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Effectiveness of Atomic Structure E-Module on Learning Outcomes of Phase E Learners of SMAN 1 Lubuk Alung

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A B S T R A C T

Atomic structure is one of the materials studied in phase E SMA/MA. This material is abstract and very important for further chemistry material. Teaching materials that can help students understand the concept are needed. There has been an atomic structure e module that has been valid and very practical but has not been tested for its effectiveness on learning outcomes. This study aims to test the effectiveness of atomic structure e-modules on student learning outcomes. The type and design of the research is pre-experimental and one group Pretest-Posttest using purposive sampling. Based on the results of data analysis, the N Gain test results were 79% with effective, meaning that the e-module of atomic structure can effectively improve the learning outcomes of students.

1. Introduction

Atomic structure is one of the materials studied in phase E of the independent SMA / MA curriculum. This material is abstract and very important for further chemical materials (Langitsari et al., 2021). In general, atomic structure material discusses the development of atomic theory, atomic constituent particles, atomic notation, electron configuration, periodic systems consisting of the development of periodic systems and their properties. Due to the abstract and complex nature of this material, students experience difficulties when learning this material so that it affects learning outcomes (Suryelita et al., 2019).

Learning outcomes are assessments obtained after the learning process (Latisma, 2011). Learners have difficulty in understanding the concept of atomic structure material. It is proven that the learning outcomes of students in phase E of SMAN in padang pariaman odd semester 2022/2023 obtained an average score of 54.7 with details of 20% of students reaching KKTP and 80% not reaching KKTP. Furthermore, it is known that the existing teaching materials have not been able to support literacy and numeracy activities so that teaching materials are needed

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according to the demands of the independent curriculum. Language is an important tool to express and communicate with the others (Sari, 2023).

The independent curriculum prioritizes understanding of concepts by strengthening literacy competencies (Salsabilla et al., 2023). Literacy activities expect students to understand concepts by understanding what they read according to the learning objectives and then applying the concept. One of the suggested models in accordance with the independent curriculum for concept application is problem-based learning (Kemendikbudristek, 2022). So that teaching materials are needed that can guide students to do literacy to understand concepts. Education is the most important factor in a person's life, because it can distinguish a person's ability to think (Bella, 2023).

Teaching materials can affect students' interest in learning (Fani & Suryelita, 2024). The easier it is to understand in understanding the concept, the more interested in using it. Teaching materials can be designed in electronic form, one of which is the E-module (Ellysia & Irfan, 2021). The advantages of e-modules are that the material can be presented in the form of writing, graphics, videos, images, animations, and evaluation questions that provide feedback for students (Khairinal et al., 2021). According to Hatimah, et al (2021) android-based e modules can support students' literacy activities because they can be used repeatedly and according to students' understanding abilities (Hatimah & Khery, 2021). Learners can use e modules anywhere and anytime. E-modules can help improve understanding of concepts independently according to the directions and instructions contained in the e-module (Romayanti et al., 2020).

The atomic structure e-module that has been developed by Ayu Permata Sari and Suryelita (2023) in accordance with the independent curriculum has been tested for validity and practicality with an average V index value of 0.83 and is very practical with a percentage of 92% from teachers and 85% from students (Sari & Suryelita, 2023). However, this e-module has not been tested for effectiveness. Effectiveness is defined as the effect or success of a product that is able to achieve certain goals or objectives that can be measured by increasing students' understanding in the learning process (Romayanti et al., 2020).

Relevant research related to product effectiveness testing has also been conducted previously by Laila, et al (2022), it is known that the e-module of atomic structure according to Curriculum-13 is effective in improving student learning outcomes by 83.5 (Mufida et al., 2022). In line with Supratman, et al (2023) explained that PBL-based e-modules on reproductive system material can improve students' literacy skills (Supratman et al., 2023). Furthermore, research by Risky, et al (2022) stated that IT-based e-modules using PBL were effectively used in learning activities by 84.12% but the learning steps of the model were a little problematic in finding references and reference data so that the results of discussions for problem solving in case studies were not maximized (Vianis et al., 2022).

