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Development of Student Worksheets Physics Based on STEM to Train Creative Thinking Skills

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Abstract: This research is a development research that aims to: describe the feasibility of STEM-based Physics Student worksheets, practitioners' assessment of STEM-based Student Worksheets, the effectiveness of STEM-based Student Worksheets in physics learning, and produce STEM-based Student Worksheets. The subjects of this research trial were 29 students of class XI MIPA at SMAN 15 Luwu. This study uses the ADDIE model development. The instruments used in this study were LKPD validation sheets, practitioner (teacher) response questionnaires, as well as test instruments for understanding creative thinking skills. The eligibility criteria for student worksheets are seen from the aspect of validity. The practicality criteria are seen from the practitioner's assessment of the student worksheets, and the effectiveness criteria are seen from the increase in students' creative thinking skills test results. Based on the results of the analysis, it is concluded that the STEM-based Physics Student Worksheets developed, based on expert assessments, have met valid criteria so that they can be used as learning resources. STEM-based Physics Student Worksheets in terms of the response of physics teacher practitioners are in the very good category and the STEM-based Physics Student Worksheets The work of STEM-based physics students is effectively used to train students' creative thinking skills.

Keywords: Creative Thinking Ability; STEM; **S**udent Worksheet

Introduction

The development of science and technology causes changes in almost all aspects of life, the many current problems are difficult to solve without the provision of skills and mastery of science and technology. A nation is required to develop the quality of human resources in order to be able to participate in global competition. Increasing human resources can be done by increasing the quality of education. By first conducting an evaluation of the learning process carried out. Students experience difficulties in understanding the material presented in the textbooks they have so that many students do not study before learning in class (Bakri & Rasyid, 2015).

Creative thinking skills possessed by students are considered important to support students in an effort to explore understanding of a concept. However, in current physics learning, students tend to memorize formulas in solving problems, and do not understand concepts so they are unable to solve real problems encountered outside the classroom (Nisa, 2018). Learning science including physics can help students develop an understanding and habit of thinking in meeting their needs and overcoming the problems they face. These statements indicate that the ability to think creatively is an important ability to improve.

Creative learning is not accidental but requires a process that supports the achievement of these abilities. To stimulate creative learning, preparation is needed, among others, by preparing a classroom environment that stimulates children to learn creatively. Physics is a subject that is not only theoretical but also mathematical. Creative thinking is a new way of seeing and doing something that contains 4 aspects, namely, fluency, flexibility, originality, and elaboration. Physics learning where there are critical and creative thinking activities that can develop an understanding, in addition to instilling attitudes and being able to use the scientific method, physics learning is not only limited to

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memorizing formulas, but requires an understanding and habit of thinking in fulfilling life needs and overcoming problems that arise. he faced. These statements indicate that the ability to think creatively is an important ability to improve.

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The results of observations and interviews with physics teachers at SMA Negeri 15 Luwu stated that the teaching materials used in physics lessons used textbooks containing material and questions, so that students were passive in learning and tended to memorize formulas. Science, Technology, Engineering, and Mathematics (STEM) is an approach that integrates more than one discipline. Learning using STEM can help students solve problems and draw conclusions from previous learning by applying it through science, technology, engineering, and mathematics (Dewi & Primayana, 2019). This situation allows students to obtain complete knowledge, be more skilled in dealing with real life problems and develop students' critical thinking.

Tseng et al. (2013) reported that Project Based Learning (PjBL) learning in the STEM field of science had a significant positive effect on students' attitudes towards the STEM field of science and was able to encourage students to choose STEM as a career choice in the future.

The use of the STEM approach can be implemented in teacher teaching materials in the form of student worksheets. Where, Student Worksheets are a means to assist in facilitating teaching and learning activities so that effective interactions are formed between students and teachers. Student Worksheets are worksheets that contain assignments done by students, contain instructions, steps to complete a task in the form of theory or practice. Student worksheets can be used to improve students' creative thinking skills (Aldila et al., 2019).

There is a development of learning models used by teachers so that physics learning is more meaningful, namely STEM-based learning, the application of STEM learning can be through the development of teaching materials, namely worksheets. Teaching materials in the form of Student Worksheets as one of the teaching materials that can be used independently are expected to support the learning process (Agustina, 2017). It is very important for teachers to develop learning resources so that learning is more effective, efficient, and does not deviate from the competencies they want to achieve and is close to the environment of students (M & Kosim, 2017).

