Preliminary Development of the Engineering Design Process Assessment Tool for Elementary Students about Flood Mitigation

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Abstract This paper is the result of research on the development of assessment instruments used to explore students' abilities in the field of engineering design processes in elementary school students. The method used in developing this instrument is to follow the development phase of ADDIE. Starting from analyzing indicators, namely identifying problems, determining solutions, making model designs, testing model designs, and re-creating models. Then the instrument design process is selected in the form of entries. The development phase is done by examining the design of the instrument by considering the characteristics of students, then the implementation is done by testing the worksheets and direct questions on students. The results of implementation show that students have been able to answer the questions given. This means that all questions used to explore students' EDP skills can already be understood by students and there are no misconceptions about the problem. The final results show that all question items can be answered clearly.

Keywords: assessment tools, engineering design process, disaster mitigation, ADDIE models.

1. Introduction

In learning content in schools students do not have challenges in the form of problem solving tasks both individually and in groups. This will have a long impact on the weak ability of students to deal with problems in daily life. So the knowledge learned in school cannot be applied by students in their daily lives (Kurniaman & Zufriady, 2019).

One of the efforts made by the teacher is to teach to improve the EDP (Engineering Design Process) skills. In this process students will be directed in assessing the problem, gathering relevant information, producing many solutions, analyzing and choosing solutions, testing and implementing solutions which are the stages used to be able to find good solutions to solve problems. EDP is one of the skills students need to be able to face future challenges with learner-centered, open, and constructivist learning. EDP is an inseparable part of STEM skills (Science, Technology, Engineering, and Mathematics). One characteristic of proper STEM learning is centered on the Engineering Design Process.

Specifically Engineering in STEM learning requires the integration of problem solving processes (thinking), the design process, the manufacturing process, the testing process, and the product revision process to be able to solve problems in learning (English, 2016). Several studies have shown positive benefits for students when the challenges of the design engineering process are incorporated into basic classrooms (Guzey et al., 2017; Toma and Greca, 2018; Wendell and Rogers, 2013).

In the literature it is said that currently it is feared students are not ready to work in the future unless the education system can focus more on STEM education from an early age. (Council, 2015) Disaster mitigation is a term used to refer to actions to reduce the impact of disasters that can be taken before a disaster occurs, including preparedness and long-term risk reduction measures. (Rosiliwati, 2012)

In the event of a natural disaster, efforts are needed to deal with disaster management. These activities include planning and managing natural disasters. In Law No. 24 of 2007, each region must have an effort in disaster management, mitigation efforts can be in the form of pre-disaster, during disasters, and post-disaster. Disasters can be in the form of preparedness or efforts to provide public understanding to be able to anticipate disasters, through providing information, increasing preparedness so that in the event of a disaster there are steps to minimize disaster. Disaster management must be with a more active plan or strategy, not only taking post-disaster action, but there must be a series of activities in preparation to anticipate if a disaster occurs. (Suhardjo, 2011) In general, disaster mitigation is categorized into structural mitigation and non-structural mitigation in practice. Structural mitigation is related to construction construction efforts, while non-structural mitigation includes land use planning, making regulations, development, and through education to prepare people to get used to living together with disasters. (Faturahman, 2018)

The objectives of disaster mitigation are 1) to increase the understanding of all parties about the importance of disaster mitigation in efforts to reduce disaster risk; 2) to increase disaster mitigation efforts; 3) encourage participation and integration among governments, between institutions, the private sector and the community in developing disaster mitigation efforts; 4) provide guidance for institutions within the city government. We cannot avoid natural disasters, but what we can do is minimize the loss of lives, property and the environment. Disasters can occur due to several factors, namely: 1) lack of understanding of the characteristics of disasters; 2) attitudes or behaviors that produce quality natural resources; 3) lack of self-warning information; and 4) powerlessness or inability to face danger. (Nirmalawati, 2011)

