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Development of E-Worksheet Problem Based Learning Model on Work and Energy to Improve Students' Physical Cognitive Abilities in Terms of Mathematical Representations and Verbal Representations

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Abstract: The aim of this study is to develop an e worksheet that refers to a competent and effective problem-based learning model. The method of this study is RnD (Research and Development). This study includes a development study using a 4D development model (Define, Design, Develop, and Dissiminate). The product of this study is the e worksheet problem-based learning model. High school teachers validate learning tools with three practical validators. Subjects were class X students in mathematics and natural science public high school 1 Baturetno. The results showed that 1) the e worksheet problem-based learning model was included in the valid category, 2) the e worksheet problem-based learning model was used effectively in e-learning.

Keywords: Cognitive ability; Effort; Energy; E-worksheet, Mathematical presentation; Problem based learning; Verbal presentation

Introduction

State Physics is a field of science that studies natural phenomena with a focus on matter, energy, and the relationship between them. Physics is basically an interesting and fun subject. Oktaviani et al. (2017) said that based on research results this happened because many concepts of physics are involved in everyday life. However, the reality of the field is contrary to this opinion, students find physics to be a difficult, frightening substance that is not present in everyday life. This is because over time, physics continues to evolve and gets a variety of problems. One of them is students 'lack of understanding of the physics material taught in class.

Based on the description of the problem, the learning outcomes for work and energy are low. One of them is the students 'cognitive physics ability. This is confirmed by the results of public high school 1 Baturetno observations. It was found that the student data component in students 'physics learning outcomes was low. In which physics learning outcomes for students, the information component is in the form of verbal and mathematical presentation skills.

According to Kilpatric, Swafford and Findell in Salkind (2007), students requires representation because students can access ideas ideas through the representation of ideas the. In addition, representation is a useful tool to aid reasoning easily communicating and convey thoughts In addition, according to Flevares and Perry in Salkind (2007) representation used to help understand on when problem solving or studying new and helpful concept clarify the concept when experienced confusion.

SMAN 1 Baturetno's findings show that students 'physical cognitive abilities are weak because students do not have mathematical abilities in the mathematical representations of work and energy. Mathematical presentation is the basis or foundation for a student to understand and use mathematical ideas in solving

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mathematical problems (Sari et al., 2019). These ideas or ideas are interpreted in the form of diagrams, figures, symbols, or mathematical writings, as Pasehah and Pasehah et al. (2019) have stated. This is in line with the view of Kurniawan et al. (2018) that mathematical performance is a way to interpret students ’abilities to the problem at hand, from which to find solutions to problems faced by students using their interpretation as a tool. If each student has the ability to represent, it is likely that they will be able to solve problems in teaching and the real world (Hartono et al., 2019). So it can be concluded that the ability of mathematical representation It is very important for students to master in determining the right strategy to be able to complete something math problems (Ramadhan et al., 2021). However, this is very important because mathematics is very related to solving problems in physics.

In addition, based on the findings at SMAN 1 Baturetno, students had low physical cognitive abilities because students lacked the ability to present verbally in terms of effort and energy. Besides that, Herlina et al. (2016) also stated in their research that the low ability of students' verbal representation is due to the lack of students in the process of solving math problems. Verbal presentation is the ability of students to define the concept of material being taught (Fatmaryanti et al., 2015). Verbal representation is usually used to express a problem at the beginning of the process and is needed to provide the final interpretation obtained in problem solving (Friedlander et al., 2001).

In addition, the cognitive abilities of physics in terms of effort and energy are weak because students rarely use energy ideas to explain everyday phenomena. Like bouncing balls, rotating cups and melting ice (Kubsch et al., 2021). We find that when energy is treated as a concrete issue and the resulting identification in the context of energy, high school students can develop an initial understanding to increase conceptual understanding (Kubsch et al., 2021). Therefore, the teacher as an instructor searches for the facilities available to the students to continue the learning process. One of the possibilities offered is that the teacher should be able to determine a learning model that suits the situation experienced by the students (Suranti et al., 2016).

A problem-based learning model is a model that uses contextual or real problems in everyday life. The problem-based learning model was chosen because it is widely believed that problem-based learning brings students real and meaningful problems that can facilitate their research (Sahidu, 2018). Holbrook et al. (2003) states that "science is easy to learn if the material makes sense to the student and is also related to human life, interests and aspirations".

In addition, a strongly confirmed finding in teaching and learning energy research is that few students develop an understanding of energy. Progress in energy learning is considered low (Herrmann, 1989; Liu et al., 2005; Neumann et al., 2013) have proposed the application of a new energy industry guidance. An approach that makes students explain phenomena from an energy perspective but without a form of energy. The proposed learning tool is in the form of e worksheet as e-worksheet has animations that support e worksheet. In addition, the e worksheet designed by this researcher is an e worksheet assisted by the phet colorado application.

