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The effectiveness of textbooks as support for learning in the Merdeka curriculum on atom structure material phase E of SMA/MA on student learning outcomes

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Abstract
Previous research has designed textbooks to use to provide support learning in the Merdeka curriculum on atomic structure material, which have been tested for validity and practicality, but have not yet been tested for effectiveness. The purpose of this study was for identification purposes how well textbooks that support student learning in the free curriculum on atomic structure material affect their learning outcomes. This quasi-experimental research is a continuation of research on Plomp's development model. This study was conducted using a pretest posttest nonequivalent control group design. The study involved 71 students in two groups, an experimental class and a control class. The results showed that the experimental class had an average N-gain value of 0.75 in the high category, and the control class had an average N-gain value of 0.65 in the medium category. The calculated t value of 9.43 and t table of 1.99 were found in hypothesis testing with t-test. The data analysis indicated that the textbooks used to teach atomic structure in the free curriculum may have contributed to improved learning outcomes for students.

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Keywords: textbook, merdeka curriculum, atomic structure, learning outcomes

1. Introduction

The Merdeka Curriculum is designed to foster independent learning in students. This implies potential for students to utilize the understanding they gain through both formal and non-formal educational avenues, and these learners are not constrained by any limitations on their comprehension of learning conceps. In addition, the curriculum calls for teachers' encouragement of students' creativity [1]. The Merdeka Curriculum gives freedom to both teachers and students to carry out learning in a enjoyable and lass demanding, so that they can develop students' interests and talents, as well as achieve quality learning [2]. The Merdeka Curriculum has several characteristics, namely a focus on essential materials, being more flexible, and the availability of a sufficient number of teaching materials. In the Merdeka Curriculum, teachers are given the freedom to use various teaching materials, ranging from textbooks, literacy and numeracy assessments, teaching modules, and others [3]. Materials often used by teachers include instructional materials.

One important part of the acquisition of knowledge is teaching materials. The content of teaching materials encompasses both general and specific learning messages, which can be employed to facilitate student learning [4]. The utilisation of teaching materials tha align with the Merdeka Curriculum is of paramount importance for enhancing the proficiency of learning [5]. One type of teaching material is textbooks. Textbooks are books written by experts in a particular field and serve as supporting tools in the processes of those learning. By having textbooks, students can more easily understand the material and maintain the learning process [6]. According to research, high-quality textbooks can also affect how students are learning [7]. In case of need, there is evidence that high-quality textbooks can also have an effect on student learning as well as the achievement of learning outcomes [8].

In the context of learning activities, learning outcomes have a role to indicate that the learning objectives have been achieved. Learning outcomes are influenced by the way in which students learn and remember the material [9]. This is because student learning outcomes allow educators to observe the progress and achievements that occur after the learning process takes place, and serve as a basis for evaluation for teachers in preparing the next teaching and learning activities [10]. One of the subjects studied at the secondary level is chemistry.

Chemistry is a complex field of study, makes it difficult for students to understand its concepts. This is due to its unique terminology, complex calculations, and abstract theories [11], such as in the topic of atomic structure. The reason for this is that atomic structure requires a type of conceptual knowledge based on relatively complex ideas, because it includes different definitions, principles, models and theories [12]. Atomic structure is the foundation for advanced materials [13]. Learners often struggle to understand this material because it has an abstract nature, and the limited materials available in school textbooks can lead to suboptimal learning outcomes.

The main textbook, Natural Science Textbook Class X Senior High School/Madrasah Aliyah Curriculum 2013, was officially released in 2021 as a directive from the Ministry of Education and Culture that must be used by all educational institutions. Science faculties such as biology, chemistry, and physics are covered in this book. However, this book still requires improvement in the completeness of teaching materials, especially for the subject of chemistry. The chemistry materials in this book cover topics such as green chemistry in the 2030 sustainable development, basic laws of chemistry around us, atomic structure and the advantages of nanomaterials, renewable energy, as well as the concept and solutions for global warming. To achieve the desired chemistry learning outcomes in phase E, students need to understand the concepts of atomic structure, the periodic system of elements, and chemical bonding. Therefore, making chemistry textbooks in addition to the main textbooks published by the government is very important to support learning in accordance with the Merdeka Curriculum.

In the context of this Curriculum, the development of chemistry teaching materials as a complement to the main textbook published by the government becomes very important. In line with previous research by [14] and [15], which shows that learning resources that support the Merdeka Curriculum are still limited. This limitation can hinder the achievement of learning objectives and result in students not having the opportunity to repeat the material that has been taught by the teacher. Several teaching materials that support the Merdeka Curriculum have been developed within one year, including green chemistry teaching materials [16], global warming [17], atomic structure [18], nanotechnology [19], the periodic system of elements [20], and chemical bonding [12].