The term EDP is part of the STEM approach (Science, Technology, Engineering, and Mathematics) or in the context of Indonesia refers to 4 sciences namely: Science, Technology, Engineering, and Mathematics. Which was introduced by the NSF (National Science Foundation) of the United States in the 1990s. (Homeland, 2017). Engineering Design Process (EDP) is an engineering design process, which is a decision making process for developing optimal solutions to meet predetermined goals. Among the fundamental elements of the design process are identifying problems, determining solutions, designing models, making models, remodeling. Some experts in the field of education have provided strong evidence that engineering design must be one of the main focuses of education. (Mangold, 2013). So the Engineering Design Process is an understanding of how technology can be developed through a design process using project-based learning themes by integrating from several different subjects. Engineering here means engineering. Techniques in learning aim to create products. So when students already understand basic knowledge and have followed the development of existing technology, products from learning outcomes can be made. Creating products or jobs in learning aims to make learning more meaningful and can prepare students to be more independent in facing natural disasters. (Khandani, 2005). The aim of the Engineering Design Process (EDP) ability is to be able to produce students who then when they are involved in the community, they will be able to develop competencies that they must be able to apply in various situations and problems that will be encountered in everyday life. This EDP ability needs to be possessed by elementary school students. With this ability will provide opportunities for students to be able to develop and demonstrate their skills so that it helps students develop in a global society (Blackley, 2018).

The implementation of EDP, which will be explained here is the exploration of EDP activities for elementary school students which leads to several stages such as identifying problems, determining solutions, making model designs, testing model designs, and re-creating models if deemed to be less than optimal so to be better.

1. Identify the problem
When going to do EDP learning the first thing to do is identify what problems are being experienced. For example, identifying problems about designing a canoe with available equipment to cope with the current flood disaster. Given the requirements and limitations of the problem in making a ship (for example: making a propeller with a length of 5cm) image below.

2. Determine the solution
Give opinions to solve problems and choose the best way. For example: what if we make the easy ones as before. Identification of the tools and materials provided (for example: can the styrofoam used be connected as a sampan bearing be connected to the propeller, in what way and the means to connect it?)

3. Create a model design
Create a model design on the design sheet according to the best solution chosen based on the results of the agreed group discussion.

4. Test the design of the model
Make a boat in accordance with the design that has been designed and do a trial run

5. Remake the model
Redesigning a boat if it is considered less than optimal with its own creativity makes another boat. (Khairiyah, 2019)

2. Methodology

This paper was written based on research using ADDIE research methods, Analysis, Design, Development, Evaluation of implementation) (Nadiyah & Faaizah, 2015). Starting from analyzing indicators, namely identifying problems, determining solutions, making model designs, testing model designs, and re-creating models. Then the instrument design process is selected in the form of entries. The development phase is done by examining the design of the instrument by considering the characteristics of students, then the implementation is done by testing the worksheets and direct questions on students. Furthermore, this instrument is implemented for use in grade 6 elementary school students, then the results are evaluated. All of these activities are explained in the discussion

3. Result and Discussion

The development of this assessment instrument aims to explore the EDP skills of students in primary schools, taking into account student characteristics, teacher abilities in teaching, and learning tools. The development of this instrument uses the ADDIE development model as follows.

3.1. Analysis

The analysis of technical design process indicators is carried out well during the learning process activities, according to the EDP stage which focuses on identifying problems, finding solutions, designing tools, making and testing tools and redesigning tools if needed.

1. Identify the problem
When going to do EDP learning the first thing to do is identify what problems are being experienced. Students will define problems, identify criteria that must be met to be able to collect good products,

gather information from various sources, and send creative ideas that can solve problems. For example, identifying problems about designing a canoe with available equipment to cope with the current flood disaster. Given the requirements and limitations of the problem in making a ship (for example: making a propeller with a length of 5cm) image below.

2. Determine the solution
Students are asked to provide opinions to be able to solve problems and choose the best way. Students determine the tools and materials that will be used to make products, and also students will determine good procedures for producing good products. For example: what if we make the easy ones as before. Identification of the tools and materials provided (for example: can Styrofoam used be connected as a sampan bearing be connected to the propeller, in what way and the means to connect it?)

