Development of the Engineering Design Process (EDP) on the Ability to Design Prototypes to Increase Natural Disaster Mitigation for Elementary Schools in Indonesia

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***Abstract*—Education is the most essential part in every aspect of providing the quality of human resources. Thus, one of the learning innovations to improve quality, especially for children, is the engineering design process. The engineering design process (EDP) is a set of processes that engineers use to solve an issue. The purpose of this study is to find out the of EDP on design prototypes of the elementary school. The application of knowledge and capability through EDP were also able to develop critical and creative thinking skills so that they can solve problems, collaborate, and communicate. The method adopted in this research is case study. Seventeen elementary students from four different schools in three different cities in province Riau, Indonesia, are selected as participants. Data are collected through interviews and analyzed using a grounded approach. Finding of this study EDP became an ability that could involve students in the learning space and students were also challenged to work collaboratively in groups that were guided by researchers. From the designs made by students, the level of ability to design student prototypes was dominated by the level of the developing stage even to the level of the continuous stage. The findings indicated that the activities using EDP were able to help students to experience real learning and find components that can be used to compound a tool and solve real problems. The findings also indicate the need to reform curriculum for teacher training programs through EDP to include matters like design prototypes.**

***Index Terms*—Ability design prototypes, engineering design process, elementary school**

I. Introduction

Education is an important aspect in efforts to improve the quality of human resources today [1–4]. The implementation of education in learning processes is through the development of various methods and approaches to improve students' skills and knowledge assisted by teachers as facilitators [5, 6]. One of the skills that elementary school students must have today is the ability to think and act effectively and creatively in solving problems to prepare students to face their lives [7–10]. Engineering practices are gaining a strong presence in primary and secondary education [11].

We currently live in the 4.0 generation era in which there has been rapid progress in the aspects of science and technology [12]. Therefore, education should equip students with updated skills to prepare students for a competitive life and to overcome global problems with their knowledge and skills [13]. The student-oriented approach and active learning through the process of observing, asking, reasoning, and trying are needed to increase the creativity of learners [14]. Each individual has the potential to be a creative human being. Creativity is a need for self-realization and is the highest human need. Creativity can be identified and nurtured through proper education. Through creativity, discoveries are possible in the field of science and technology, as well as in all other fields [15, 16].

Students living in the technological age must have the ability to solve problems [17]. The ability to solve this problem can make students wiser in facing and determining solutions to life problems they face [18]. This is certainly a concern for teachers as an important factor in the world of education to create a learning atmosphere that can make students have these abilities [19, 20]. In addition, teachers should provide learning that can foster creative skills, the ability to innovate, the ability to communicate, the ability to collaborate, the ability to think critically, the ability to research and be information literate, and have the concept and operation of technology [21–24].

The most important challenge these days is to focus on the problems frequently faced by the students in their lives. The phenomenon that is frequently happening in Indonesia today is dealing with natural disasters. Natural disasters are becoming an important phenomenon currently because of their implications. With the occurrence of natural disasters, students are required to understand the consequences of natural disasters, and how the right solution to deal with the natural disaster situation [3, 25]. Generally, Indonesian people have a relatively low awareness of disaster mitigation practices. This is reflected in the use of slash-and-burn practice by farmers and companies in clearing land for farming, especially in Sumatra Island, whereas this practice can lead to serious and wide-ranging risks.

In primary school, attention should be paid to how students learn and use engineering vocabulary and grammar, taking into account the student's existing ideas about engineering, various cognitive skills, and intellectual development [11, 26]. Understanding disaster mitigation is one of the essential issues for students to understand [27]. It becomes an inspiration for researchers to contribute to improving students' understanding of disasters. The concept of natural disasters will be easy to understand with the application of EDP (Engineering Design Process) in designing solutions to challenging engineering problems [28].

The development of the EDP model in Indonesia has been investigated in several studies. Syukri *et al.* [29] found that

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the use of EDP in physics teaching and learning module was more effective in increasing the students' skills in solving physics problems compared to the existing module. Another study revealed by Lidinillah *et al.* [30] relates the importance of EDP as an element in the STEM curriculum in elementary school. This is because EDP in elementary education can encourage students to be more aware of their role and presence in society.