The initial findings from the observation carried out at SMAN 1 Lareh Sago Halaban, it was found that 41.2% of students faced difficulties in understanding chemistry lessons, especially the material on atomic structure, and 41.2% of students indicated that the teaching resources currenly in use at the school are not as conducive to learning the chemistry material, especially the atomic structure material. From the following is a summary of the findings from the surveys with the chemistry teacher at SMAN 1 Lareh Sago Halaban, it was found that the students' learning outcomes on the atomic structure material were still around 60%. One of the solving that can be used to reduce the above problems is by using a textbook.

Susanti (2024) developed of textbooks to provide support for the Merdeka Curriculum learning on phase E atomic structure material", a textbook that discusses atomic structure material to support learning on Merdeka Curriculum. The textbook has gone through validity and practicality tests, to reach the prototype 4 in the Plomp development model and having a validity rate is 0.94 with a practicality rate of 72%. The developed textbook meets the requirements to be tested in the next stage, which is the assessment phase to determine the effectiveness of the textbook.

2. Identify, research and collect idea

This study is a continuation upon previous research that employed the Plomp educational research design model. This research on effectiveness is carried out at the assessment phase stage. The effectiveness stage is carried out through a quasi-experiment with a pretest-posttest non-equivalent control group design [21]. The Sampling was done using a purposive sampling technique [22]. This study comprises a full sample of 71 students from class X Phase E, which are divided into 36 students of class X E.2 and 35 students of class X E.7 at SMA Negeri 1 Lareh Sago Halaban for the 2023/2024 academic year. Figure 1 and Table 1 show the research design, using O1 as the pretest and O2 as the posttest for the experimental class, the control group was assessed using O3 as the pretest and O4 as the posttest for the control group. The treatment X was applied to both groups.

Table 1: Pretest-Posttest NonEquivalent Control Group Design [23]

Group	Pretest	Treatment	Posttest
Experimental	O_1	X	O_2
Control	O_3		O_4

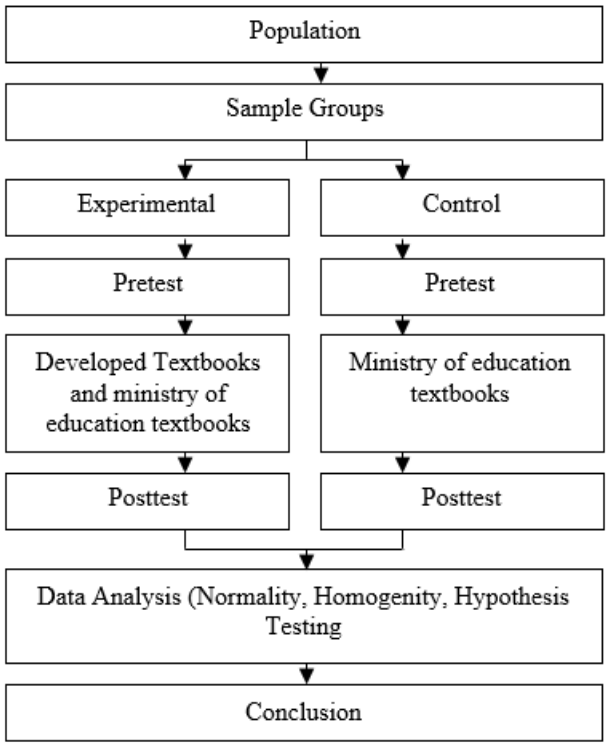

Fig 1: Research Methodology Diagram

A cognitive knowledge assesment was utilized as the research instrument. This test was applied before (pretest)

and after (posttest) learning using the textbook. Ten students who had studied the atomic structure material were given 50 multiple-choice questions as part of the cognitive knowledge instrument trial. The scores obtained were analyzed using reliability tests, validity tests, difficulty index tests, and discriminating power tests.

In order to ascertain the efficacy of the evaluated textbook, a comprehensive assessment of the students' pre- and post-test results will be conducted. Hypothesis testing is used to analyze the data obtained and to test whether there are significant differences. The normality and homogeneity of the data are first checked using the Lilliefors test and the F-test before the hypothesis testing is performed.

3. Results

This study aims to determine how effective textbooks supporting Merdeka Curriculum learning on atomic structure material are for student learning. Research results are based on what students learn in the cognitive field. After research at SMA N 1 Lareh Sago Halaban, primary data in the form of learning outcomes were collected. During learning, the experimental class used the Merdeka Curriculum supporting textbooks and Ministry of education textbooks, while the control class used Ministry of education textbooks. Test scores form learning outcomes. The test comprised twenty selectable responses, with a total of five points awarded for correctly identified answers and zero points for responses that were not correct.