3. Designing a model
Create a model design on the design sheet according to the best solution chosen based on the solution taken. Students will design models individually and analyze each design created based on predetermined criteria

4. Create a model
Students are asked to make products according to designs that have been designed, conduct trials and identify the advantages and disadvantages of assembled products.

5. Remake the model
Redesign products with pictures if deemed less optimal with the creativity of each student.

3.2 Design

The second step is design, where an outline of the learning strategy is made or learning and assessment activities are determined. The design phase should be systematic and specific. Systematic means a logical, orderly method of identifying, developing and evaluating a set of planned strategies targeted for attaining the project's goals. Specific means each element of the instructional design plan needs to be executed with attention to details. In this study the assessment tools were constructed in the form of worksheets and a list of questions in the form of concept maps.

3.3 Developing

The instruments in this study were worksheet, question items, rubrics and interview guidelines (fig.1). This instrument was developed through 5 stages of EDP which was then broken down into several indicators. From each of these indicators, the EDP assessment rubric is made with a score or ranking from the ranking or I-IV score which will finally categorize the EDP level.

Worksheet in this study was developed through each stage of the Engineering Design Process (EDP). Worksheet is designed as an effort to increase student independence, critical thinking skills, and student creativity. So that when confronted in a global society and can think in EDP terms, it will be easier to compete and produce new products. Question stuffing is an instrument used as a measuring tool to be able to find out the success of research by looking back at students' abilities. In the initial design of this test is given in the form of essays so that students more easily bored in the work on the questions.

One of the considerations in preparing this assessment tool is being able to increase students' interest in learning. For this reason, this test was developed by giving tests in the form of coherent questions like map pad which have been adjusted to the cognitive level of elementary school students. This test

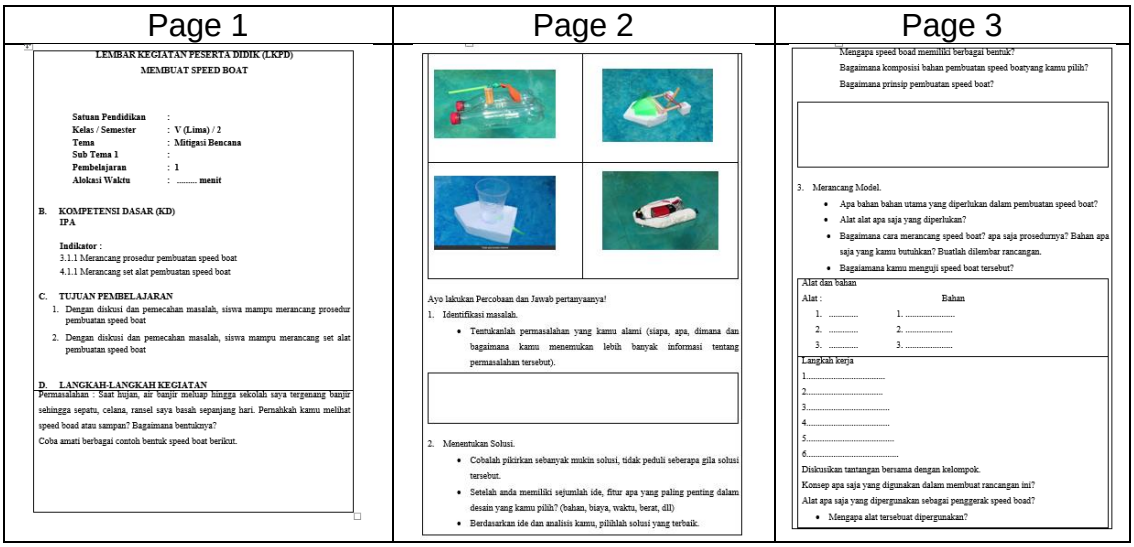
will make it easier for students to solve problems because they are considered more practical and simple. The following are other considerations in developing this instrument