Initially, the worksheet was known as the student worksheet. The worksheet is a sheet that contains the tasks that students must complete. According to Daryanto (2014) student worksheets are sheets that contain tasks that must be done by students. Evidence from the research literature suggests that spreadsheets can increase student engagement, learning, and equality in the classroom (Koretsky et al., 2018).

According to Afridiani et al. (2020), learning using the e worksheet problem based learning model has a significant effect on the ability to understand mathematical concepts. Learning to construct students ’understanding of mathematical concepts is better with the e worksheet problem based learning model than without the e worksheet problem based learning model. With the problem based learning model. E worksheet students are expected to be able to improve students ’physical cognitive abilities, one of which is the ability to perform mathematically and verbally present students’ physics.

Method

Research methods used in research and development (R&D) are used as research design, and 4D models are used as a research model developed. There are 4 stages to this study, namely: 1) definition; 2) design; 3) development (developing); 4) dissemination (disseminate) (Sugiyono, 2019). This method and model was chosen because it aims to produce a problem-based learning model for e worksheet physics. The purpose of this study is to improve students ’physical cognitive abilities in terms of students’ mathematical presentation abilities and verbal presentations.

The data obtained from this development study are qualitative and quantitative. Qualitative information was obtained from the comments and suggestions for improvement provided by the validator as version material. Information obtained for the evaluation of each criterion point in each opinion. The score for each criterion score is converted to a score on the Likert scale. The Likert scale used is ss (strongly agree) with a score of 4, s (agree) with a value of 3, i.e. (disagree) with a value of 2, and sts (strongly disagree) with a value of 1.

Quantitative analysis is a validity analysis, a feasibility analysis, and an efficiency analysis.

Validity analysis is used to determine the level of feasibility of a problem-based learning model for a learning device. Based on the results of the validation test survey, several suggestions for improvement are obtained that can be used as a reference for the finalization of the learning tool product. The validation analysis techniques used in this study are as follows:

Validity Test

The results of the e worksheet assessment based on problem-based learning conducted by four high school physics teachers in the form of qualitative data are converted to quantitative values by AIken validation. The content feasibility assessment is used using Aiken's (1985, 132-133) formula to determine whether all the instruments used are valid in terms of content:

$$V = \frac{\sum s}{[n(c-1)]} \quad (1)$$

Information:

V = Content Quality Factor
s = r-lo
lo = Lowest rating points
c = Highest qualification scores
r = Number provided by the validator
n = Number of validators

Table 1. Interpretation of Results V Aiken (Istiyono, 2020)

Average result	Classification
V0.8 ≥	Valid
0.4 <V <0.8	At the moment
V 0.4 ≤	Not valid

Efficiency Analysis

The analysis of the effectiveness of learning tools was analyzed on the basis of the growth of cognitive abilities, which were examined on the basis of students' mathematical and verbal physics performance abilities. The cognitive development assessed on the basis of students' mathematical and verbal physics performance abilities is analyzed by looking at the results of the pre-test and post-test and calculated using the Standard Gain equation. The standard gain is determined by the following equation.

$$Std < gain >= \frac{\bar{X}post\ test - \bar{X}pre\ test}{\bar{X}maks - \bar{X}pre\ test} \quad (2)$$

Information:

$\bar{X}post\ test$ = Average score after test
$\bar{X}pre\ test$ = Average score for the pre-test
$\bar{X}maks\ test$ = Maximum number of points

The N-Gain values are then grouped into three categories, listed in Table 2 below.

Table 2. Criteria for N-gain (Sundayana, 2016)

N-Gain value	Category
0.00 <g <0.30	Low
0.30 <g <0.70	At the moment
0.70 <g <1.00	Long

Result and Discussion

Pre-teaching activities are carried out before modeling and implementation. Pre-primary education aims to analyze needs through observation and research. Pre-primary education begins with pre-analysis, student analysis, task analysis, conceptual analysis, and the definition of learning objectives.

An initial analysis was conducted to identify the basic problems in learning physics at SMAN 1 Baturetno, which included curriculum and field problems. SMAN 1 Baturetno's curriculum is the 2013 curriculum. With regard to field problems, it is observed that students have difficulty understanding physics and that physics is not contextual, so problem-based learning tools are used.

In addition, a student analysis is conducted to determine students ’characteristics, including students’ background knowledge, skills, and initial attitudes. Based on the results of the analysis, it was found that SMAN 1 Baturetno students still lacked mathematical presentation and verbal presentation, so only their cognitive abilities were examined in this study.

The researcher then performed a task analysis to determine the learning materials to be used. The materials used in this study are labor and energy. Work and energy were chosen because the students think the material of work and energy is abstract. This material is also suitable for developing students ’cognitive abilities, namely in the sections on mathematical presentation and verbal presentation.