Cognitive domain learning outcome data were collected through pretest and posttest scores. The difference in pretest scores is relatively moderate at 4.33. There was, a significantly differential post-test score, however, the experimental group achieved an average of 82.78 while the control group attained an average of 74, a significant difference of 8.78 (Figure 2). Students had high posttest scores, which showed their ability to understand the conceptual material [24]. The N-gain value was calculated to compare the conceptual abilities of students in the experimental and control groups. The mean N-gain value for the experimental group was 0.75, which indicates a high level of gain, while the mean N-gain value for the control group was 0.65, which indicates a medium level of gain.

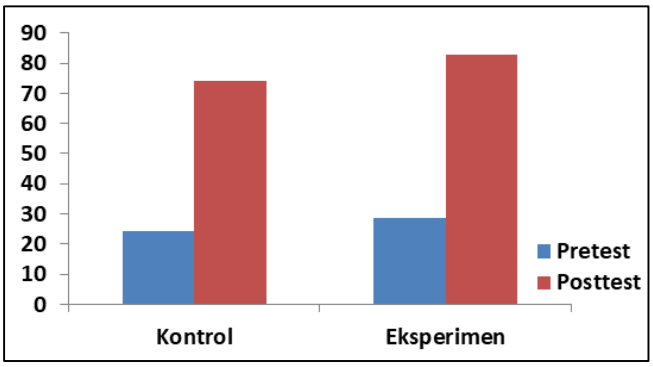

Fig 2: The attached graph illustrates the average pretest and posttest scored

Table 2: Average N-gain Test Result

Class	N	Average N-gain	Category
Control	35	0,65	Low
Experiment	36	0,75	Tall

Before conducting the hypothesis testing, the collected data were tested for distribution. Two tests were carried out to test for normality, using the Liliefors test, and homogeneity, using the F-test. The Liliefors test resulted in L-calculated values of 0.09354 and 0.101794 for the control and experimental groups, respectively. Compared to the L-table value (N = 36 and N = 35, α = 0.05), the L-calculated values are higher. Meanwhile, the F-test to compare the variances of the control and experimental groups resulted in an F-calculated value of 1.61, which is less than the F-table value (N = 36 and N = 35, α = 0.05) of 1.76, as the F-table value is higher. Therefore, the sample data are normally distributed and have the same variance.

The initial hypothesis test was conducted under the assumption that the data were normally distributed and had no variance after the distribution and homogeneity of the data were found. Two-tailed analysis-also known as two-tailed analysis-was used to conduct the test with a significance level (α) of 0.05. Since the calculated t value of 9.43 exceeds the acceptance range, the null hypothesis is rejected. In light of the aforementioned findings, it can be reasonably concluded that there is a notable discrepancy between the mean posttest scores between the experimental and control classes.

Table 3: Hypothesis Test Results

Groups	Df	t-count	t-table	Decision
Experiment	36	9,43	1,99	H_0 is rejected
Control	35			

The above-mentioned results show that the textbook as a learning support for the free curriculum on atomic structure in senior high school is effective in improving student learning achievement. The experimental class had an N-gain value of 0.75. When students use textbooks, they can gain a deeper understanding of the ideas. The scores obtained by students reflect the concepts they gained after the learning process [25]. The results of this study are in line with the findings of previous research similar research that used instructional materials as learning support for the Merdeka curriculum on basic chemical laws material, which resulted in an N-gain value of 0.71 [24]. In additional research assessing how effective the Merdeka curriculum teaching materials are on chemical bonding materials, a calculated t value of 31.02 was found, which is larger than the t table values of 2.03. This value indicates that the teaching materials are effective [26]. Additionally, research on the effectiveness of textbooks on the topic of main group chemical elements resulted in high N-Gain scores [8]. As a result, the findings of this study are consistent and supported by the findings of previous studies.

The atomic structure textbook used in this study was designed as a learning tool with easy-to-understand language that does not confuse students in understanding the approach ach of atomic structure material. The design of this textbook is not only attractive, but also in accordance with the atomic structure material and has been adapted to the spesificstiond set forth in the Merdeka Curriculum textbooks. The material presented has been arranged systematically so that the concept of atomic structure is easy to understand. Attractive textbooks with pictures and illustrations can increase students' interest in reading. This is in line with previous research conducted by [27] and [28], which stated that students'

enthusiasm for reading and their ability to store information can be increased when the instructional materials used include attractive colors, images, and illustrations.