The explanation of some relevant research above explains that e-modules are effective in learning activities and can improve students' understanding. This study uses an e-module of atomic structure that has been designed in accordance with an independent curriculum that can guide students in conducting structured/directed literacy activities to understand concepts and then applied using a problem-based learning model. The main purpose of this study was to determine the effectiveness of the atomic structure e module. The use of E-modules of atomic structure is expected to be effective as teaching materials in learning activities. so that this research can be a reference for using e-modules as effective teaching materials in the implementation of learning at school.

2. Methodology

This type of research uses pre-experimental with a one-group pretest-posttest design. This study used one class to test the effectiveness of the atomic structure e-module on students' learning outcomes. The one-group pretest-posttest design table can be seen in Table 1.

Table 1. One-Group Pretest-Posttest Design (Sugiyono, 2017)

Class	Pretest	Treatment	Posttest
Eksperiment	O_1	X	O_2

The research was conducted at SMAN 1 Lubuk Alung in the academic year 2023/2024 even semester. There were 10 E phase classes and XE.3 class was chosen as the sample class selected by purposive sampling technique. The purposive sampling technique is used by taking into account expert judgment, in this study the sample selection was assisted by the teacher with consideration of the scores of students in each class that had been tested for normality. The research procedure consists of the preparation stage, the implementation stage and the final stage.

The research instrument used is a test instrument consisting of 20 multiple choice questions in accordance with the learning objectives that are valid and have met the standards so there is no need to retest. Then the learning outcomes data were analyzed using the N-gain test to determine the criteria for the effectiveness of the atomic structure e-module. The N-gain test was conducted to determine how effective the use of the atomic structure e module is. The N-gain test uses the N-gain formula as follows:

$$\text{N} - \text{Gain} = \frac{\text{score } posttest - \text{score } pretest}{100 - \text{score } pretest}$$

$$\text{Rata} - \text{rata N} - \text{Gain} = \frac{\sum \text{N} - \text{Gain students}}{\text{number of students}}$$

The criteria for determining the level of effectiveness of e-modules with the application of interventions can be seen in Table 2.

Table 2. Criteria for Determining the Level of Effectiveness (Sukarelawa, 2024)

Percentage (%)	Criteria
>76	Effective
56-75	Quite Effective
40-50	Less Effective
< 40	Not Effective

3. Results and Discussion

Results

The atomic structure e-module used in this study was developed by Ayu Permata Sari and Suryelita (2023) has been compiled relevant to the independent curriculum using the Plom model and has been tested for validity and practicality with an average V index value of 0.83 and is very practical with a percentage of 92% from teachers and 85% from students. The atomic structure e-module is able to create literacy activities for understanding concepts and applying concepts with a problem-based learning model related to atomic structure material. This module presents initial competencies, learning objectives, triggering questions, meaningful understanding, learning activities to be carried out, assessment, student reading materials and reflection.

