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The Development of Research-Based Electronic Teaching Materials on Alternative Energy Source Materials to Improve Science Process Skills of MTs Students

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ABSTRACT

Science learning in the digitalization era contains a combination of theory and practice in the process of finding a concept. The use of textbooks in the era of digitalization needs to be developed into teaching materials for supplements that are packaged electronically. The purpose of this study is to determine the effectiveness of research-based electronic teaching materials implemented in Alternative Energy Source materials towards improving the skills of the science process (KPS) of MTs students. Based on the results of the study, the results of the observation of students' science process skills obtained an average score percentage of 88.28% with a breakdown of observing indicators of 90.63% and communicating 85.94%. Meanwhile, the cognitive learning outcomes of students' science process skills were 81.25 with details of each student's science process skill indicators, namely classifying 84.38, interpreting 91.41, formulating hypotheses 76.56, conducting experiments 74.22, and concluding 79.69. The results of the analysis of the N-gain value of 0.70 high criteria. Thus, based on these results, the use of research-based electronic teaching materials on Alternative Energy Sources materials contributes to the improvement of the science process skills of MTs students.

Keywords: research, research-based electronic teaching materials, science process skills.

INTRODUCTION

Science learning in the era of digitalization mandates that learning be carried out in an integrated manner. The scientific method in this learning generally contains a series of data collection activities through observation and experimentation, then formulates and tests hypotheses. According to Agus et al. (2016) The scientific method refers to the techniques of investigating phenomena or symptoms that occur, acquiring new knowledge, or correcting and blending previous knowledge. To be called scientific, the method of inquiry must be based on evidence from observable, empirical, and measurable objects with specific principles of reasoning.

Fadilla & Maharani (2019) mentioning that in scientific work as well as in the scientific method there are science process skills that need to be trained. Salsiah (2015) mentioning that the scientific method is a planned systematic work procedure, the assessment is sourced from empirical data obtained carefully using various means in accordance with the rules to be able to solve a problem. Science learning is aimed primarily at mastering science concepts that are applicable and meaningful to life. According to Isnawati (2014) In the teaching and learning process, teachers tend to choose approaches, methods, and learning strategies that only encourage students to remember

and memorize existing concepts, so that the science process skills in students are not optimal. In the process of learning science, there are still few concrete objects involved in the learning process. While the demands of the digitalization era, students are asked to adapt to technology, but must be adjusted to the characteristics of students in class VII. Thus, educators will be greatly helped by the presence of concrete objects that are integrated with the use of technology to train students' science process skills on Alternative Energy Source materials.

The science process skills of students that are expected to appear in science learning are observing, classifying, formulating hypotheses, interpreting (interpretation), as well as conducting experiments and communicating. There are still many found that class VII students when conducting practicum activities have not been able to state the relationship between the two variables and have not been able to express how to solve problems. Likewise, for interpreting activities, students still have difficulty when connecting the results of observations of a natural phenomenon even in drawing conclusions. In terms of communicating, students still struggle when given the opportunity to explain the results of the experiment, compile and submit reports systematically and clearly. The development of skills of this process must be adjusted to the age of the student so that it does not cause a burden to the student and according to the level of development. Online and offline learning collaboration continues to be carried out by educators. So as to allow the use of digital teaching materials to be utilized in the learning process.

Based on the results of observations of teachers and students at MTs Negeri 1 Purbalingga, the teaching materials used today only use teaching materials sourced from textbooks. The teaching materials only contain concepts, materials that are considered incomplete and not yet in-depth so that teaching materials are needed that present new information that can improve students' science process skills. As with the demands of science learning, it is a combination of practical / laboratory and theoretical activities. That's also expected to happen by the NSES (National Science Education Standards) book. When learning to apply learning by doing, students' knowledge and skills in processing information in science learning will be more meaningful and meaningful (Mıhladız & Doğan, 2014). Same expectations as the findings Kaptan & Timurlenk (2012) as a science teacher, it is expected to be able to have good knowledge, content, and pedagogics to teach science concepts with different characters for each student. Similarly, the constructivist view states that one's knowledge is related to experience and the importance of remembering and expressing through one's experience can construct knowledge. In the construction process, active learners are indispensable for learning to be successful. Furthermore, philosophically it can be said that scientific knowledge is logical when reviewed rationally and tested when reviewed empirically.