The relationship between EDP and natural disaster mitigation was revealed by Sulaeman *et al.* [31] who developed STEM-Based Teaching Materials on global warming. The results show that teaching materials on global warming using EDP in Indonesia are suitable to use and continue to implementation and evaluation stages. However, research that reveals the effectiveness of EDP in increasing understanding of natural disaster mitigation in Indonesia at the elementary school level is still relatively low. This makes the basis for this research to reveal the effectiveness of EDP for elementary school level in Indonesia which can have implications for the development of learning curricula.

The purpose of this research is to determine the efficiency of the engineering design process at the elementary school level, specifically to improve natural disaster mitigation. We expected that using the engineering design process, students would be able to develop their basic framework from the scratch using their existing modality to resolve the problems. The hypothesis in this study is that engineering design processes are positively significant to increasing basic understanding of natural disaster mitigation. We also aimed this study can contribute to the field of education as a learning innovation for elementary school.

II. Theoretical Background

A. Engineering Design Process

Engineering Design Process (EDP) is a learning that uses certain steps and techniques to guide students in solving a given problem [32]. Engineering Design Process (EDP) is a series of steps that guide students to solve a problem [33]. The EDP process is carried out repeatedly as needed, so that students can make improvements to find new designs and arrive at the right solution [34]. The Learning Engineering Design Process (EDP) encourages students to learn from failure so that students have the ability to create innovative solutions in the face of challenges according to concepts that have been understood [35]. In engineering design process (EDP) learning, teachers no longer master learning but only serve to monitor and guide students in the problem solving process [36].

Engineering Design Process (EDP) is a learning system that is expected to stimulate students' problem-solving skills [33]. EDP is the process of designing systems, components, and processes to meet expected learning goals. EDP guides students in designing prototypes as solutions to solving the problems they have analysed. Not only that, EDP also requires students to test the effectiveness and redesign the prototype design as a new, better solution [8, 33, 37]. Through EDP, it will be easier for students in the designing technique processes that include brainstorming ideas, researching, and gathering information to help solve problems, test solutions, and then improve the solutions being made. This solution improvement allows students to face failure thus supports the conception that failure is not a reason to stop but to continuously improve their solution. This ability is highly important as students will be prospective researchers in the future to develop an eligible technology to prevent and control disasters, as well as to have potential in analysing and making designs and policies to anticipate and manage natural disasters in their respective regions. Therefore, they should be considered as a seed of the future agents who need to be trained further regarding the growth of natural disaster awareness and prevention

The development of the project was expected to enhance the students' situational interest. The effect of EDP on students' ability to relate the topic under discussion to the project under development, by students were tasked with building a wind turbine [38].

Science learning must be integrated with engineering design because students can learn two aspects at once, namely science and engineering [39]. Educators are expected to emphasize STEM education through the EDP in learning [40]. The Engineering Design Process (EDP) is a new trend within science education reform [41]. Science teachers lack information about the use of EDP in science learning. One of the developments increasing recently to advance the quality of education is through the EDP (Engineering Design Process) learning approach [42]. Through EDP, students can face future challenges with learner-oriented, open, and constructivist learning. EDP is an inseparable part of STEM (Science, Technology, Engineering, and Mathematics) skills, which a good STEM learning focuses on the process of design engineering (Engineering Design Process) [40, 43–45]. Researchers in science education have worked with researchers in science, technology, engineering, and mathematics (STEM) to investigate the phenomena of identity formation in areas such as mathematics, technology, and engineering [41, 46]. Engineering in STEM learning includes combining the process of problem-solving (thinking), design process, manufacturing process, testing process, and the process of revising a product to solve problems in learning [44]. The implementation of the STEM approach has pervaded various fields and disciplines, especially science education [47]. A model lesson that uses this framework is discussed. Misconceptions regarding the EDP that children have displayed through this lesson and other design challenge lessons are highlighted. Through understanding these misconceptions, teachers can do a better job of helping students understand the system of ideas that helps engineers attack problems in the real world [26].

Some studies have depicted positive benefits for students when the challenges of the design engineering process are incorporated into the basic classroom. In academic literature, it is concerned that students are not ready for the future workforce unless the education system can focus more on STEM education from an early age [48]. Involving students in the STEM curriculum demonstrates how engineers apply scientific, technical, and mathematical knowledge to problem-solving and that an integrated learning approach is a more relevant, less fragmentary, and more stimulating

experience for students [26]. STEM in elementary school is guided by the understanding that engineering represents the application of science and math concepts to make life better [26]. The current primary school education tends to only involve the process of remembering and understanding. Teachers barely provide problem-solving tasks both individually and in groups [28]. Therefore, when students face some problems, they are having difficulties in solving the problems. This can lead to low quality of education. Thus, there needs to be an EDP approach. In this process, students will be directed to examine problems, collect relevant information, produce some solutions, analyse and select solutions, test and implement solutions which are the stages applied to find good resolutions in solving problems.