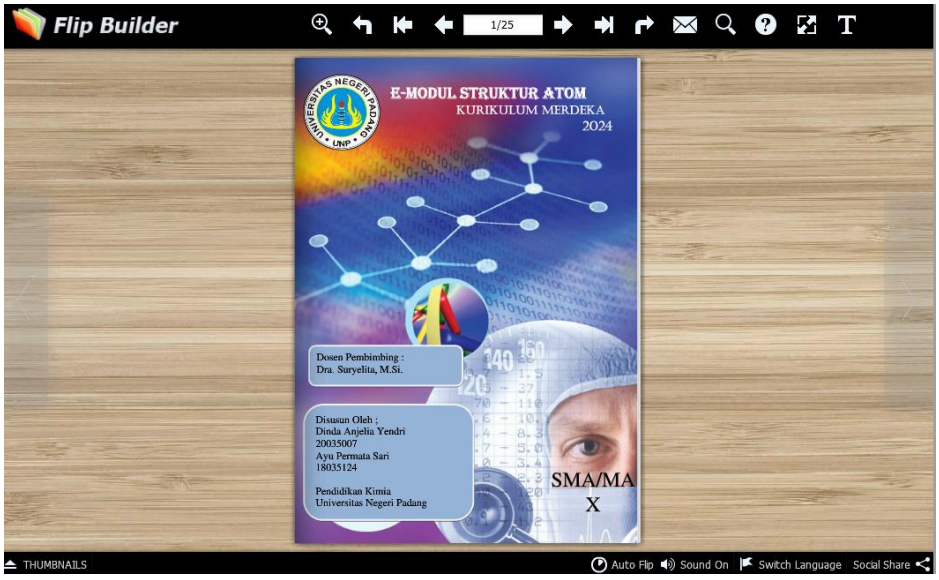

Figure 1. Atomic Structure E-Module Cover

The atomic structure e-module guides students to carry out literacy activities that contain concept understanding material, videos and powerpoints that must be understood by students and then given example problems, comprehension tests, formative tests and enrichment questions to see the extent of students' understanding obtained. Furthermore, the application of concepts using problem-based learning syntax is thus expected to increase student learning outcomes. So that researchers are interested in testing the effectiveness of e-modules of atomic

structure on the learning outcomes of students in phase E of SMAN 1 Lubuk Alung.

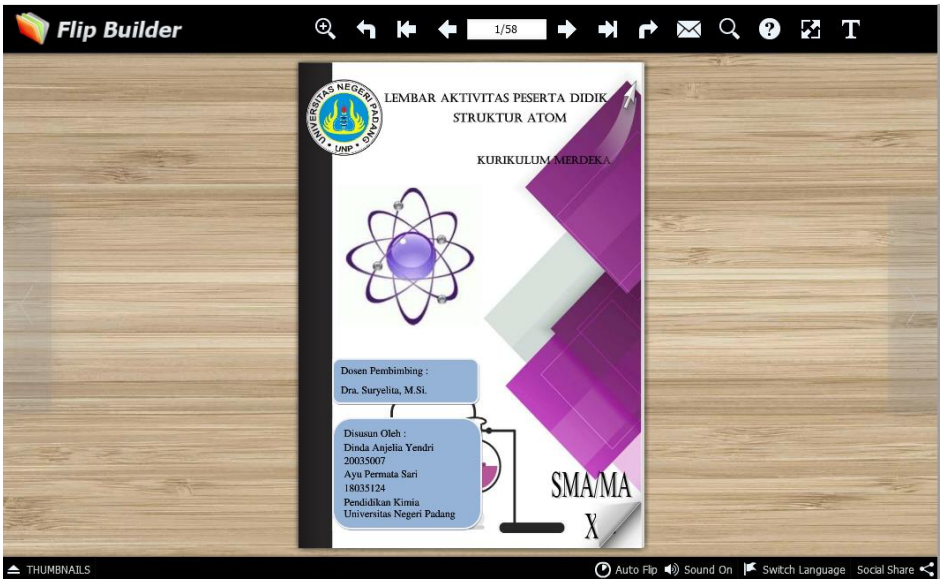

Figure 2. Atomic Structure Learner Activity Sheet Cover

The data from this study are the learning outcomes of students (cognitive domain). The data obtained are the results of pretests and posttests that have been carried out by students using 20 multiple choice questions so that the average can be seen in Table 3.

Table 3. Average Score of Pretest Posttest

Value	Average Value	Lowest Score	Highest Score	Standard Deviation
Pretest	36,2	10	70	15,6
Posttest	86,3	70	95	7,7

The N-Gain test aims to determine how effective the use of atomic structure e-modules is by calculating the amount of improvement before and after learning using the normalized gain formula (N-Gain). The results of the calculation of the N-Gain value can be seen in Table 4.

