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Development of Chemistry Learning Module Based on Discovery Learning on the Periodic Properties of Elements

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Abstract: *21st century education requires students to develop competitive skills known as 4C skills. This study aims to: (1) determine the feasibility of the discovery learning-based module that has been developed. (2) determine the practicality of using the discovery learning-based module that has been developed. This study was conducted with a Research & Development approach using the 4D model. This study was conducted at SMAN 1 Tiganderket. The results of this study indicate that the discovery learning module that was developed obtained an average validation of materials and media of 3.2 and 3.1 (feasible) while the average teacher response was 98% and student response was 99.76% (very good). This shows that the discovery learning module on the material of periodic properties of elements that was developed is feasible and very good for use in chemistry learning in high school.*

Keywords: *discovery learning; model 4D; module*

INTRODUCTION

Education in the 21st century is a challenge. The world of education bears a great responsibility in balancing these challenges. Preparing human resources who master 21st century skills will be effective if pursued through education (Redhana, 2019). According to Prihadi (2018) Partnership for 21st Century Skills, requires students to be able to develop competitive skills that are in accordance with the characteristics of 21st century skills2 (Maulidia et al., 2023). These skills are known as 4C, namely critical thinking, creativity, collaboration and communication (Anwar, 2022).

Chemistry is one of the subjects that requires the application of 21st century skills. In essence, learning chemistry is based on facts, the results of thinking and products resulting from research by experts, which are then directed at the methods, attitudes and scientific products that students have and ultimately there will be an increase in student learning outcomes (Simanjuntak & Purba, 2024). Learning skills in the 21st century can be seen when student-centered learning (two-way) is applied, not one-way learning, namely on the teacher (Maulidia et al., 2023).

Chemistry education at SMAN 1 Tiganderket is still dominated by teachers (teacher centered). This results in teachers playing a more active role while students are passive. Teachers are more dominant in transferring knowledge, resulting in a lack of opportunities for students to express ideas or

ask questions (Pada & Larutan, 2021). Resulting in the interaction between teachers and students is still not well established. Many students feel bored and inactive in learning and lack of student understanding of the material presented. The lack of variation in learning models, learning media, and teacher creativity in implementing learning has an impact on student activity in learning (Purba & Siregar, 2020). Likewise, in the use of media, teachers only use teaching materials such as textbooks provided by the school. The research results (Purba & Fitri, 2021) state that the teaching materials usually available in schools are only textbooks, with each student having only one book. This is the cause of students being less active and independent in learning so that it is necessary to use educational media that can solve problems (Accraf & Khery, 2018). Supported by the results of interviews with several students that most of them consider chemistry learning boring and uninteresting because they only need to memorize. So that the 21st century skills that students must have are not fulfilled.

Addressing the problems in chemistry learning, which is considered uninteresting and boring, interactive learning media in the form of teaching materials are needed. Procurement of quality teaching materials is one of the efforts to improve the quality of education (Zulfajri, 2016). Without teaching materials, teachers will have difficulty in increasing the effectiveness of learning, while students will also have difficulty in learning (Novita & Septryanesti, 2019). Thus, teaching materials are needed in the form of modules.

A module is a teaching material that is designed in an integrated manner that can be used during learning with or without a teacher, in other words, students can learn independently at school or at home according to their respective learning speeds (Handayani et al., 2016). Modules can also be developed to be more interesting (Sugiharti & Anugrah, 2023). The development of this module can also be combined with a learning model that can improve the effectiveness of student learning. The application of learning models can improve students' science abilities (Dibyantini & Azaria, 2020). The use of learning models is a consideration in the practicality and attractiveness of the module content, so that students are more interested and find it easier to understand the learning. One model that can be used is the discovery learning model. Discovery learning is a learning model to develop active ways for students to learn through their own discovery and investigation, so that the results obtained are more meaningful, long-term and difficult for students to forget (Aliyah et al., 2023). Research result (Brigenta et al., 2017) concludes that the development of physics modules based on discovery learning is good in improving conceptual understanding. While the research Meiliawati (2018) states that the learning outcomes using the discovery learning model improve students' conceptual understanding of the material on the periodic properties of elements. In this case, the researcher conducted research on the development of teaching materials in the form of modules integrated with learning models. The results of the study (Panggabean & Harahap, 2020) indicate that the average value of student learning outcomes taught using the discovery learning model is greater than the KKM value.

Based on the problems that have been raised, the solution that can be done is the development of teaching materials based on interesting learning models in chemistry learning. The development carried out in this study is a discovery learning-based chemistry learning module on the material of periodic properties of elements using the 4D development model. The use of this model does not require a long time and the stages are simpler (*Maydiantoro*, 2021). This study aims to determine the feasibility of discovery learning-based modules and the practicality of using discovery learning-based modules that have been developed.