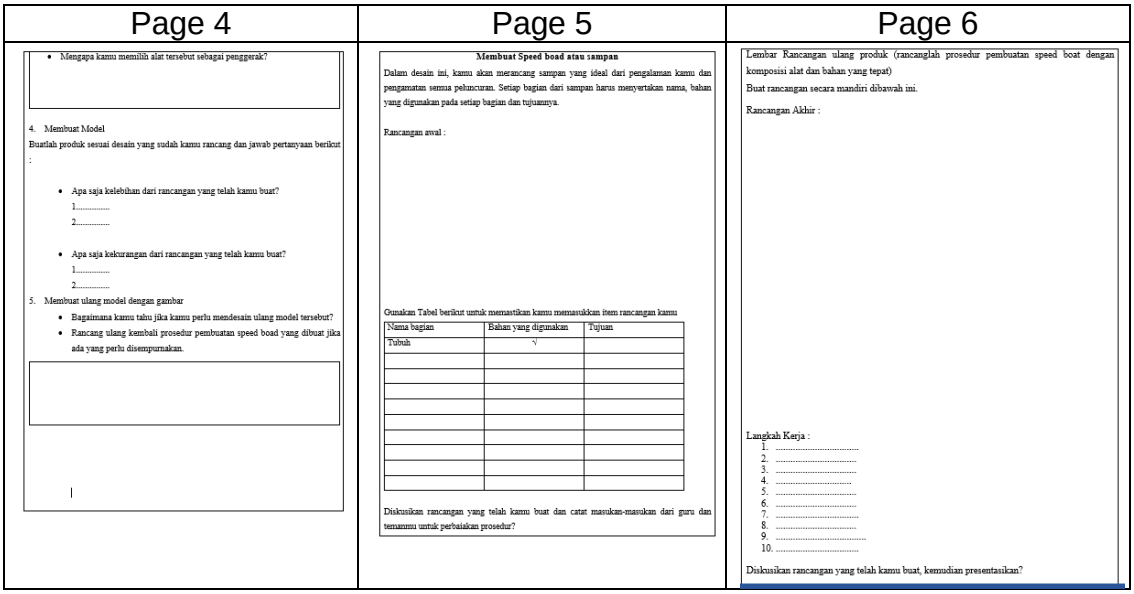
1. Student Activities
Teaching and learning activities become important principles in ongoing activities. Students are not only passive in listening to the teacher but a student must be able to be actively involved and really really in all stages of EDP activities such as identifying problems, determining solutions, designing products, making products to re-making products when needed.

2. The ability of teachers to manage learning
A teacher must be able to master the material, the ability to apply the stages of EDP and how to deliver it is one of the conditions for success or failure of EDP learning. If a teacher is not able to convey the material well, then students will have difficulty making learning less effective.

3. Learning devices
Appropriate EDP learning tools are very important in efforts to achieve learning objectives. Besides this learning device makes it easy for students in learning activities.

The application of EDP in primary schools has a relationship with the characteristics of students themselves. Where elementary school students aged 7-12 years are still in the concrete operational stage, at this stage the child is able to develop logical thinking, but is still limited to concrete objects, and capable of doing conservation. So they show that in the process of thinking they cannot be separated from the concrete world or factual matters. At this stage students are more interested in practical, factual, concrete daily lives. The level of curiosity is higher and they want to learn. They will enjoy working in groups so that the application of EDP should be applied early on





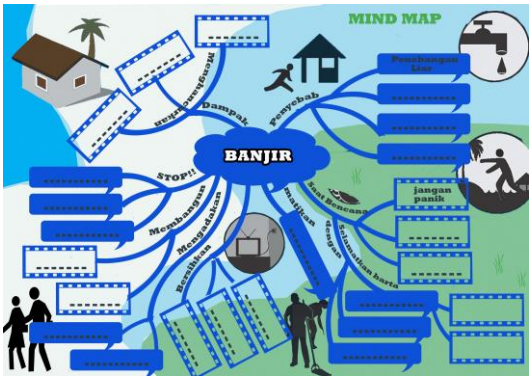


Figure. 1 student worksheet

Rubric

EDP assessment data that have been retrieved are then qualitatively assessed through the design rubric. The EDP rubric used in the EDP assessment was adapted through the research rubric (Crismond and Adams, 2012). Value data that have a scale of 1-4 are then averaged and analyzed with descriptive analysis.