Table 4. N-Gain Test Results

Number of Leaners	Pretest average	Posttest average	N-Gain Percentage	Criteria
34	36,2	86,3	79%	Effective

The results of the N-Gain calculation show that the average percentage of N-Gain in the sample class is 79% with the effective category. This can be interpreted that the e-module of atomic structure is effective to improve the learning outcomes of students on atomic structure material. Analysis of the answers obtained on the atomic structure e-module is carried out to determine the level of how far students understand the material in accordance with the predetermined learning objectives.

The average score of the atomic structure e-module answers in accordance with the learning objectives can be seen in Table 5.

Table 5. Average Value of E-Module Acquisition

No.	Learning Objectives	Average Score of Comprehension Test of Atomic Structure E-Module
1	TP-1, TP-2, TP-3	93,38
2	TP-4	88,5
3	TP-5	99,41
4	TP-6 (PBL)	91,80

Discussion

The research was conducted to determine the effectiveness of the atomic structure e-module. The level of effectiveness of e-modules can be seen from the learning outcomes of students before and after using e-modules. This research only has one class as a sample that is used as the object of research, namely students of class XE.3 SMAN 1 Lubuk Alung. The data obtained in this study in the form of pretest scores and posttest scores which can be seen in Table 3. The data from the research were then analyzed. Data analysis conducted N-gain test. In accordance with the criteria in Table 4, the overall average percentage of N-gain is 79%, including the "Effective" category. This means that e-modules can effectively improve students' understanding in the learning process of atomic structure material. This can be seen from the learning outcomes before and after using the atomic structure e-module. The greater the average percentage of N-gain, the higher the effectiveness of the e-module. The learning outcomes of students have increased.

The study used a test instrument in the form of multiple choice questions totaling 20 items that were in accordance with the learning objectives. This test instrument is used to measure the extent of students' concept understanding of atomic structure material. This material has six learning objectives that must be achieved by students consisting of atomic theory material, atomic notation, number of neutrons, protons, electrons, and electron configurations, and periodic systems. Furthermore, the data obtained is analyzed in accordance with the learning objectives to see how effective the atomic structure e-module is in improving students' understanding.

Analyze the % correct tabulation of learners to see the learners' achievement of each learning objective (TP). Overall, learners have successfully achieved the learning objectives set for this material. TP-1 is related to the development of atomic theory. On this TP, learners experienced an increase of 3% compared to other TPs, so it became a concern for researchers. This material was studied at the first meeting. After conducting the assessment, the researcher analyzed the questions on this TP-1. The tabulation analysis of % correct pretest-posttest of students according to the learning objectives can be seen in Figure 3.

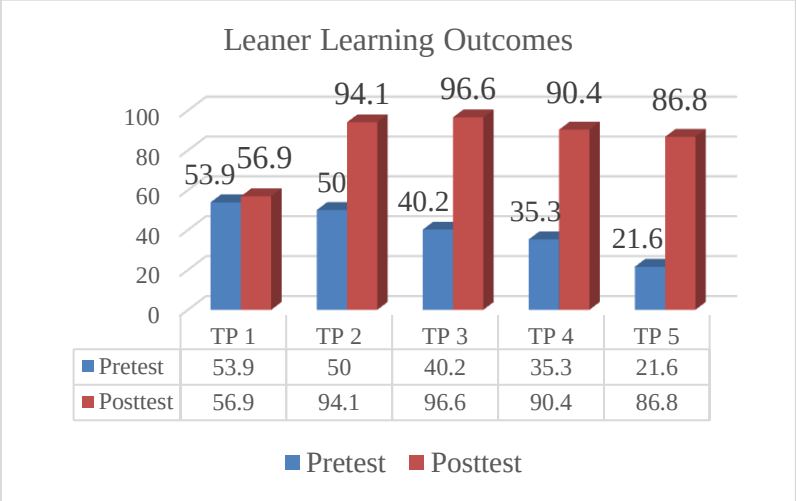

Figure 3. Tabulation Analysis of % Correct Pretest-Posttest

Researchers asked directly with students in front of the class regarding students' answers, stating that students forgot the TP-1 material because the TP-1 learning distance was far enough away from the posttest so that they focused on new material, it was proven that in Figure 3 for the next TP students experienced a high increase. This is in line with the research of Sari et al (2018) which states that the learning outcomes of atomic theory are low due to the memory of students at the end of learning atomic structure filled with new material (Sari et al., 2018). However, if analyzed from the e-module comprehension test on this material during the learning process, students obtained an average score of 93.38 (Table 5). So it can be concluded that students have achieved the first TP-1 properly and correctly.