Learning materials about renewable energy sources are compatible with this research-based electronic teaching material. Where there is a benefit from the relationship between learning resources, the surrounding environment and this material. Students will become more understanding about the concept of energy, changes in the form of energy, alternative energy sources from waste utilization and how to use waste in everyday life. Through this experiment, students will be able to build their own knowledge and be able to apply the knowledge they have in everyday life. Of course, TeBel is integrated with innovative Student e-Worksheets to facilitate the learning process.

LITERATURE REVIEW

Research-based teaching materials used in research Febriyanti et al. (2017) contains a combination of theory and research activities, so that students can understand concretely the application of the concepts

studied. Similar to teaching materials used in research Fitriyati et al. (2015), the use of research-based teaching materials also helps the achievement of biotechnology subject competencies, especially in applications in everyday life. With the help of research-based electronic teaching materials, according to the results of the study Chrysti (2014) the learning process will focus on the activities and creativity of students by developing intellectual, mental, physical, and social skills. Aligning with the findings Fadela et al. (2016) The scientific approach is very effective in improving the science process skills of learners as drivers of discovery and development of facts. This confirms that learning using research-based electronic teaching materials helps students in finding a science concept found in the learning process through activities that are integrated with technology so as to improve students' science process skills. The expected indicators of science process skills appearing taking into account the samples used are students of class VII MTs namely the skills of observing, classifying, interpreting, formulating hypotheses, conducting experiments, inferring, and communicating (Warianto, 2011).

As the research has been done by Fuadi et al. (2021) digital teaching materials have become a primary need during the Covid-19 pandemic. The electronic teaching materials used are certainly those that have a contribution to students in research learning, one of which is used is the development of science practicum materials and activities in the Electronic Student Worksheet (e-LKPD). Digital-based teaching materials are able to overcome limitations in student activities during the pandemic and even post-pandemic.

From the obstacles that have been presented, there is a need for an innovation designed to overcome problems in the field. Innovation is carried out in order to make the quality in the learning process better. Research-based learning in the surrounding environment also has an important role for the growth and development of students and also the application of knowledge in the surrounding environment. Based on the falsifications found, one of the science materials innovated through experiments can be used on materials for changing the form of energy, namely research-based electronic teaching materials by utilizing surrounding waste, the goal is that the use of research-based teaching materials can improve science process skills in MTs students.

MATERIALS & METHODS

The research approach used in this study is R&D type research to answer research questions. R&D method developed by Thiagarajan in Mulyatiningsih (2014) has four stages (4D) of activity, namely define, design, develop, and disseminate. The selection of this model is based on systematic consideration and is based on the theoretical foundation of learning.

The data that has been collected will be analyzed by analyzing the data of the science learning process in the form of observations of students' science process skills, pre-test and post-test results on the use of research-based electronic teaching materials. The description of data analysis techniques is listed in Table 1.

Table 1. Data Analysis Techniques

Problem formulation	Shape Data	Instruments	Analysis Techniques
Improving the science process skills of MTs students using research-based electronic teaching materials	Pre-test and post-test result data Descriptive data on students' process skills during the class VII science learning process using research-based electronic teaching materials	Test Student science process skills observation sheet	Validity and reliability test Data interpretation

STATISTICAL ANALYSIS

To find out the increase in Pre-Test and Post-Test scores in the use of research-based electronic teaching materials through the N-gain Test. The criteria for improving students' science process skills can be seen

from the Pre-Test and Post-Test scores after using research-based electronic teaching materials. Equation of Gain Score can be calculated by the following gain formula

$$g = \frac{S_{post} - S_{pre}}{100\% - S_{pre}}$$ Information:

g : Gain factor
S_{pre} : average Pre-Test score (%)
S_{post} : average Post-Test score (%)

The criteria for the N-gain test results are then interpreted into the criteria in Table 2.

