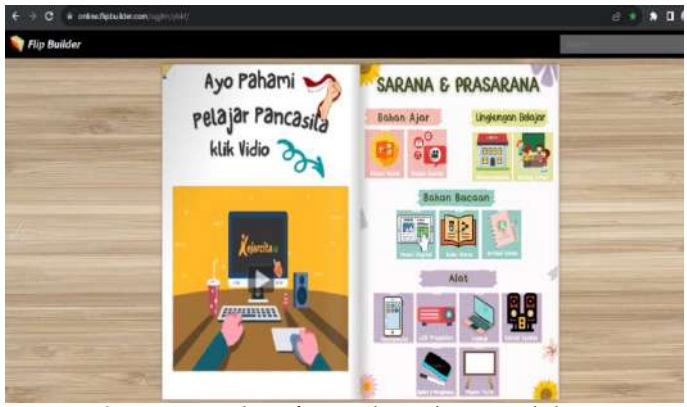

Figure 5. Display of Digital Teaching Modules

Digital teaching modules developed are then validated regarding material, design and language. The validators involved were six people. Validation needs to be done to determine whether the e-module chemistry material being developed can be implemented in the learning process as carried out by Maisarmah (2022) and Yuliana et al. (2023). The validation results can be seen in Table 1.

The assessment results of the three validators in Table 1 show that DI-based interactive digital teaching modules are declared valid in terms of material, language and design with several inputs. The material expert's assessment showed that the CP and ATP material atomic structure reviewed the material presented. The evaluation of linguists shows that the preparation of interactive digital teaching modules in terms of language is easy to understand, according to language rules, the accuracy of sentence structure, the accuracy of spelling and consistency in the use of words. Some of these indicators are needed to facilitate communication by using effective language to create good performance (Asemanyi, 2015; Waridah, 2016).

Table 1. Results of Validity Data Analysis

Evaluator	Rated Aspects	Score	Average	Category
Concept Expert	Quality of content and purpose	2.47	2.57	Good/ valid
	Quality of learning process	2.65		
	Display of material	2.46		
	Concept up to date	2.68		
Design Expert	Cover display	2.81	2.66	Good/ valid
	Content display	2.74		
	Aspect of use	2.43		
Language Expert	Communicative	2.65	2.54	Good/ valid
	Readibility	2.53		
	Straightforward	2.45		

The design expert's assessment shows that the preparation of interactive digital teaching modules using the Canva application and Flip PDF Corporate

Editon 2.4.10.2 contains aspects of reliability, maintainability (can be easily managed), usability (easy to use and simple to operate) and compatibility (learning media can be installed/installed). Run on a variety of existing hardware and software). Alfian et al. (2019) said the development of software-based media or software must include maintainability in the form of analyzability and changeability, portability, namely testing in running applications on several types of devices and usability. Based on these assessments, it can be stated that interactive digital teaching modules in terms of language, material and design are feasible to try out (Alfian et al., 2019; Jatmiko et al., 2022; Marlina et al., 2022; Prabasari & Wahyuningsih, 2021).

Implementation Stage

A valid teaching module means testing is feasible, and the implementation stage will provide practical and effective data. The implementation stage is important because students are the target of the product test being developed. The implementation phase presents two data, namely, practicality and effectiveness. The implementation phase consists of three meetings, the first is the presentation of material on the development of atomic structure, and the second meeting is followed by material on determining the configuration of electrons, quantum numbers, protons, electrons and neutrons. Then at the third meeting, it continued with giving problem-solving tests and questionnaires on student responses to the learning process using interactive digital teaching modules. The method of implementing interactive digital teaching modules can be seen in Figure 6.

Figure 6. The Learning Process Using Interactive Digital Teaching Modules

Practicality Data

The learning process was observed by six observers whose job was to keep the activities of students and teachers. The observation sheet aims to obtain practical data. The activities assessed consist of three aspects, namely preliminary activities, core activities and closing activities. These results can be seen in Table 2.

Table 2. Results of Practicality Data Analysis

Assesed Components	Average Score	Category
Teacher Activity	3.31	Good
Student Activity	3.42	Good

The results of the data analysis in Table 2 can be concluded that using interactive digital teaching modules is practical or easy to use, starting from the preliminary activities, the core activities carried out to the closing activities. The observation results show that teaching activities obtain an average score of 3.31 in the good category. At the same time, students' actions get an average value of 3.42 in the good category. So that it can be said that the use of DI-based digital interactive teaching modules fulfils the practical test requirements in the good category; this is because the teaching modules developed are the result of a diagnostic assessment so that they are truly by the basic abilities, learning styles and learning environment of students. Purba (2021) states that with a diagnostic assessment, teachers can determine adjustments to the level of challenges in the learning process, such as concepts that must be repeated and ideas that are only directly taught. The study results indicate that a diagnostic assessment can be used as evaluation material to continue decision-making as reinforcement which aims to help overcome difficulties in the teaching and learning process (Conforme et al., 2019).