LITERATURE REVIEW

A. Module

According to (Zebua & Harefa, 2022) a module is a learning tool in printed form that is systematically arranged and packaged, containing a set of planned learning experiences and designed to help students master learning objectives based on basic competencies or competency achievement indicators, instructions for independent learning activities (self-instructional), and providing students with the opportunity to test themselves through exercises presented in the module.

Modules are also the easiest media because they can be studied anywhere and anytime without having to use special tools, convey learning messages, increase student motivation, the learning load is distributed more evenly, and teachers can find out the level of student learning success (Ramadayanty et al., 2021). Learning using modules provides students with the opportunity to recognize their strengths and improve their weaknesses through repetition of parts of the material that they have not yet mastered (Aliyah et al., 2023).

From the several opinions above, it can be broadly concluded that a module is a learning media that is arranged in an integrated and interesting way, containing planning and learning objectives to be achieved and can be studied independently by students. Thus, the module is designed and packaged attractively so that it can guide students to learn more actively and enjoyably so that students' abilities can be honed and explored optimally.

According to (Rahmi et al., 2021)The advantages of the module are: (1) Students can complete the material based on each individual's learning speed; (2) The module is an integrated learning package; (3) Validated. Meanwhile, the disadvantages are: (1) Compiling a good module requires certain skills; (2) It is difficult to determine the scheduling and graduation process; (3) Requires different management because each student's learning speed is different.

In order to overcome these weaknesses, researchers developed an attractively designed learning module that only focuses on one topic to make it more structured and time efficient in achieving learning completion.

B. Discovery Learning

The discovery learning model is a learning activity that guides students to play an active role independently in finding new relevant concepts, facts, and knowledge through analysis and inference. In addition, discovery learning-based learning is a technique used by teachers in the learning process, students are directed to actively seek, find and research their own solutions to problems and are able to express their opinions, formulate problems, plan experiments, analyze and draw conclusions (Purwasi & Fitriyana, 2020).

Meanwhile, according to(Syahrir & Negeri Makassar, 2023)which states that discovery learning is a way of presenting material that places students in the position of discovering for themselves the concepts, principles, and problem solving that must be mastered to achieve learning objectives. Meanwhile, according to(Halawa & Harefa, 2024). The discovery learning model is a model in which ideas or concepts are conveyed through a process of discovery.

The learning model has syntax and learning stages that must be implemented. Based on the application of the discovery learning model, there are six learning syntaxes, namely: stimulation, problem identification, data collection, data processing, verification, and generalization (Nuraeni, 2022).

C. Model 4D

The four-D (4D) model was developed by Sivasailam Thiagarajan, Dorothy S. Semmel, and Melvyn I. Semmel in 1974. This

model consists of four stages of development. According to Thiagarajan (1974) in (Waruwu, 2024). The details of the activities carried out at each stage of 4D development are: (1) Define, this stage is the product development needs analysis stage. To analyze it, developers need to analyze and collect information about the extent to which development needs to be carried out. (2) Design, the design stage which includes preparing test standards, selecting media and selecting formats. (3) Develop, the stage of validating the product, conducting revisions and trials. (4) Dissemination, the final stage is distributing the product.

The study used the 4D development model. The use of this model is more time-saving and each stage is relatively easy in the development of a product. The advantage of this model lies in the involvement of material analysis and task analysis in determining learning objectives. In addition, each step in this model is explained in detail and is easy to do (Vahlia & Agustina 2016).

METHOD

The type of research conducted is development research (R & D) with a 4D model. This research was conducted until the development stage.

This study uses non-test instruments in the form of a questionnaire on the suitability of standard teaching materials BSNP (National Education Standards Agency) and teacher and student response questionnaires. The material validation questionnaire will be assessed by 2 validators and media validation by 1 validator while the response questionnaire consists of 1 respondent as a teacher and 36 respondents for students.

Data analysis from material and media experts was developed using a Likert scale as in the following table.

Table 1. Likert Scale

Evaluation	Information	Score
SB	Very good	4
B	Good	3
K	Not enough	2
SK	Very less	1

The assessment of the suitability of the materials is shown in table 2 below.