Table 2. Criteria Gain factor (g)

Score Interval	Criteria
$g \geq 0.7$	High
$0.3 \leq g < 0.7$	Medium
$g < 0.3$	Low

Observation sheets of science process skills during the learning process will be analyzed using quantitative descriptive methods through percentages. The percentage obtained is based on the observation score of the student's science process skills with a criterion score. The assessment uses calculations from the Likert scale presented in Table 3. (Riduwan, 2015).

Table 3. Likert Scale

Scale Value	Criteria
0	Very Bad
1	Bad
2	Enough
3	Good
4	Excellent

Next, the result of the calculation is calculated the percentage using the following formula

$$\boldsymbol{Percentage}(\%) = \frac{\boldsymbol{Number\ of\ score}}{\boldsymbol{Maximum\ score}} \boldsymbol{x100}\%$$

The criteria for the percentage of observation of students' science process skills are then interpreted into the criteria in Table 4.

Table 4. Score Interpretation Criteria

Score Interval (%)	Criteria
0 – 20	Very Less
21 – 40	Less Viable
41 – 60	Decent Enough
61 – 80	Proper
81 - 100	Very Decent

RESULT

The improvement of science process skills of MTs students in the use of research-based electronic teaching materials is measured based on the improvement of student learning outcomes using instruments with test and non-test techniques in the form of multiple-choice questions and observation sheets of students' science process skills. Data from observations before the use of research-based electronic teaching materials showed an average percentage of science process skills of 67.19% with details on the observing aspect (observation) of 69.53%, while in the aspect of communicating a percentage score of 64.84% was obtained. During the learning activities after using research-based electronic teaching materials on Alternative Energy Source material, the average percentage of science process skills score was 88.28% with details of observing aspects (observations) of 90.63%, while in the communication aspect, a percentage score of 85.94% was obtained.

In addition to observing students' science process skills before and after the use of research-based electronic teaching materials, research data were also obtained through tests. The effectiveness of research-based electronic teaching materials to improve the science process skills of MTs students is obtained from Pre-Test and Post-Test scores. The questions given during the Pre-Test and Post-Test are 20 multiple-choice questions that have been tested for validity. Learning was carried out for 8 JP and Post-Test was carried out at meeting 3 for 2 JP. Improving students' science process skills is obtained by N-gain Test from students' Pre-Test and Post-Test score data using research-based electronic teaching materials. The use of the N-gain Test aims to compare how students' learning outcomes before and after using research-based electronic teaching materials on Alternative Energy Source materials. Comparison of students' Pre-Test and Post-Test scores using research-based electronic teaching materials is presented in Table 5.

Table 5. Student Science Process Skills Test Value Analysis Results

No	Data	Value Pre-Test	Value Post-Test	N-gain	Category N-gain
1	Lowest Value	25	70		
2	Top Rated	60	95		
3	Average Value	38.28	81.25	0.70	Tinggi

The improvement of students' science process skills towards the use of research-based electronic teaching materials can be seen from the results of learning students' science process skills through tests and observations of students' science process skills before and after learning and can be presented in graphic form in Figure 1. and Figure 2.

