Creative Thinking Skill: Development of Problem Solving Worksheet in Physics

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Abstract: This research aims to study the use of problem-solving worksheet to improve Madrasah Aliyah students' creative thinking skill in learning Physics. The worksheet of Work and Energy is designed for the students' use with the problem-solving approach. This research is developed from the model of ADDIE – Analysis, Design, Development, Implementation, and Evaluation. The developed worksheet is validated by an expert of Physics, an expert of teaching materials, and a Physics teacher. It is then tested in two experiments (limited and extensive). The subjects of the limited experiment are 6 students; while the large trial involves 75 students. The students' creative thinking skill is analyzed with essay tests adopting TTCT (Torrance Test of Creative Thinking) with the indicators of fluency, flexibility, and elaboration. The research findings show that the problem-solving worksheet is considered good. It is based on the average rating given by validators of 4.15 on 0–4.2 scale. This worksheet is beneficial to be used by students for improving their creative thinking ability. Preparation of the worksheet also improves the students' creative thinking skills. This is reasonably based on the results of the average n-gain which increased by 0.6 point, falling into the medium category.

1 INTRODUCTION

Education has an objective that students have qualified competences involving three aspects: attitude, knowledge, and skill. It means that students are expected to grow with a positive attitude, a critical, creative, innovative and collaborative thinking, honesty and openness in their life (Scott, 2015).These competences should be built on early stages through formal and informal educations. Based on the goal, a contextual Physics learning which is easy to understand and generates students' thinking ability is required. Thus, students are able to discover how a concept or theory is formed. They will not be trapped in the nature of passive learning. Students should have the ability to formulate problems, identify problems, and find solutions to their problems (Ubaidillah, 2016).

In the 21st century, students are required to have high order thinking skills to be able to compete in the society. One of those high order thinking skills is creative thinking. The skills can be built in students through the learning process that they are involved in. This is in accordance with what is described by Patel that learning is fundamental process that involves the student's creativity (Patel C, 2017). Students' experiences through learning that involve creative thinking skills are proven to improve their knowledge skills (Thompson, 2017). Initially, creative thinking skills are considered only to be possessed by a genius, but the development of research results shows that creativity is a skill that could be mastered through practice (Faulkner, 2008). Creative thinking skills can be developed in each person through educational processes from the young to adult ages. Treatments given for the sake of students' creative thinking skill improvement can be done by utilizing the worksheets that correspond to the students' characteristics. It is in-line with the study conducted to students in India which shows that there is a positive relationship between the acquisition of students' knowledge with the dimensions of their creative thinking skills (Mohanty, 2015). Meanwhile, a good learning

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process could not be separated from the utilization of teaching materials as a guide for students to develop their knowledge. Teaching materials should be made by the teacher in accordance with the learning objectives and students' needs. One of the teaching material forms that can accommodate the learning objectives and needs is worksheets. Student worksheets need to be developed to make learning process effective. It could be designed to stimulate their creative thinking. To train and develop students' thinking skills, a proper learning strategy is also essential. The use and development of problem-solving strategies are highly effective to improve students' performance in exploring thinking skills (Selçuk et al., 2008).

Therefore, teaching materials and appropriate learning strategies are very influential on students' thinking skills. In fact, many teachers still use conventional teaching materials, including traditional worksheets (Prastowo, 2011). A good worksheet is a worksheet fitted to the learning strategy being used. If the chosen strategy is problem-solving, the worksheet should lead students to problem-solving activities. It in turn accommodates students to finding, identifying, and solving the problem.

A problem-solving model is regarded as a learning process which improves students' ability in high order thinking, one of which is creative thinking skills (Widodo and Kadarwati, 2013). Problem- solving models with high order thinking will bring students to their experience using knowledge and skills to discover non-routine patterns of problem- solving. The discovery results in a more meaningful learning, specifically learning through problem- solving result in individuals who are capable of creative thinking (Soriano de Alencar, 1993).

For that reason, this research aims to improve students' creative thinking skills through problem-solving strategies built in student worksheets, designed in accordance with the problem-solving stages. Previous studies have always linked problem-solving models to problem-solving abilities, whereas in this study problem-solving is the basis for the preparation of worksheets to improve creative thinking skills.

2 METHOD

This developmental research refers to the development model of ADDIE, standing for Analyse, Design, Development, Implementation, Evaluation (Gustafson and Branch, 1997). The research design is illustrated in Figure 1.