Student Response

Assessment of student responses is carried out at the end of the meeting. The results of student responses can be seen in Table 3.

Table 3. Data for Student Response Analysis

Assesed Aspects	Score	Average	%	Category
Use of Teaching Modules	2.91	2.98	74	Good
Benefits of Teaching Modules	3.04			
Understanding Material with Teaching Modules	2.96			

According to the research results in Table 3, it was found that students gave good responses. A positive reaction implies that students are interested in using DI-based interactive digital teaching modules and are enthusiastic about participating in learning activities. The use of modules helps to understand the material because it provides videos and pictures, making it easier for students to grasp the meaning of the material being taught. In addition, teaching modules can be accessed on the internet for learning wherever and whenever. The use of teaching modules in the learning process becomes more efficient because there are audiovisuals that are easy to understand (Dawadi, 2022; Pikoli & Lukum, 2021). Using teaching materials that are appropriate to students' learning styles has a positive impact on learning outcomes (Weng et al., 2019; Yusuf & Erviana,

2019). Based on student responses, it can be concluded that DI-based interactive digital teaching modules are acceptable for use in the learning process, especially in atomic structure material.

Problem-Solving Ability

The problem-solving skills test was analysed using a one-group pretest-posttest research design and was measured using a test instrument. The test given is a description test based on indicators of problem-solving skills. The pretest and posttest results of measuring problem-solving skills are first carried out by the initial test, namely the normality and homogeneity tests as prerequisite tests. The results of the normality and homogeneity tests show that sig is greater than 0.05, so it is concluded that the data obtained to measure students' problem-solving skills is normally distributed and homogeneous. The t-test is a smaller sig value than 0.05, so using interactive digital teaching modules as a result of development can improve students' problem-solving abilities. The increase in problem-solving skills can be compared before the value of the treatment or pretest and after the treatment or posttest using the score gain test.

Table 4. Gain Test of Problem Solving Ability Score

Indicator	Score Gain Test			
	Spre	Spost	N-gain	Category
Understanding Problems	34	55	0.31	Medium
Develop a Completion Plan	46	70	0.44	Medium
Execute the Completion Plan	59	65	0.15	Low
Re-Checking Completion Results	38	60	0.36	Medium
Average			0.32	Medium

Based on Table 4, the problem-solving ability test shows the difference in n-gain values for each aspect of problem-solving, which can be classified into two categories: medium and low. Problem-solving skills are measured using pretest and posttest description tests. The three indicators in the medium category are understanding the problem, preparing a settlement plan and re-examining the settlement results, meaning that students can understand the problem, develop a settlement plan and re-examine the payment results. While the low category, namely carrying out a settlement plan, means that students need to be proficient in working on existing problems. Implementing the settlement plan has a low sort because, in learning, students still need help answering existing questions.

The results of the recapitulation of problem-solving skills were obtained in the medium category because DI-based interactive digital teaching modules are unsuitable for measuring students' problem-solving, especially in atomic structure material. In addition, students still need help solving existing problems, so their skills in implementing the solution plan still need to improve. But in general, interactive digital teaching modules can improve problem-solving skills. This is to the results of previous studies state that the application of differentiated learning can improve problem-solving abilities; the increase in average test scores shows this (Cornelius et al., 2018; Dalila et al., 2022; Sutrisno et al., 2023).

Evaluation Stage

The implementation stage illustrates that the interactive digital teaching module gets a positive response from students and improves problem-solving abilities. Some of the suggestions from the implementation stage are optimizing DI-based interactive digital teaching modules. Based on this, the researcher assessed that the developed DI-based interactive digital teaching modules could improve students' problem-solving abilities in the medium category.

Some improvements for the next stage are first; a comprehensive explanation is needed to students in filling out diagnostic assessments, especially non-cognitive diagnostics, so that students don't just fill in what is not by themselves. Second, the grouping of students is according to their learning styles so that the material in the LKPD is presented according to the groups of students (Visual, Kinesthetic and Auditory). Third, focusing on increasing the dependent variable using DI-based interactive digital teaching modules should start with cognitive learning outcomes as the basic level of the learning process output. If student learning outcomes increase, they can continue at a higher level of skill or ability. Such as problem-solving skills, critical thinking skills and others

Conclusion

The quality of developing DI-based interactive digital teaching modules refers to the ADDIE model, which is valid from the assessment of material, language and design experts. Practical because all aspects of learning activities can be carried out. Effective because students give a positive response. Students have increased problem solving abilities but in the medium category.

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Author Contributions
Ayu Rahayu: preparation of the original manuscript, results, discussion, methodology, conclusions. Rosti: perform analysis, proofreading, review, and editing.

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Conflicts of Interest
The authors declare that there is no conflict of interest regarding the publication of this paper.

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