Development is an important factor in teaching and learning activities, especially in secondary schools. Worksheets can help schools achieve quality learning. Application of Student Worksheets can condition learning activities to be more well-planned, independent and with clear results (outputs). Student Worksheets developed according to the needs of teachers and students who are able to improve the quality and quality of learning. Learning with the integration of STEM aspects is a form of learning that is compatible with the curriculum system that applies in Indonesia (Zulaiha & Kusuma, 2020).

The need to develop a STEM-based Physics so that students can analyze and generalize the knowledge provided so that students can be creative and capable. The developed STEM-based Physics Student Worksheet also helps teachers use learning resources that are more efficient and innovative to use in learning Physics at SMA Negeri 15 Luwu. Based on the description above, the authors conducted research with the title "Development of STEM-Based Student Worksheets to Train Creative Thinking Skills of Class XI IPA Students of SMAN 15 Luwu". It is hoped that this worksheet can be used by educators and facilitate the delivery of material to students.

Method

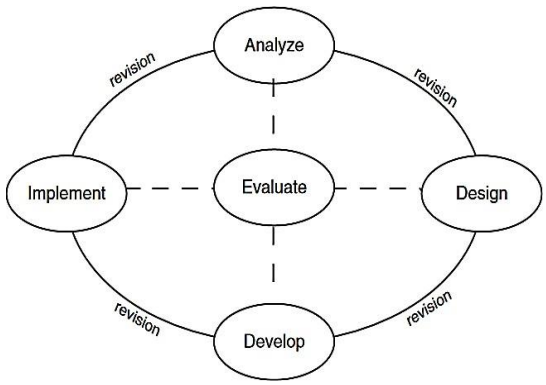

Figure 1. ADDIE Development Model

Development (research & development). The development research in question is research conducted

to produce a physics worksheet. This development research used the ADDIE Model developed by Brach (2009) covering the stages of Analysis, Design, Development, Implementation and Evaluation. The activities carried out at each stage of development can be seen in Figure 1. The activities carried out at each stage of development can be described as follows:

Analysis

The development of STEM-based Student Worksheets begins with analyzing the problems or school needs needed to improve physics learning. The concept at this stage is needs analysis to determine the right problems and solutions as well as determine student competencies which are the basis or reference in the development of STEM-based physics Student Worksheets. This preliminary research is expected to obtain aspects of needs analysis including:

Needs Analysis

Conducted to determine the background of the problems encountered in the physics learning process, so that from these problems it is deemed necessary to develop STEM-based Student Worksheets. The STEM-based Student Worksheet Development stage is carried out by defining several stages of the needs of developing Student Worksheets including defining the objectives of the learning process as well as students.

Student analysis was carried out to determine the behavior and characteristics of students including background knowledge, cognitive development of students and the ability to think creatively.

Material analysis was carried out by identifying the subject matter listed in the physics subject syllabus for class XI MIPA in the 2013 curriculum used at SMAN 15 Luwu for making STEM-based Student Worksheets.

Design

At the design stage is the planning stage of the STEM-based student worksheets that will be developed, which includes identification of facilities and infrastructure, selection of formats, and initial design. STEM student worksheet. The design stages of STEM-based student worksheets are as follows: Identification of facilities and infrastructure, selection of formats, and initial design of student worksheets.

Development

This stage is the stage of making STEM-based Student Worksheets which aims to test the validity of Student Worksheets that have been designed for use in the learning process. Further validation of the products that have been made, product validation is carried out by 3 (three) competent validators to assess the developed Student Worksheets and provide input or suggestions. Based on the results of the assessment and suggestions if it is declared invalid, then the initial Student Worksheet is revised so that a new Student Worksheet is obtained and then validation is carried out again by the expert/expert until the Student Worksheet is declared valid and feasible to be tested.

Implementation

The implementation phase of the STEM-based Student Worksheet that has been developed will be tested on a number of respondents. The test subjects in the research on the development of STEM-based Student Worksheets were students in class IX IPA SMA Negeri 15 Luwu Academic Year 2021/2022. The trial design used was "Post-test one shot case study". In this design the test is carried out once, namely after giving the treatment. The test carried out after giving the treatment (O) is called the post-test. According to Sugiyono (2019) the design of this trial is described as follows:

Figure 2. Research Trial Design

Note:

X : Treatment (independent variable)

O : post-test (after applying the Worksheet)

Evaluation

The evaluation was carried out to find out the results of expert assessments, teacher responses, student responses to the developed STEM-based Student Worksheets. After the STEM-based Student Worksheets are declared valid and feasible to use, a creative thinking ability test is then carried out to see the effectiveness of the STEM-based Student Worksheets that have been developed.