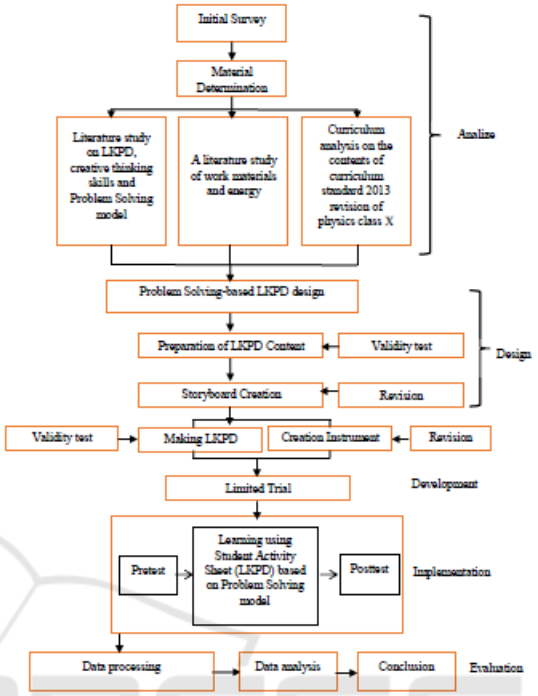

Figure 1: Research Design

The instruments used in this research are*(1)* validation sheets, *(2)* a questionnaire of student's responses, and *(3)* a creative-thinking-skill test adopted from TTCT (Torrance Test of Creative Thinking) which is a description referring to three indicators; namely *fluency, flexibility,* and *elaboration*(Harvey et al., 1970, Kim, 2006). The validation sheets are given to three experts: one learning-material expert, one teaching-media expert, and one physics teacher, to determine the feasibility of the designed worksheet. The questionnaire is used to figure students' response out, to understand their comments and suggestions to the worksheet. The questionnaire is given in both limited-scale and wide- scale. In addition, to find out the improvement of students' creative thinking skills, two tests are given each before and after the use of the student worksheet with problem-solving strategies.

The assessment of the student worksheet conducted by the three validators is designed on four aspects: learning materials, language, presentation and graphics. The validators give the material aspects of the student worksheet an A, which means 'excellent'. Meanwhile, the

linguistic, presentation and graphics aspects get a good grade, B. Because the validation result is good or excellent, the student worksheet has been considered valid so it is eligible to try in the classroom (Kartika, 2016).

The limited-scale test is conducted to six students. Through this limited trial, students' responses are interpreted. The average score of students' response on the limited scale is 3.26, it means all the students give good responses to the worksheet. This interpretation refers to that if the score range is $3.5 > X \geq 2.5$ (Mardapi, 2008), it is in the agreed category and the designed worksheet are feasible to be used on a wide scale. After a limited-scale test, large-scale or field tests were conducted. This activity includes the implementation of the tests of creative thinking skills (pre- and posttest) and the application of the problem- solving-based student worksheet.

The data is analyzed both qualitatively and quantitatively. The qualitative analysis involves the validators' reviews and recommendation as well as the students' responses. The quantitative analysis covers the examination of the feasibility of the student worksheet, students' responses and students' creative thinking skills. To decipher the students' creative thinking improvement, normalized gain (N- gain) value was determined. The formulation of N- gain value (Hake, 1999):

$$d = \frac{\textit{posttest score} - \textit{pretest score}}{\textit{maximum score} - \textit{minimum score}}$$

The interpretation criteria of N-gain value are in the following table:

Table 1: Classification of N-Gain

N-Gain	Classificati
$d < 0.3$	L
$d < 0.3 \leq$	Medium
$d > 0.7$	H

3 RESULTS AND DISCUSSION

3.1 Analysis

The first stage is analyzing the needs of learning based on the curriculum. A needs analysis is done through observation and interviews on the students and teachers. It results in the need for materials that can enhance creative thinking skills of students, since the school previously used the worksheet from a publisher that only contains brief and material-reserved exercises. With the old worksheet, students' thinking skills are not trained. It also does not support the effective learning of physics that it can make students feel bored.

Based on an analysis of the competence of the basic curriculum as a guide, creative thinking skills can be developed through learning with problem-solving strategies applied in a worksheet-based problem solving. This is because the learning outcomes demonstrate that the learners should be able to propose ideas for solving problems relating to the concept of Work and Energy.

3.2 Design

The second phase of this research is to make the design of a customized worksheet with a model of learning problem-solving. Preparation of the worksheet includes introduction and the core. The introduction consists of the cover, the manual, concept maps, core competences, basic competences, and learning objectives to be achieved by students in learning.

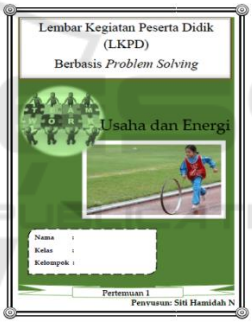

Figure 2: Worksheet Cover

The cover contains the title, student identity, and learning and discussion information.

Figure 3: Worksheet Instruction

The manual section contains instructions and frequently-asked questions regarding the worksheet.