The 2nd learning objective is related to atomic notation material. In Figure 3, students experienced an increase in understanding of 44.1% with details of 32 students who answered the posttest questions correctly. The 3rd learning objective related to determining the number of protons, electrons and neutrons obtained an increase in correct answers of 56.4%. This is in line with the acquisition of the e-module score on the comprehension test TP 2 and 3 students obtained an average score of 93.38 (Table 5). The atomic structure e-module provides comprehension test questions that are able to guide students to find out the extent of understanding that has been understood by students. The comprehension test questions consist of atomic notation questions that will calculate the number of protons, neutrons and electrons by students, and can write atomic notation in accordance with the direction of the e-module. So that students can understand and achieve this TP properly and correctly.

The next learning objective is the 4th learning objective with a percentage increase of 55.1%. In this TP, students learn the material of Bohr's electron configuration and quantum mechanics. This happens because during the learning process students are eager to understand and memorize the order of writing the electron configuration. In line with the acquisition of understanding test scores with an average of 88.5 students (Table 5) on the atomic structure e module.

Comprehension test for Bohr electron configuration material, students are directed to do 4 questions related to electron configuration with an average score of 96.41. Furthermore, for the quantum mechanical electron configuration material, students are directed to work on comprehension test questions so as to obtain an average score of 80.59. Thus, students are able to understand TP-4 seen from the learning process and also on the posttest which obtained a high average score.

The 5th learning objective is to learn about the periodic system. This TP experienced the most significant increase of 65.2%. According to research by Oktavia, et al (2019), the periodic system of elements is one of the chemical materials that is poorly understood by students because it contains material on the periodic system of elements that tends to make students memorize the properties of the periodicity and difficult to distinguish without trying to understand it (Oktavia et al., 2019). However, in this study, students managed to achieve these learning objectives well, marked by an increase in student learning outcomes and also the learning process that was passed. In the e-module comprehension test, students were guided to work on 5 questions that contained the periodic system, electron configuration, determining groups and periods, and sorting elements based on their periodicity with the results of the e-module score on this material of 99.41 (Table 5).

The last learning objective is problem-based learning. Learning activities using e-modules can cause students to be active and able to understand concepts and then apply problem-based learning (PBL). Problem-based learning (PBL) is a learning activity designed to focus on students to solve problems and develop critical thinking knowledge (Ulger, 2018). PBL is able to guide students to understand theory, practice, apply knowledge and skills in finding solutions to problems (Siregar & Simatupang, 2020). PBL provides equal opportunities for students to play an active role in learning activities (Rusman, 2016). PBL syntax includes: 1) Orienting learners to the problem, 2) Organize learners in learning, 3) Assist investigation, 4) Develop and present work, 5) Analyze and evaluate problem solving (Arends, 2012). The PBL model can be implemented in teaching materials.

In TP 6, learners are able to find solutions to problems given in the atomic structure e-module regarding sorting, classifying, and distinguishing the elemental properties. The achievement of this TP is seen from the problem-based learning activities that students go through with the acquisition of PBL activity sheet scores and assessment of students' PBL aspects. Based on Table 5, the acquisition of students' PBL activity scores obtained an average of 91.80. This means that students are able to solve the problems given well. In this PBL learning activity, an assessment of aspects of problem-based learning activities is also carried out to assess students using a predetermined assessment rubric.