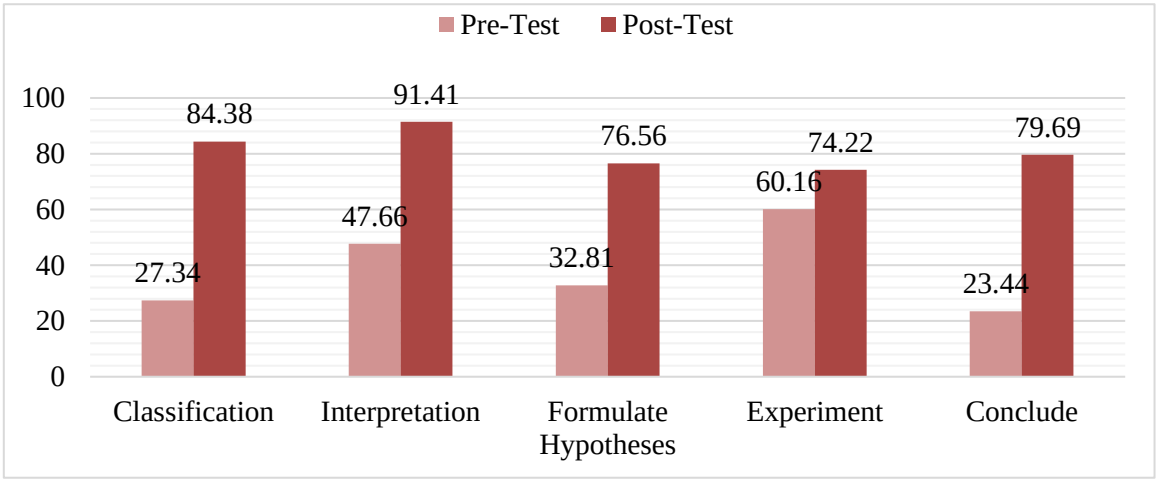

Figure 1. Student Science Process Skills Learning Outcomes

Meanwhile, for Figure 2. presented research results with non-test instrument techniques on the aspects of observing (observation) and communicating.

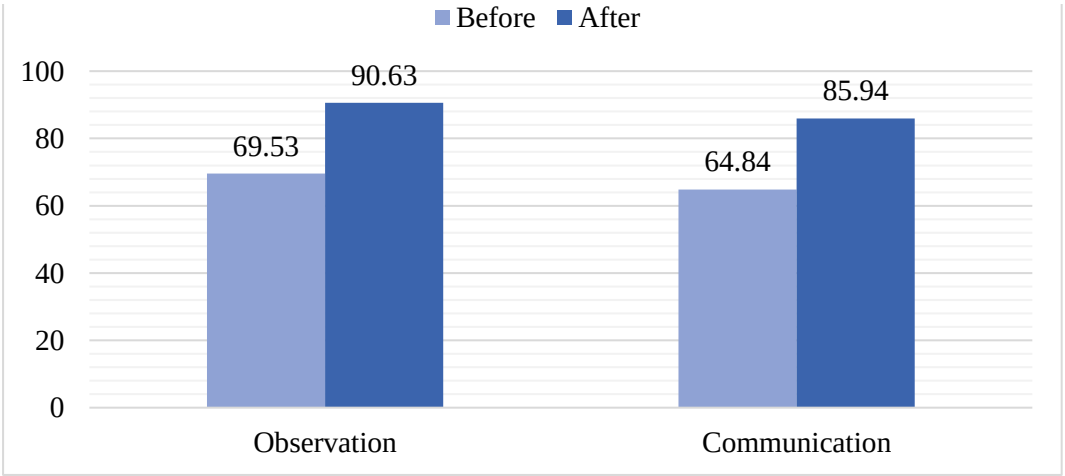

Figure 2. Results of Observation of Students' Science Process Skills towards the Use of Research-Based Electronic Teaching Materials

DISCUSSION

Improvement of students' science process skills towards the use of research-based electronic teaching materials is obtained from students' cognitive learning outcomes through Pre-Test and Post-Test in class VII MTs, as well as observation of students' science process skills before and after the use of research-based electronic teaching materials learning process. The questions in the Pre-Test and Post-Test contain five indicators of students' science process skills

including classification, interpretation, formulating hypotheses, conducting experiments, and inference. Something similar was done by Ilmi et al. (2016) on the development of an instrument for the assessment of science process skills in the form of multiple choice tests. Meanwhile, the observation of students' science process skills during the learning process contains two indicators, namely observing (observation) and communicating. The Pre-Test is carried out before the provision of research-based electronic teaching materials, while the Post-Test is given after the learning process using research-based electronic teaching materials.