B. *The Implementation of EDP in Primary Schools*

The application of EDP in primary schools has a relationship with the characteristics of the students themselves. Where elementary school students aged 7-12 years are still in the concrete operational stage, at this stage, children are able to develop logical thinking, but are still limited to concrete objects, and are able to do conservation. So they show that in their thinking process they cannot be separated from the concrete world or things that are facts. At this stage, students are more interested in factual and concrete everyday practical life. Their level of curiosity is higher and they want to learn. They will like to work in groups so the application of EDP from an early age should be implemented. Engineering learning activities provided opportunities for students to engage in real-world learning challenges that allowed them to use their experiences both inside and outside school [11].

The Engineering Design Process EDP has strengths and weaknesses in its implementation. One of the strengths of learning EDP has brought many benefits to students, teachers and more. This statement is supported by several previous studies that stated that the introduction of EDP could increase the participation, interest, and self-image of 274 primary school students [11]. There are some weaknesses in the implementation of The EDP [49]. Teachers still have difficulties in designing scientific learning using EDP. Most educators have difficulty identifying the right projects and stages to implement EDP. Students are also still struggling to understand the relationship between the projects they have developed and the topics studied. Most computing-related research aims to improve student attitudes and skills related to student cognitive abilities. Calculation procedures such as problem definition, information gathering, planning, construction, testing, evaluation, and modification help train students' attitudes and skills. This is because the EDP steps performed for students tend to focus on activities to develop the project. For courses with learning objectives, such as learning concepts (content), authors should have variations in other phases of learning to balance concept evaluation with student-trained attitudes/skills [11].

Student activities factors affect the EDP learning process [50]. The activities of the teaching and learning process become an important principle in the ongoing activities. Students are not only passive in listening to the teacher but a student must be able to be actively and genuinely involved in all stages of EDP activities such as identifying problems, determining solutions, designing products, making products to remaking products when needed [26, 28, 51]. The ability of teachers to manage learning. A teacher must be able to master the material, the ability to apply the EDP stages and the method of delivery are one of the conditions for the success or failure of EDP learning [52]. If a teacher is not able to convey the material well, then students will have difficulty making learning less effective [7]. Appropriate EDP learning tools are very important in an effort to achieve learning objectives. In addition, this learning device provides convenience for students in learning activities [53].

III. Research Methodology

A. *Research Design*

The research method is descriptive qualitative used in research because it involves qualitative data and analysis stage. Qualitative methods for processing data obtained from the field through observations and interview [54–57]. The description design method is used for the purpose of collecting and describing information concerning the current status of phenomena [58].

B. *Participants*

The research was conducted at public elementary schools in Indonesia. The sampling method used is purposive random sampling, with the characteristics of elementary school students in grade 5. The basis for consideration refers to Berk's who found that the developmental tasks of students aged 11-12 years are expected to have creative basic skills in problem solving [59]. Participants who were selected and voluntarily wished to take part in this study had science grades that were at an average level (65 out of 100). The participants involved in the research are presented in Table I.

TABLE I: Participants of the Study

Participants (Initials)	Gender	Age	Sum
AJ, FA, GBMN, US, GTS, AJ, SS, and YAR	Male	11	8
TP, EN, NA, IF, DAP, IEP, MD, NM, and SIW	Female	11	9
Total			17

C. *Data Collection Tools*

The research instrument used was Student Worksheet (LKDP) (Appendix 1). Each step in the given LKDP was developed based on the stages of EDP. When conducting the research, students began the disaster mitigation learning activities through EDP in three meetings. In the first meeting, they were given a problem. At this meeting, students were first provided with a basic notion of the disaster mitigation concept. The given problem was that there was a school that often experienced a flood. At this meeting, the students were asked to identify problems and find solutions to the problems given in the worksheet. In filling out the worksheet, the researcher guided the students. Students were also required to

determine the right solution in addressing the flood problem in this first meeting. The second meeting was to design the appropriate tools and components. Students were required to create a problem-solving tool design that could be used in solving the flood problem. The following meeting was to create and test the tools. After the students designed the tool as a solution to the problems, researchers were capable of knowing the ability of disaster mitigation through the Engineering Design Process.