In addition, the researchers performed a conceptual analysis. Conceptual analysis examines what concepts are needed in work and energy material to determine cognitive abilities for students ’verbal and mathematical presentation.

The final step in the analysis is the definition of learning objectives. The determinations are based on the core competencies and basic competencies values determined in the previous concept analysis. This is followed by a series of indicators measuring the achievement of learning outcomes, on the basis of which the design of learning tools is prepared.

It is then planned what products students will need. The product used in this study is an e worksheet problem-based learning model. This product is used to improve the ability of mathematical presentation and verbal presentation, both of which are part of students ′cognitive abilities.

The next phase, i.e. the development phase, includes activities to design for predetermined products (Sugiyono, 2019). The development phase is the production of learning tools that support learning. The original product is in the form of the e worksheet Problem Based Learning model. The purpose of this phase is to produce competent and effective learning tools.

This development phase is a technique to validate or evaluate the feasibility of product design. In this activity, experts in their field carry out the evaluation. Based on the validation results, it is possible that product design still needs to be improved as suggested by the validator. The suggestions given will be used to improve the materials produced and the learning plans. The results of the test are then used for reviews so that the learning tools have really met the needs of the students.

Efficiency refers to the condition of effective learning tools used in learning. The effectiveness test determined the results of cognitive development, which was assessed on the basis of mathematical and verbal presentation skills. The effectiveness test is calculated on the basis of cognitive pre- and post-test scores, which are assessed on the basis of mathematical and verbal performance. In connection with the development of learning models, development activities are carried out in the following stages.

Validation with a Validator

Expert validators and practical validators validated the learning tools generated as a result of the design phase and received suggestions for improvement (Al-Tabani et al., 2014). Validated issues are learning tools in the form of e worksheet. The validators involved are practicing validators, namely three teachers. The development product is submitted to the professional validator by submitting a questionnaire to the validator to assess whether the development product is valid or not, as well as criticisms and suggestions for improvement. Validation results are calculated based on the Aiken V-formula, which is calculated based on the content validity factor. The content validity factor (V) is calculated based on the results of the validators.

Based on the results of the analysis using the V Aiken equation, it is known that the mean produced is 0.87654, which, as seen in the interpretation table, is included in the valid category. Thus, it can be concluded that the developed e worksheet Physics media can be used as a tool in the learning process.

Then, based on the results of the analysis with the V Aiken equation, it is known that the mean produced is 0.90196, which as seen in the interpretation table is the V Aiken value in the valid category. Thus, it can be concluded that the developed Learning Implementation Plan (RPP) is suitable for use in the learning process.

Revision

Checks will be made after the product validator has validated the product. Suggestions for improvement from the validator will be taken into account when reviewing the product. The researchers made revisions to produce suitable learning tools for testing.

Field Test

The problem-based learning model of the worksheet, revised on the basis of the validator's suggestions, is then tested in school education. Results of field tests conducted in class X MIPA 1 SMAN 1 Baturetno with a total of 18 students. Field trials investigated the effectiveness of the problem-based learning e worksheet model under development. An aspect to be assessed is the increase in students ′physical cognitive abilities in terms of mathematical and verbal presentation abilities. This is done to determine the effectiveness of learning. The improvement in students 'physical cognitive abilities in terms of mathematical and verbal performance is reflected in the results of the pre- and post-test of students' physical cognitive abilities. mathematical and verbal physics presentation skills. Students are pre-tested before completing their learning, then learning is performed and then a post-exam is given. The increase in students' physical cognitive abilities can be known by analyzing the scores of the pre-test and post-exam scores using standard confirmation scores.

Based on the results of the N-amplification analysis, the N-Gain value for cognitive abilities is 0.38. Based on these results, the results of the N-amplification analysis are moderate. Based on this, it can be seen that cognitive abilities are increasing in terms of students ′ability to present mathematical and verbal physics. This is consistent with Sundayana (2015) that an N-win score ranging from 0.3 to 0.7 has a moderate improvement grade. Thus, it can be seen from the growth results that the e worksheet model of problem-based learning is used effectively in learning.

Conclusion

The Based on the results of the study and discussion, it can be concluded that the results of the e worksheet validation test of the developed problem-based learning model are in a valid category and the e worksheet model of problem-based learning is feasible. used in learning. In addition, a field test was performed after performing the validity test. From the results of the field experiments, it can be concluded that the developed e worksheet problem-based learning model has proven to be effective in improving cognitive abilities, which are examined on the basis of mathematical and verbal representations of students 'physics. With regard to the suggestions that additional researchers may make, namely given that the problem-based learning e worksheet model offers learning benefits such as improving cognitive abilities based on mathematical and verbal representations of students' physics, teachers or other researchers to develop e worksheet: n problem-based learning models on a larger scale.

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