During the learning process using research-based electronic teaching materials, students' science process skills are also assessed based on observations. The assessment process must be carried out in real and direct periodically, so that it will produce an authentic assessment (Budi Poernomo et al., 2018). In observing indicators (observations), during the use of research-based electronic teaching materials, students encounter more relevant facts from presenting pictures, video shows, research on energy cases, research data and being able to collect information about Alternative Energy Source materials. When conducting a practicum, students maximize the use of the senses, for example when reading measuring instruments in the right position while conducting experiments. Reading instructions for the use of research-based electronic teaching materials, reading the energy phenomena presented, are also widely done by students after providing research-based electronic teaching materials. This is strengthened by the results of research Fransiska et al. (2018) that through discovery activities, students will be actively involved in the learning process by constructing their own knowledge through an experiment or experiment.

The indicator of science process skills in communicating is also an initial problem for grade VII students, but after the use of electronic teaching materials during learning, the communication process skills have increased because in the electronic teaching materials there are many activities that require students to explain and analyze the results of the experiment. The skills to ask questions during experiments and present the results of experiments are greatly maximized by students, although there are some that must be given a stimulus first regarding the experiment being carried out. This limitation is in accordance with the findings of the study by Puspita et al. (2015) that in delivering the results of the discussion, some students only presented reading the results of the discussion according to the questions in the LKPD alone without developing the answer to the analysis. Limitations in compiling reports are also still visible from some students because they are not used to using electronic devices in learning. Nonetheless, in delivering the report, students were enthusiastic as they found new ways to learn digitally. These results show an improvement in science process skills during the science learning process towards the use of research-based electronic teaching materials. This is reinforced by the results of research by Ruddamayanti (2019) If e-book (electronic book) is a technology-based media that can be used to support learning activities either at school or home.

Based on Figure 1., the increase in learning outcomes is described from each indicator of students' science process skills, namely grouping (classification), interpreting (interpretation), formulating hypotheses, conducting experiments, and concluding. The first indicator of science process skills in the Post-Test question is grouping (classification) where there is an increase because when using research-based electronic materials there are many activities to observe objects contextually, so that students are familiar with the activities of grouping learning resources around or in the teaching materials. In addition, students are getting used to recording each observation separately during the practicum and research process presented. In the electronic teaching materials developed, there are several student

activities and discussions in groups to group alternative energy sources presented with illustrations that are easy to find differences and similarities. These reasons are in line with the research that has been carried out by Fadela et al. (2016) that activities in observing activities are able to make students have more curiosity than before, so that students will be trained in grouping the phenomena they find.

The second improved indicator of science process skills occurs in interpreting or interpreting activities. In learning activities, students are trained to find patterns from research data presented in electronic teaching materials. Trained students bring up what might happen before conducting an experiment. The electronic teaching materials developed are designed with various displays of research data in the form of tables, graphs, and statements about natural phenomena that are happening so that they can help students to practice the skill of drawing temporary conclusions before being proven through experiments. In fact, students are able to connect the results of observations both from the results of other people's research and the results of research conducted with each group. This is strengthened by the results of research Syafi'atun et al. (2022) which mentions that when students are involved in a project-based learning, students easily absorb the information conveyed by the teacher.

The improvement of science process skills also occurs in the third indicator, namely formulating hypotheses. The research results presented in the form of graphs and tables are able to train students to state the relationship between the two variables displayed. Contextual problems and phenomena are also widely presented in research-based electronic teaching materials so that students will be better trained to understand the statements that arise about these phenomena and then test their correctness through a simple research experiment with their study group. This analysis aligns with the research that has been carried out Marjan et al. (2014) that students' science process skills cannot be separated from the scientific approach in science learning. Activities carried out individually or in groups in science learning will train students' science process skills when making decisions by testing their correctness through experiments.