Questionnaire Instrument. Questionnaire is an instrument used as a measuring tool to be able to determine the success of research by looking back at students' abilities. In the initial design, this test was given in the form of an essay so that students were more easily bored in working on the questions. The Questionnaire Instrument in Table II.

TABLE II: THE QUESTIONNAIRE INSTRUMENT

Steps	Questionnaire
Identify the Problem	a. Name and explain the causes of the flood disaster b. Name and explain the impact of the flood disaster c. Make a brief description of the flood events that you have experienced
Determine the solution	a. In the event of a flood disaster, what actions can you take? b. What is the appropriate way to deal with the flood disaster?
Design a Model	a. When a flood disaster occurs, your shoes and backpack get wet with water, how do you react to this condition? b. What are the simple basic principles in your model?
Make a Model	a. Try to describe the tools and materials as well as the stages of making the model you made b. Describe the purpose of making the model using the material you choose.
Recreate a Model	How do you know if you need to redesign the product?

D. Data Collection

This study's data is based on an evaluation of three planned sessions. Each meeting is structured around the steps outlined in the questionnaire instrument. The data collected in the first step pertains to the level of problem identification and resolution. The data collected in the second step reveals the level of design abilities required to address the challenge. Finally, the data collected is information regarding the participants' abilities to redesign the designs that have been created. Each piece of data is collected in the form of a worksheet and will be analysed and evaluated as it progresses through stages.

E. Data Analysis

The data obtained was analysed using Miles' and Huberman' qualitative data analysis technique consisting of three stages, which were data reduction, data presentation, and conclusion/verification drawing stages [60]. The learning and teaching design matrix was adapted and applied in this research to categorize the capabilities observed through the Engineering Design Process. The matrix consisted of five stages: identifying problems, determining solutions, designing a product, creating and recreating the product. The students' Engineering Design Process rubric by Crismond and Adams was adapted to match the Engineering Design Process indicators observed during the learning process through the EDP listed in the rubric. The EDP assessment data that has been taken is then qualified through the engineering design process (EDP) assessment rubric. The rubric used in assessing the engineering design process capability is adapted through a research rubric [61]. The ideas in this study focus on 5 stages of EDP. Value data that has a scale of 1-4 are then averaged, analysed and discussed with descriptions. Each indicator was rated from 1 to 4 which each scale represented an EDP capability category. The EDP rubric for the categories of designing products is presented in the Table III.

TABLE III: EDP ASSESSMENT RUBRIC (DESIGNING PRODUCTS)

Categories	Level 1	Level 2	Level 3	Level 4
Identifying problems	Not able to define the problem properly.	Less able to define the problem properly.	Almost able to define the problem properly.	Able to define the problem properly.
	Too hasty in solving problems without being able to understand the problem.	Able to solve problems with an effort to understand the problem.	Able to solve problems with adequate understanding.	Able to solve problems with good understanding.
Determining Solutions	Do not identify problems to determine solution.	Start to simply identify problems to determine solution.	Able to identify problems well to determine solution.	Able to identify problems well to find solution and collect information regarding the solution effectivity.
	Believe there is only one solution to solve a problem without any prior identification.	Believe there is more than one solution to solve a problem without any prior identification.	Believe there is more than one solution to solve a problem with prior identification.	Believe there is more than one solution to solve a problem with any prior identification and discussion.
Designing Models	Propose ideas without designing or describing models.	Propose ideas by only using words.	Propose ideas with words and describing models.	Propose ideas by using words, drawings, and procedures.
Creating Models	Do not prepare tools and materials in making products.	Prepare tools and materials less than 50%.	Prepare tools and materials quite completely: 50% or more, but not more than 100%.	Prepare tools and materials in 100% (complete) from required.

	Do not create the product according to the design.	Create the product according to the design, but less exact.	Create the product which is quite in line with the design.	Create the product based on the design.
	Do not test the product whether it works or not.	Test the product whether it works, but the subject is not able to assess the effectivity.	Test the product whether it works and the subject is able to assess the effectivity.	Test the product whether it works, and the subject is able to assess the effectivity and also how to make the product better.
Re-creating Models	Unable to provide an explanation regarding why the problem occurs so the product has to be re-created.	Provide a less in-depth explanation regarding why the problem occurs so the product has to be re-created.	Provide a quite in-depth explanation regarding why the problem occurs so the product has to be re-created.	Provide an in-depth explanation regarding why the problem occurs so the product has to be re-created.
	Does not suggest ways to solve problems.	Suggest less effective ways to solve problems.	Suggest quite effective ways to solve problems.	Suggest effective ways to solve problems.