Result and Discussion

Expert Validation Results of STEM-Based Physics Student Worksheets

The initial design of the STEM-based physics Student Worksheet that has been compiled was validated by experts to determine its feasibility before conducting a limited trial. STEM-based physics Student Work Sheet is considered feasible to be tested if it fulfills four aspects, namely presentation, language, completeness and applicability.

As for the validation results by the validator on the STEM-based physics Student Worksheet which has been developed in the presentation aspect, a score of 89 is obtained from an ideal score of 108 using the Aiken's V formulation, an expert agreement validation index is obtained of 0.77 and is declared valid. In the content aspect, a score of 79 was obtained from an ideal score of 108 using the Aiken's V formulation, an expert agreement validation index was obtained of 0.76 and

was declared valid. In the language aspect, a score of 78 was obtained from an ideal score of 108 using the Aiken's V formulation, an expert agreement validation index was obtained at 0.75 and declared valid, using Aiken's V formulation, an expert agreement validation index was obtained at 0.76 and declared valid.

The results of the assessment of experts/experts on STEM-based physics Student Worksheets in terms of presentation, content and language can be seen in Table 1.

Table 1. Results of Expert Assessment of Physics Student Worksheets

Aspect Appropriateness	Percentage Score (%)	Index Validation	Conclusion
Display	82.4	0.77	Valid
Content	73.1	0.76	Valid
Language	72.2	0.75	Valid

Table 1 above shows that the validation results provided by the validator team have strong consistent responses. Thus, the physics worksheet that has been developed is declared to meet the eligibility criteria (valid) so that it can be used. The researcher refers to the results of the discussion by following the suggestions and instructions from the validator in revising, researchers, so that this STEM-based physics worksheet is feasible for field trials.

Results of Practitioners' Assessment of STEM-Based Physics worksheets

After the practitioner's assessment of the physics worksheet was carried out, which was based on the responses of eight practitioners who are members of the Luwu Regency Physics Teacher Deliberation Community. Assessment of physics worksheets includes aspects of content feasibility, presentation feasibility, language feasibility, and graphic feasibility. Data from the results of the analysis of teachers' response assessments regarding the physics worksheets that have been developed can be seen in Table 2.

Table 2. Percentage of Teacher Responses to Student Worksheets

Rated aspect	Percentage (%)	Category
Material	83.5	Very Good
Display	84.8	Very Good
STEM	84.4	Very Good
Language	83.6	Very Good

Table 2 shows the results of the assessment of 8 physics subject practitioners on the physics worksheets that have been developed, namely an average percentage of 83.5% of practitioners rate the material aspects of the worksheet in a very good category, an average percentage of 84.8% of practitioners rate the presentation on the worksheet is in the very good category, the average percentage of 84.4% of practitioners assesses the STEM LKPD in the very good category, and the average percentage of 83.6% of practitioners assesses the graphs on the worksheet in the very good category

Results of the Effectiveness Analysis of STEM-Based Physics Worksheets

The effectiveness of the developed physics worksheets was measured using a test of creative thinking skills given to students. Creative thinking skills tests are given to students after learning using physics worksheets to find out the final creative thinking skills of students using STEM-based physics worksheets to find out the improvement in students' thinking skills after using the STEM-based physics worksheets. The results of the analysis of students' creative thinking skills tests after being given STEM-based physics worksheets showed that there were no students who were in the very good, poor and very poor categories. While in the good category, there are 24 students who have creative thinking skills with a percentage of 89%. In the moderate category, there are 5 students who have creative thinking skills with a percentage of 11%. This section presents a discussion of research results which include several things, namely: 1) analysis of the validity of STEM-based physics worksheets, 2) analysis of teacher responses to the use of STEM-based physics worksheets, and 3) analysis of the effectiveness of using STEM-based physics worksheets

Expert Assessment of Valid STEM-Based physics worksheets

The results of the 1st draft that has been designed will be validated by means of expert validity. From the results of expert validity using the Aiken's V expert validity model, the physics practicum module that has been developed is generally in the valid category.