Meanwhile, the concept map depicts the basic concepts being studied as well as the relation of each other.

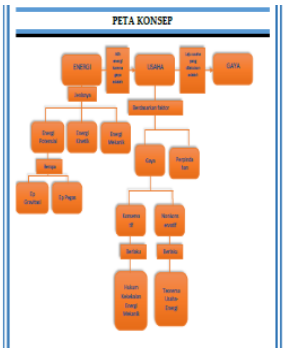

Figure 4: Concept Map

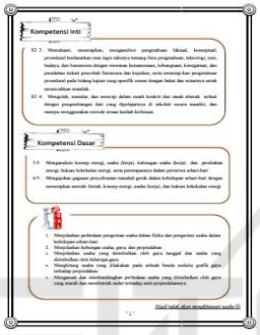

Figure 5: Competences and Learning objectives

The last part of the introduction contains the core competence, knowledge and basic skills, and the learning objectives the students are expected to achieve in the material of Work and Energy.

The main part of the worksheet contains the materials and problems to solve, the experiment section, discussion section, self-evaluation section, and communication section. This part is shown in figure 6, 7, 8, 9, 10, and 11.

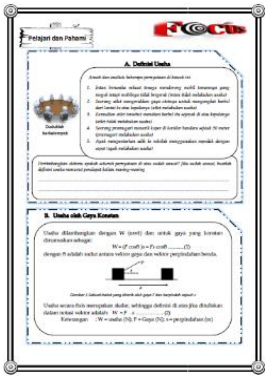

Figure 6: Problems in the Worksheet

Figure 6 presents the problems and materials. Problems related to learning material are given to the students to solve. The material is presented to give students insight of the matter that can help them in solving the problem.

Figure 7: Problem and Solution

Figure 7 presents the example of the problem and how to solve it. The given problem is associated with the application of the Work and Energy concept in daily life.

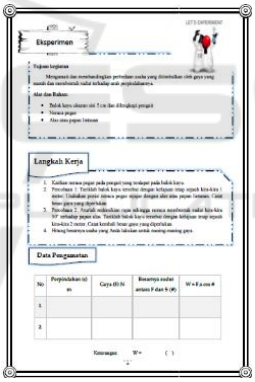

Figure 8: Experiments

Figure 8 shows the section of which students need to do experiments for solving the problem in accordance with the experimental results.

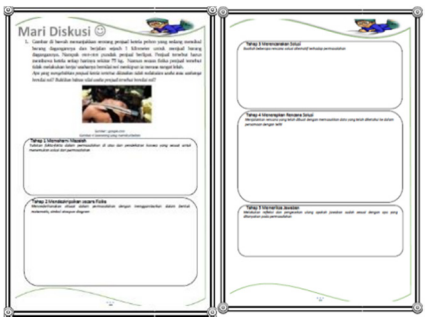

Figure 9: Discussion

Figure 9 presents the section of which students conduct discussions. Here, students are expected to be able to link the results of the experiment with the concepts of physics and its mathematical equation. It is so that when they find such problems in everyday life related to the concept being learned, they will be able to resolve it with the creative ideas they have.

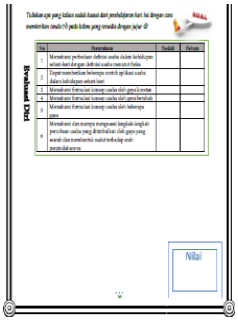

Figure 10: Self-Evaluation

Figure 10 presents the self-assessment part of the worksheet. Here, students are expected to assess themselves based on what they did in the previous activity. This is done to see how well the learning objectives are achieved.

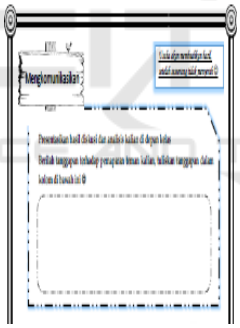

Figure 11: Communication

Figure 11 shows the communication section. Here, students are expected to communicate the conclusions of the learning process they already experienced with the worksheet. The final conclusion shows the students' understanding of the material so far.

3.3 Development

The worksheet development stage involves the validation, in which experts assess and provide inputs towards the designed worksheet. The results of the validation from three validators on the four aspects are presented in table 2.

Table 2: the result of validation

Assessment	Sco	Interpretat
Material	4.3	Very
Language	4.1	G
Presentation	4	G
Graphics	4.2	Very
Average	4.1	G

Based on table 2 above, the overall assessment of the worksheet is in the "good" category. It happens because the worksheet is designed in accordance with the needs analysis result and the curriculum. It, therefore, corresponds to the core competences and basic competences students need to have by the end of the lesson.