IV. Findings

The findings of EDP stage is integrated into the LKDP which is given in three meetings.

A. First Meeting

The LKPD stage at the first meeting, students were first given a basic understanding of the concept of flood disaster mitigation. The concept of flood disaster mitigation is given to schools that often experience flooding during the rainy season. At this meeting, students are asked to identify and search for solutions to the problems provided in the worksheet.

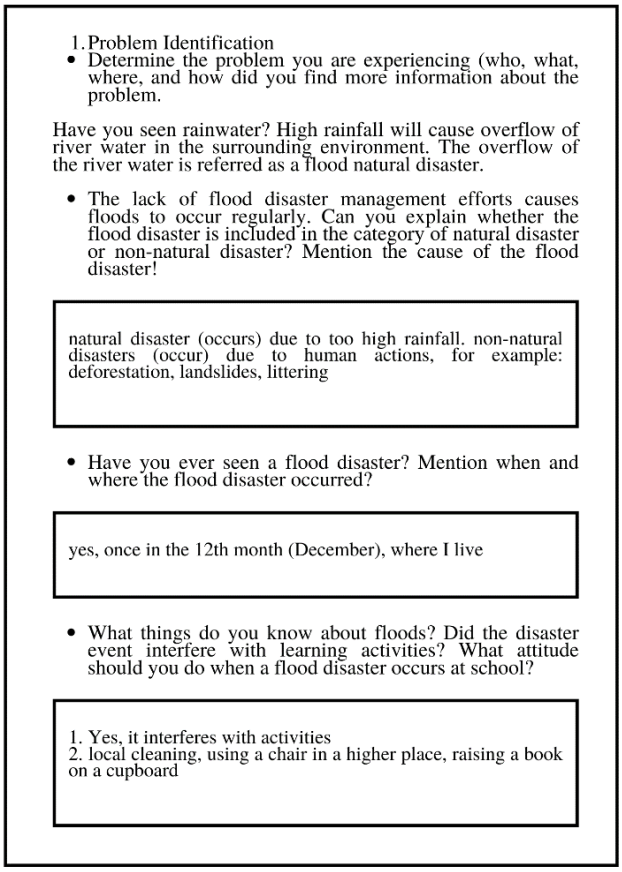
At the stage of identifying problems, students are classified as having the stage 3 (developing) and 4 (advanced) ability to identify flood disasters (see Table IV). In the third and fourth stages, with the help of image media and pop-up, students can better define the problems. Students can solve problems with a good understanding and believe there is more than one solution to solve problems with a prior identification.

TABLE IV: Fifth-Grade Pelalawan Students' Ability to Identify Problems

Levels	Categories	Number of Students
1	Beginner Stage	-
2	Upper Beginner Stage	-
3	Developing Stage	5
4	Advanced Stage	12

Here is the students' filled worksheet in the category of identifying problems can be seen following Fig. 1.

At the stage of determining solutions, students are classified as having the stage 3 (developing) ability to determine the solution to flood disasters (see Table V). In terms of determining solutions, students can do a further study of the problem so that they can provide solutions from the given reading materials. Students believe that there is more than one solution to solve the problems with the prior identification by filling out the mind map related to flood disaster mitigation.


1. Problem Identification
- Determine the problem you are experiencing (who, what, where, and how did you find more information about the problem.

Have you seen rainwater? High rainfall will cause overflow of river water in the surrounding environment. The overflow of the river water is referred as a flood natural disaster.

- The lack of flood disaster management efforts causes floods to occur regularly. Can you explain whether the flood disaster is included in the category of natural disaster or non-natural disaster? Mention the cause of the flood disaster!

natural disaster (occurs) due to too high rainfall. non-natural disasters (occur) due to human actions, for example: deforestation, landslides, littering

- Have you ever seen a flood disaster? Mention when and where the flood disaster occurred?

yes, once in the 12th month (December), where I live

- What things do you know about floods? Did the disaster event interfere with learning activities? What attitude should you do when a flood disaster occurs at school?