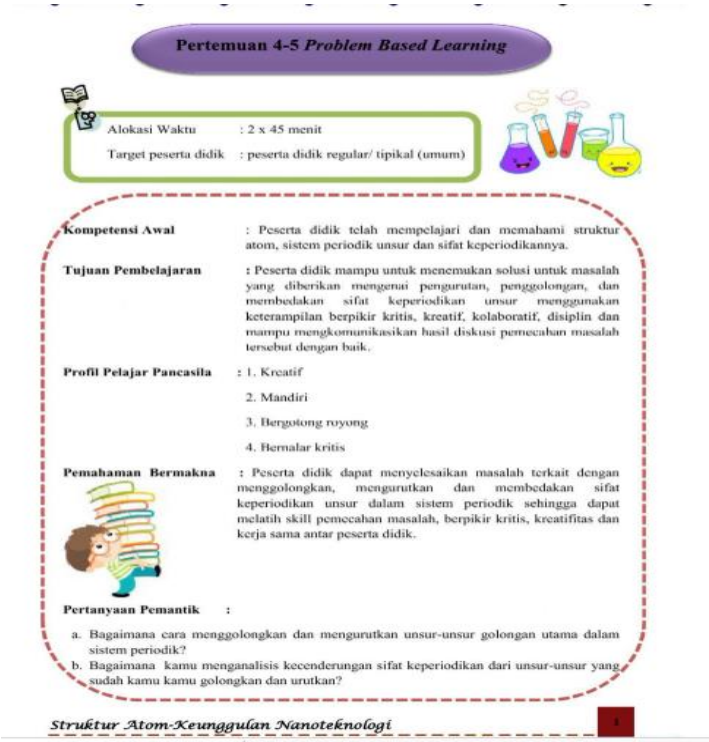

Figure 4. Learner PBL Activity Sheet

Analysis of the PBL assessment aspects of students has several criteria that are assessed, namely: 1) Pronunciation and performance; 2) Presentation/demonstration display; 3) Oral communication skills; 4) Answer accuracy; 5) Cooperation between group members. The assessment criteria are divided into very good (90-100), good (80-89), sufficient (70-79), less (<70). Based on the results of the analysis of the PBL assessment aspects of students, it is known that 82% of students obtained very good and 18% good and 0% sufficient and less. This proves that students succeed in solving the problems given which are guided by student activity sheets that are able to guide students based on PBL syntax by applying the understanding of concepts possessed by students.

E-modules are effective as teaching materials in the learning process. Because it is able to guide students to understand concepts through literacy activities and then applied with PBL. Learners can understand concepts independently by following the activities listed in the e-module and with teacher guidance. E-modules contain materials, videos, ppt, and teaching materials contained in the learner activity sheet related to learning objectives. After collecting all the information and understanding the concept correctly, students are directed to work on the comprehension test contained in the learner activity sheet to see how far the understanding that students have understood through literacy activities that have been carried out for further application in problem-based learning on atomic structure material.

The atomic structure e-module causes learners to actively follow the activities listed in the e module and with teacher guidance. Learners have high enthusiasm when using the atomic structure e-module so that it can increase the motivation of students to start learning. The e module of atomic structure is interactive, when working on questions the teacher can announce who finishes working first, this is where the spirit of competence of students to compete who finishes quickly and correctly so that learning has the potential to create a pleasant learning environment (Azzara & Iswendi, 2024). Thus, students become more motivated and able to understand the subject matter well (Sari et al., 2017).

The obstacles experienced during the research were that some students did not have packages and the cellphones used by students ran out of battery. However, at the next meeting the researcher saw the enthusiasm and motivation of the spirit of learning from students marked by having their respective internet data and cellphone batteries fully charged because they already knew that learning using e-modules so that learning could take place smoothly as it should.

4. Conclusion

This study is to determine the effectiveness category. The results obtained showed that the e module of atomic structure was included in the effective category with an average N-gain of 79% towards improving student learning outcomes. With these results, e-modules can be used as teaching materials in atomic structure learning activities. This research was tested on a small scale so that it does not represent the use of effective e-modules on a large scale. So it is recommended to test the atomic structure e-module on a large scale so that the e-module can be disseminated and used in the learning process.

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