This textbook has contained chemical representations, as seen in Figure 3, which are used as a link to help students recognize and understand the concepts being taught [29]. Concrete and abstract chemical materials can be more easily understood by students using multirepresentation [30]. Through observing these models, students can gain an understanding of the concept of isotopes. Chemistry textbooks equipped with multirepresentation are very helpful for students with diverse basic abilities [31]. Chemical representation is very important for understanding chemical ideas and helping students form mental models [32]. There are three levels of multirepresentation in chemistry learning, and the relationship between these levels and mental models can be seen in Figure 4. Macroscopic knowledge is concrete and amenable to observation through the five senses. At the submicroscopic level, students can study abstract concepts, such as the process of neon formation. At the symbolic level, chemical symbols, equations, and formulas are used. The symbolic level in this textbook shows the constituent molecules of neon.

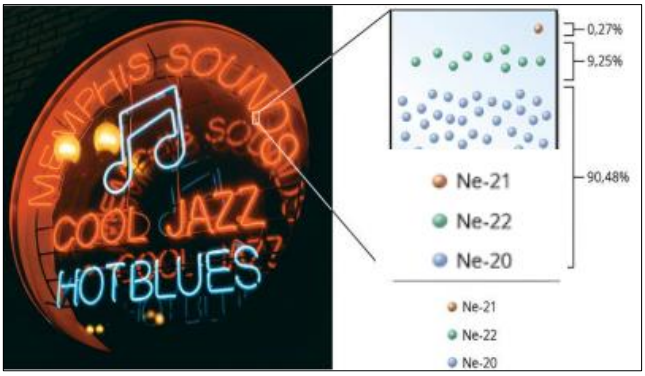

Fig 3: Natural neon isotopes contain three isotopes

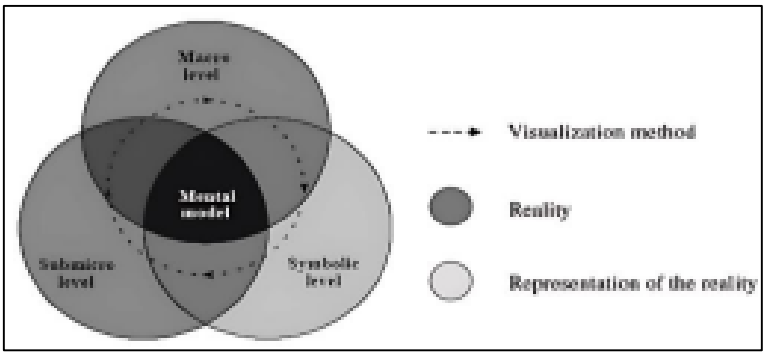

Fig 4: The relationship between mental models and multirepresentation [32]

The researcher explained the multirepresentation present in the textbook during the learning process. After the learning was completed, the researcher provided exercises to assess the students' understanding of the material through structural model diagrams. Students were asked to find the concept from the neon isotope model. Based on table 3 number 1 and 2, students were able to explain the concept of isotopes, but had not yet found the complete concept of isotopes. Based on number 3, students found a more complete concept of isotopes. The students' answers showed that they had understood the concept that isotopes are elements with different mass numbers but the same atomic number (differences in the number of neutrons). The results of the exercise activity showed that students were able to depict various mental models and demonstrate their imaginative abilities. In addition, students also showed critical thinking skills towards the mental models, especially those presented in this textbook.

Table 4: Responses Students

Students	Responses
Students 1	Isotopes are a collection of atoms that have the same atomic number.
Students 2	Isotopes are atoms that have the same mass and atomic number.
Students 3	"Isotope" is a word that refers to objects with the same number of protons or atoms but different mass and neutron numbers.

Textbooks are very important for learning because they can help students learn independently according to the Merdeka curriculum. In addition, this textbook can also assist teachers in developing the Pancasila learner profile by improving students' communication and collaboration abilities. The use of this textbook-based content material significantly increases students' academic achievement. The improvement in learning outcomes occurs because this textbook facilitates the students' ability to explain the relationships between concepts through the relevant multi representation of the taught material. Moreover, this textbook is also able to direct students to see how the concepts presented can be applied in real-world situations. This ensures that students can properly master the concepts and maintain their understanding of the material. This is in line with research [9] which shows that how well learners understand and retain material affects their learning outcome.

4. Conclusion

The results showed that the experimental class using the Merdeka curriculum learning support textbook on atomic structure material obtained an average N-gain value of 0.75 compared to the control class of 0.65. In addition, the t-count value of 9.43, which is greater than the t-table value of 1.99, indicates that the textbooks in question are disigned to facilitate the Merdeka pertaining to the atomic stucture material.

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