The inputs provided by the three validators are presented as follows: The media expert adds an editorial to the example of stage 5 for the first worksheet, which is at the checking stage of the answer, the phrase "reasonable answer" plus its redaction with "searched quantity and conclusion", this applies to all including the second worksheet. The material expert suggests an answer sheet on a special sheet because in essence the worksheet is a guideline/activity guide for learners. While the physics teacher gives suggestions for image display should be more focused, and use a clearer color primer to illustrate the more cheerful and assertive.

Media expert judgment corrected item of question for 5th stage for student work sheet in answer checking stage. The sentence containing "logic answer" was revised into "the number searched and conclusion". This applied to all worksheet two. The experts suggested to give students other answer sheet since students' worksheet are guidance for them. Physics teachers suggested that the image should be more focused using primary colours to make it better.

3.4 Implementation

In implementation, based on the results of the pretest and posttest data analysis, there is an increase in students' creative thinking skills. It implies that the problem-solving-based student worksheet is applicable for learning Physics. The highest score in the creative thinking test is 81.25 and the lowest score is 60.42 with N-Gain value 0.60, which is categorized 'medium'. Table 3 shows the data of N-Gain value analysis per indicator of creative thinking skills.

Table 3: N-Gain Value per Indicator of Creative Thinking Skills

Creative Thinking	N-Gain	Interpretation
Fluency	0.82	High
Flexibility	0.70	High
Elaboration	0.55	Medium
Average	0.60	Medium

The average N-gain value per indicator illustrates students' creative thinking improvement. Improvement of creative thinking skills will occur by using high order thinking learning strategy (Malik et al., 2017). The use of the student worksheets developed by teachers can improve the creative thinking skills of students (Herman, 2015). However, the improvement of students' creative thinking skills after the use of the problem-solving-based student worksheet is not optimal. The improvement remains in the medium category. It is caused by several factors. One of the factors is the problems (cases) given in the test. The problems/cases are not routine issues faced by the students, so they have difficulty in interpreting sentences into mathematical form. Consequently, they find it difficult to solve the problem (Alghafri and Ismail, 2014).

From Table 2, it can be seen that the lowest N-Gain is elaboration which is 0.55, regarded as 'medium'. The highest N-Gain is fluency which is 0.82, regarded as 'high'. The low ability is decomposition or elaboration because the students did not fully understand how to develop or explore their ideas which are important to solve the problems and to identify the steps of problem-solving; and, generally, the given problems are not common in students' life. They are difficult to interpret the question into physical phrases (Nozari and Siamian, 2014, Putra, 2012).

The result of N-Gain value analysis based on business and energy concept can be seen in the table below.

Table 4: N-Gain Value per Sub Concept

Concept	*N-Gain*	Interpretation
Work	0.58	Medium
Potential Energy and Kinetic Energy	0.55	Medium
Energy	0.60	Medium
Energy Conservation	0.65	Medium
Average	0.60	Medium

From table 4, the lowest N-gain value is the sub- concept of *energy* which is 0.55, whereas the highest N-gain is the sub-concept of *energy conservation*. In the sub-concept of *potential energy* and *kinetic energy*, students are still difficult to understand and apply kinetic-energy-work theorems, potential energy-work, and the variations of questions in the worksheet. This is consistent with the previous research results that the varied questions of potential energy problems often lead students to confusion because their understanding of the concepts is not complete (Singh and Rosengrant, 2003).

3.5 Evaluation

In evaluation, a discussion is conducted about the students' response towards learning using the problem-solving-based worksheets.

Table 5: Analysis of students' responses on the wide-scale experiment

Aspects	Average Score	Qualification
Content	3.02	Agree
Presentation	3.03	Agree
Language	3.01	Agree
Motivation	3.11	Agree
Average	3.16	Agree

Table 5 shows the results of the questionnaire response analysis on the wide-scale experiment. The average score of students' response is 3.16 out of 4. The score is in the 'agree' category. This indicates that there is a positive or good response from students after the use of the problem-solving-based worksheet. It is in line with the research conducted by (Mariati, 2012). If the result of the response analysis is 'agree or 'strongly agree' on a broad scale, it gives an idea that the student worksheet can be accepted by the students in the learning process. The use of the problem-solving-based worksheet can boost creative thinking skills. It is shown by the good response from students, and is further strengthened by the creative thinking test result.

4 CONCLUSIONS

The feasibility of this developed worksheet is valid from the aspects of learning materials, language, presentation and graphics. The material used in the worksheet was considered 'good' by the three

validators. Similarly, the students' responses to the worksheet are also very positive. It is illustrated by the statement of 'agree' from students. This research can show that the designed student worksheets with problem-solving strategies improve students' creative thinking skill to the medium category. However, this research is unable to present the specific aspects of creative thinking skills performed by the students. Further research can be developed in terms of evaluation and application of the worksheet by teachers.

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