Table 2. Module Eligibility Criteria

Score	Criteria
$3{,}25 \leq \bar{X} \leq 4{,}00$	Very worthy
$2{,}50 \leq \bar{X} < 3{,}25$	Worthy
$1{,}75 \leq \bar{X} < 2{,}50$	Less worthy partially revised
$1{,}00 \leq \bar{X} < 1{,}75$	Absolutely not worth a total revision

(Widoyoko, 2013)

The average score assessment from experts uses the following formula:

$$\text{Average Score} = \frac{Amount\ Validation\ Score}{Amount\ Aspects\ Tested} \quad (1)$$

For validation of material experts include aspects of content feasibility, presentation and language and suitability of discovery learning. While validation of media experts consists of aspects of module size feasibility, cover design and content design. While the analysis of teacher and student response data is calculated and then converted according to the criteria of the percentage results of teacher and student response questionnaires using certain categories are shown in table 3 as follows.

Table 3. Respondents' Practicality Criteria

Percentage	Criteria
0 - 39%	Fail
40% - 59%	Not enough
60% - 74%	Enough
75% - 84%	Good
85% - 100%	Very Good

To calculate the average percentage of teacher and student responses, the following formula is used

$$p = \frac{\Sigma x}{\Sigma xi}\ x\ 100\% \quad (2)$$

(Ramadhani & Izzati, 2023)

Based on the results of the validation questionnaire and respondent questionnaire calculations, the feasibility and practicality of the developed module will be known.

RESULTS AND DISCUSSION

Define Stage

This stage is the initial step taken by researchers with the aim of analyzing the basic needs of why it is necessary to develop

teaching materials, which consists of several stages, namely teacher interviews, needs analysis by students, concept analysis, and formulation of learning objectives.

The result of this stage is that students often feel bored, uninteresting and consider chemistry learning, one of which is the material on the periodic properties of elements, only needs to be memorized. This is due to the limited teaching materials used by teachers and learning in class is still centered on the teacher so that it seems monotonous. Teachers have never used modules in the learning process so interactive teaching materials are needed that can be additional teaching materials for students in learning.

At the define stage, an analysis of the learning objective flow (ATP) is carried out to determine the learning outcomes and competencies that students must have. Based on this stage, it can be concluded that ATP can be a guideline in the preparation and development of learning modules in the classroom.(Bahja et al., 2023). Then the researcher analyzed the independent curriculum chemistry books and K-13 chemistry books used by the school. The analysis of this chemistry book was carried out by identifying the shortcomings and advantages of the book, then creating aspects that will be developed in the module as a reference for researchers in compiling discovery learning-based modules on the material of periodic properties of elements. Based on this, a solution was found so that a "Discovery Learning-Based Module on Periodic Properties of Elements" was created.

Design Stage

The design stage is carried out by compiling a draft and selecting media so that a discovery learning-based chemistry module is created on the material of periodic properties of elements. At the stage of compiling the module draft, the initial concept is designed to be used in developing the module. Furthermore, the selection of supporting media is carried out in the process of making the module. These supporting media are Microsoft Word and Canva. The module is arranged systematically consisting of the front, opening, contents and closing. In the module there are images, graphs, tables or information boxes and others arranged as attractively as possible and in accordance with the discovery learning syntax which consists of 6 stages, namely providing stimulation, identifying problems, collecting data, processing data, proving, and drawing conclusions (Haerullah & Hasan, 2017).

The design stage carried out in 6 discovery learning syntaxes is solid. The stimulation stage is presented with questions in the form of triggers and accompanied by images or statements to arouse students' curiosity so that they dig up the information needed. The problem identification stage (problem statement) students are directed to identify problems related to the stimulus stage which are then formulated in the form of a hypothesis (temporary assumption). The data collection stage contains literature or sources of information and project assignments that aim to help students collect data. The data processing stage contains various questions related to the data collection that has been carried out so that the data will become information that is easy to understand and functions as concept formation and generalization. The proof stage students are directed to convey the results of data processing which aims to prove the truth of the hypothesis made. The conclusion drawing stage, students draw conclusions from the data obtained based on the verification results.

The design results contain discovery learning syntax at the design stage as follows.

Figure 1. Design of the developed module content

Develop Stage

The development stage is the final stage in this research which consists of several

stages, namely validation of the module's suitability by expert material validators and media experts, revision of the e-module according to the validator's suggestions for improvement and assessment of responses by teachers and students to the developed module.

The following are the assessment results by 2 expert material validators which can be seen in table 4.

Table 4. Material Validation Results

Assessment Aspects	Validators	
	Lecturer	Teacher
Content Eligibility	2,9	3,3
Presentation Eligibility	3,2	3,5
Language Eligibility	3,1	3,2
Discovery Learning	3,3	3,4
Average	3,125	3,35

Based on the expert validation results table, the average assessment for each aspect can be seen as follows.