3.4 Implementation

Related to the implementation the results are as follows

1. Identify the problem

Students have been able to identify problems that concern them related to the disaster that occurred. In the problem identification column, students have identified as shown in fig.2

Figure. 2 identify the problem

2. Determine the solution

In this field students have been able to determine solutions in choosing the right tools in solving problems in flood disasters (fig.2)

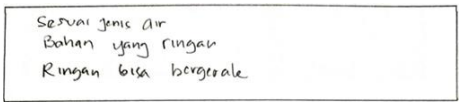


Figure. 3 determine the solution

3. Design a model

Students have been able to design the model well based on the questions asked (fig. 4)

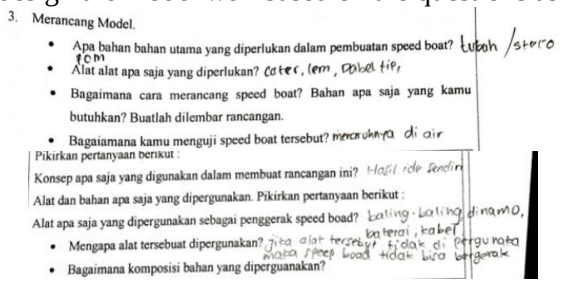


Figure. 4 Design a model

4. Test the design of the model

Students have made the design in the form of simple drawings, but the size does not appear to indicate that there is a scale mark. Likewise students have been able to make their own steps to complete the design they made (fig.5).

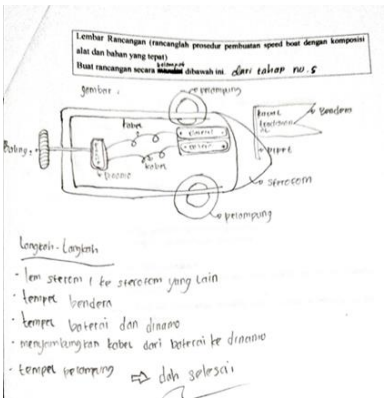


Figure. 5 Test the design of the model

5. Re-create the design model

Students can re-create models that were previously designed, still in the form of illustrated images and better (fig.6).

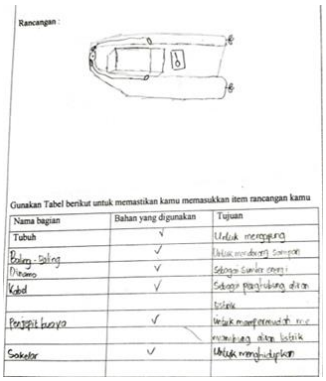


Figure. 6 Re-create the design model

3.5 Evaluation

Following are the results of evaluations from students, the form of evaluation is in the form of mind maps as follows.

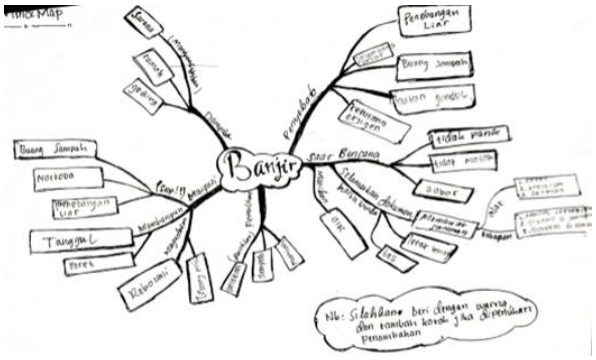


Figure.7 Evaluation

The results show that students have been able to answer all the questions from the mind map created.

4. Conclusion

Based on the analysis data, the Instrument Design Process Assessment Instrument developed can be applied in the learning activities of flood disaster mitigation. Limited test results also indicate that students are able to answer the questions posed well. Overall questions related to EDP have been answered well. This means that this instrument can already be used to measure students' EDP skills.

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