An instrument is said to be valid if the instrument can accurately measure what it is intended to measure. So it can be said that the validity relates to the accuracy of the measuring instrument. With a valid instrument will also produce valid data. According to Miller et al. (2009) states that the main characteristics that must be possessed by a measuring instrument are its valid character and level of use. So in an instrument it is very important to measure a level of validity.

According to Allen & Yen (2002) states that the validity of a test device can be interpreted as the ability of a test to measure what it should measure. So that students are also expected to be able to apply the things they learn in the real world or work environment (Winarni et al., 2016).

So that the physics practicum module instrument developed has been validated and declared valid and is in accordance with the competency standards of learning outcomes even though the instruments that have been used still need a little revision. This is in line with Yusup's research (2018) which states that the instrument has an important position in research because the instrument plays a role in the data collection process. Valid instruments can produce valid data as well so as to lead to conclusions that are in accordance with the actual situation. Thus, this practicum module is declared to meet the eligibility criteria (valid) so that it can be used.

Practitioners' Responses to STEM-Based Physics Worksheets

The teacher's response to the physics practicum module that has been developed can be found by distributing response questionnaires to ten teachers who are members of the Makassar City Physics Teacher Deliberation Community. In this study, the researcher gave a questionnaire to the teacher as an assessment questionnaire for the physics practicum module being developed.

The results showed that all aspects of the STEM-based physics worksheet assessment component assessed by practitioners obtained percentages above 80% for each component can be seen in table 4.5. (Yuanita & Kurnia, 2019) states that the STEM aspect of learning refers to the fields of science, technology, engineering (science engineering), and mathematics which make learning more interesting.

In general, the practitioner's response score to the implementation of STEM-based physics worksheets is in the very good category (Cantrell et al., 2006) states that engineering aspects are integrated in the form of design information (engineering and work methods) that apply physics concepts and mathematical aspects which are integrated into the physics equations of each chapter in the form of using number symbols to calculation and measurement of the product to be designed.

Practitioners' responses that are in the very good category can be used as a benchmark that practitioners feel comfortable with physics worksheets that are developed to be easy to use in the learning process so that they can easily understand physics concepts in order to easily solve given physics problems. So it can be concluded that the STEM-based physics worksheets that have been developed can help student teachers in the physics learning process so that they can easily understand physics concepts contextually and more easily and provide convenience to train students' skills in making simple works to increase student creativity. in learning.

The Effectiveness of Student Worksheets Based STEM

The STEM-based Physics Worksheet that has been developed is then tested for its effectiveness on Static Fluid material. The developed STEM-based Physics LKPD consists of integrating aspects of science by describing the concepts of physics itself, then looking at how the use of technology in everyday life relates to subsequent learning of Physics by using science engineering techniques, students can train and improve skills to create a simple work produced in learning using STEM-based Physics worksheets.

The students' physics creative thinking ability test can be seen in Table 4.5. It was found that 24 students were declared complete or in good criteria with a percentage of 89% and as many as 5 students were still in the sufficient criteria with a percentage of 11%. The factors that influence some students still have sufficient value, namely the processing time which is considered too short, students still do not understand the questions properly. In line with research conducted by (Almuharomah et al., 2019) states that the STEM Physics Worksheet is integrated with local wisdom "beduk" to improve creative thinking skills and is suitable for use as a companion to textbooks and worksheets that existed before at school and received good student responses.

Based on the explanation above, it can be concluded that learning effectiveness is the level of success achieved from a particular learning method in accordance with the planned learning objectives. In this study the success rate was that there were 24 students who entered the good category with a percentage of 89%.

Conclusion

Based on the results of the research and discussion that has been done, it can be concluded as follows. Based on the assessment of experts (experts) on STEM-based physics worksheets to train creative thinking skills that have been developed, they meet valid criteria so that they can be used as learning resources in learning physics. Practitioners' response assessment of the developed STEM-based physics worksheets gave a positive response in the very good category. The effectiveness of STEM-based physics worksheets can be seen from the tests of students' creative thinking abilities and physics learning activities. It was obtained that a percentage of 89% of students scored according to the criteria so that it can be said that STEM-based physics worksheets are effective in learning in class XI MIPA 1 SMA Negeri 15 Luwu.

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