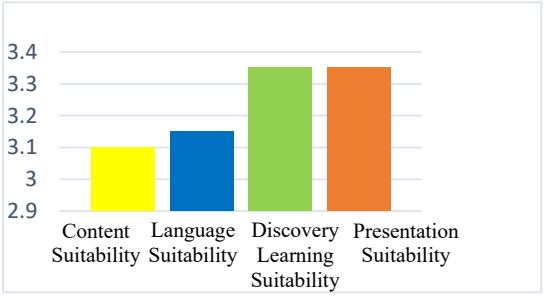

Figure 2. Results of Material Validation by Lecturers and Teachers

From Figure 1, the validation results of the discovery learning-based module developed by the researcher can be seen. The average analysis of the module that has been developed is 3.2, which means that the module is valid with an average description of the content feasibility aspect of 3.1; the presentation feasibility aspect of 3.35; the language feasibility aspect of 3.15; and the discovery learning feasibility aspect of 3.35, so it can be concluded that the Discovery Learning-based module on the material of periodic properties of elements for class X of SMA is feasible to use.

Meanwhile, the media validation results can be seen in the following table.

Table 5. Media Validation Results

Assessment Components	Score
Module size	3,0
Module cover design	3,4
Content design	3,4
Average	3,1

The results of the analysis show that media validation obtained an average value of 3.1 with a valid category. Thus, it can be concluded that the module in terms of size, display design and content design has met the criteria for being suitable for use in the learning process.

The following is an example of the results of developing a cover design for the "Discovery Learning-Based Chemistry Learning Module on the Periodic Properties of Elements" material.

Figure 3. Developed module cover

Furthermore, in the development of this teaching material, a practicality test was carried out which was obtained through teacher and student responses.

Table 6. Teacher Response Results

Assessment Components	Percentage of assessment
Visualization	96%
Efficiency and Creativity	100%
Text Presentation	100%
Average	98%

The results of teacher responses show that the module meets the criteria of "very good" with an average teacher response of 98%. This shows that the developed module has a positive impact for use in learning.

Table 7. Student Response Results

Assessment Components	Percentage of assessment
Interest	99,77%
Material	99,53%
Language	100%
Average	99,76%

The results of student responses show that the module meets the criteria of "very good" with an average of 99.76%. It can be concluded that the developed module received a positive response from students, which means that the discovery learning-based learning module is good / interesting to use.

DISCUSSION

There are several stages carried out in the development of the module, including validation tests by experts. Expert validation is the process of assessing the product being developed so that the weaknesses and strengths of the product are known.(Afriyani, 2020). The aim of the validation test is to produce standard teaching materials that are suitable for use.(Sari et al., 2017). In this study, the criteria used to assess the feasibility of teaching materials are adjusted to the National Education Standards Agency (BSNP), for validation by material experts consisting of aspects of content, presentation and language feasibility and adding aspects of discovery learning integrated into the module. While media expert validation consists of aspects of module size feasibility, cover design and content design. Validation is the process of assessing whether a product design in this case the discovery learning module is feasible and provides a positive response or not when used as teaching materials. Therefore, each expert is asked to assess the product, so that its weaknesses and strengths can be identified (Sugiyono, 2017).

The results of the validation of materials and media on the developed teaching materials meet the criteria of "feasible" with values of 3.2 and 3.1. This shows that the discovery learning-based module developed is feasible to use in learning. Meanwhile, the results of research conducted by (Simanjuntak & Purba, 2024) shows that the development of e-modules based on discovery learning meets the module eligibility requirements with very valid criteria.

Furthermore, in the development of this teaching material, a practicality test was conducted which was obtained through teacher and student responses. The development of teaching materials needs to be tested for practicality to find out how good and interesting the use of the module as teaching material is according to students and teachers. This means that in this case the response is a reaction or impression experienced by respondents after observing activities related to the senses and assessing an object.(Ardianti et al., 2019).

The results of the practicality questionnaire assessment by teachers and students showed that the module met the criteria very well with the assessment response by teachers of 98% and students of 99.76%. This shows that the discovery learning-based learning module received a positive response and is good for use in learning. Research results (Nasution & Sutiani, 2022)stated the same thing that the use of discovery learning-based modules is very interesting with a percentage of teacher responses of 92.01 & and students of 89.91%.

CONCLUSION

The validity results of the discovery learning-based module on the material of periodic properties of elements obtained an average assessment result based on the expert validator instrument of material and media obtained an average value of material validation of 3.2 and media validation of 3.1 with the criteria of being suitable for use as teaching materials. Meanwhile, the results of the practicality questionnaire assessment by teachers and students showed that the module met the criteria very well with an assessment response by teachers of 98% and students of 99.76%. This shows that the discovery learning-based learning module on the material of periodic properties of

elements is good to use as teaching materials.

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