The fourth indicator on the skills of the process of science has also improved although not so significantly. When conducting experiments, students are indeed accustomed to preparing and using the tools to be used and are directly involved in conducting experiments on the previous material. This is reinforced by the research that has been carried out by Permatasari & Trisnawati (2021) that the enthusiasm of students in practicum activities is seen when trying measuring instruments using laboratory equipment. Furthermore, experimentation activities in science learning train students in determining what will be carried out systematically in the work steps presented in student worksheets on research-based electronic teaching materials. In line with the findings Sun et al. (2014), Teachers strive to conduct student-centered activities to develop students' skills in collaboration, experimentation and inquiry. The statements contained in research-based electronic teaching materials contribute to determining what will be observed, measured, recorded by students. Moreover, research-based electronic teaching materials are integrated with Google Documents which can make it easier for students to record observation results and answer discussion questions in groups to train the ability to analyze an experimental result.

Summing up becomes the fifth indicator of the assessed process skills. In this indicator, at first students always find it difficult when asked to deduce the form of a statement, graph, or table that is transformed into a concept. However, the continuous use of research-based electronic teaching materials equipped with illustrations of phenomena about energy, research results in the form of data graphs and tables of observations from research that has been carried out by others, science process skills for the concluding

aspect have increased because students through discussion activities, research-based electronic teaching materials are able to train students to build a new concept about alternative energy sources, Both when analyzing the results of other people's research, conducting experiment activities, and analyzing observational data so as to open up space for students to express opinions about concepts that have been learned after the experiment. That way, the activity of compiling conclusions in a science learning can be carried out using scientific methods and providing stimulus from various indicators of science process skills that have been analyzed previously. This is in line with the research conducted by Subali et al. (2019) That to train students in discovering new facts and concepts, teachers need to focus on learning with the components of scientific methods, namely the activities of observing, questioning, processing information through experiments, associating, and communicating.

The improvement in student science process skills learning outcomes towards the use of research-based electronic teaching materials is shown in Figure 1. indicates that the result of the Post-Test value is higher than the Pre-Test value. According to the findings Hiğde & Aktamış (2022) Showing the steps in the scientific process seen in the student's overall activities, students can improve their science process skills. It is clear that there are differences in learning outcomes in students' science process skills, so it can be concluded that after implementing research-based electronic teaching materials on Alternative Energy Source materials, students are able to train and strengthen students' science process skills during the learning process, as well as research-based electronic teaching materials are effective in improving the science process skills of MTs students. which is associated with the improvement of the science process skills of each student. Correspondingly, the findings Yolanda et al. (2017) mentioned the use of LKS based on an effective scientific approach to improve students' science process skills, both for students with low cognitive and high cognitive, so that it is not too significant in the difference in science process skills of each student.

The increase in learning outcomes in class VII MTs students is evidenced by an N-gain of 0.70 with a high category. The N-gain value is obtained from the comparison of the Pre-Test and Post-Test results of MTs students. High N-gain scores indicate that the use of research-based electronic teaching materials has the advantage that it can improve the science process skills of MTs students. Science learning involving technology and research helps students to practice students' science process skills more easily and flexibly, because the learning carried out involves abundant learning resources around the MTs environment. Contextually and naturally, students are trained to discover science concepts regarding Alternative Energy Sources that are integrated with technology through a research-based teaching material.

Research-based electronic teaching materials for MTs students are teaching materials that are compiled systematically, indicators of competency achievement that have been adjusted to the syllabus, there are research results that have been carried out, and questions presented in research-based electronic teaching materials are adjusted to the science process skills of MTs students. Research-based electronic teaching materials developed make student competency test questions not only presented as cognitive learning outcomes, however, it contributes to training and improving the science process skills of grade VII MTs students. Similar to the findings Kruea-In & Thongperm (2014) Having adequate science process skills is considered a significant aspect of science learning.

CONCLUSION

Based on the formulation of the problem, data analysis of research results and discussion, it can be concluded that research-based electronic teaching materials contribute to the improvement of the science

process skills of MTs students on Alternative Energy Source materials shown and proven by an N-gain value of 0.70 high criteria. In the observing process skills, a percentage score of 90.63% was obtained, the process skills of classifying were 84.38, the science process skills of interpreting were 91.41, the science process skills of formulating hypotheses were 76.56, the science process skills of conducting experiments were 74.22, the science process skills of concluding were 79.69, and the science process skills of communicating obtained a percentage score of 85.94%.

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