1. Yes, it interferes with activities
2. local cleaning, using a chair in a higher place, raising a book on a cupboard

Fig. 1. Identifying problems (translated).

TABLE V: Fifth-Grade Pelalawan Students' Ability to Determine Solutions

Levels	Categories	Number of Students
1	Beginner Stage	-
2	Upper Beginner Stage	-
3	Developing Stage	17
4	Advanced Stage	-

Here is the worksheet in the category of determining the solutions can be seen following Fig. 2 and Fig. 3.

2. Mapping Solutions
Discuss and write down the impacts and solutions of the flood disaster into the following mind map:
Student' answers (restructured):

The impact of the flood can destroy (*dampak*):
- plant
- Street
- house

Cause of the flood (*penyebab*):
- illegal logging
- Avalanche
- littering
- clogging the sewer

Stop the flood with:
- no more littering
- clean shower
- don't be dirty

Prevent flooding by building (*membangun*):
- embankment
- dam

When a flood occurs, must hold (*mengadakan*):
- shelter
- medicine

Cleaning up the flood with (*bersihkan*):
- drain
- school
- house

When a flood occurs, turn off (*matikan*):
- electricity

When disaster occurs:
- do not panic
- don't bathe in dirty water
- don't just throw trash

when the flood, save property with:
- Speed boat (using dinamo and engine)
- canoe
- car

Fig. 2. Mapping solutions.

B. Second Meeting

The LKPD stage at the second meeting, students are asked to design appropriate tools to be used in solving flood problems.

At the stage of designing the product, students are asked to design solutions to the existing problems. This study found that most of the students are in the advanced stage with 70%, and 30% of students are in the developing category (see Table VI). Out of 17 students, 12 students design the model well, and 5 students design the model without considering the procedure. This indicates that the ability of disaster mitigation has been able to result in the Engineering Design Process, namely in the product design category. At this stage, students are trained to be able to compare the original model with the design having been created and whether the design can be created into a model. This ability has creative and innovative impacts on the students. This ability must be improved so the students have the capabilities to encounter the issues that exist in society.

At the beginning of this meeting, the researcher first greeted the students. The researcher asked the students' condition and readiness to learn, and the researcher conveyed the learning objectives. Next, the researcher asked about whether they had seen objects such as boats during flood evacuations, where they had seen them, and which main component was driving the boats. The learning process was carried out in accordance with the designed lesson plan. The core activity was conducted by organizing students to sit in predetermined groups. Next, the researcher gave the worksheet in the form of a design sheet and each of them had to draw a boat design on the provided design sheet. When students were not able to express their ideas to design and write down each component of the boat, the researcher asked students to observe the designed drawings. The student must observe what components were required from the boat design and described them on the design sheet. When doing observation, the researcher found that all students began to make different boat designs. Here is a sample of a student's design can be seen following Fig. 4.

Visiting Uncle's House in Town

Dodi went to his uncle's house in a big city with his father. Uncle's house is around the river. But unfortunately, the river in the city overflowed so that in interfered with the access road to uncle's house, said the father "uncle;s house, Dad?", Father replied while stroking Dodi's head "calm down, uncle;s house has been made high so it won't be flooeded, son."

Father said, because of the flood disaster, Dodi and Dad finally boarded a speedboat for the next trip. Actually, Dodi did not want to continue his journey to uncle's house which was flooded. However, Dodi was curious to take a speedboat that he had never been on before. Everyone who goes to the city chooses to use the help of a speedboat to get to their destination quickly. Father gave advice to Dodi to keep the forest preservation. There are many cases, such as forest fires, massive illegal logging that is carried out intentionally to exploit these forest resources which has resulted in several forest areas being deforested. So that it will lead to natural disasters such as floods experienced by Uncle's city. Dodi now understands the importance of preserving the forest. They promised to always keep the forest conservation.

1. What causes the road access to uncle's house to be blocked ?
Hit by a flood
2. How do Dodi and dad get to uncle's house quickly ?
Using speedboat
3. What is Dodi's father's advice ?
To maintain the sustainability of the forest

Have you ever seen a spped boat? What the shape ? Take a look at the various examples of the following speed boat shapes.

- Is the solution using a speed boat important in dealing with flood disasters?

Important because if there is no speed boat, you can't carry goods

- Observe the speedboat above, is there a difference?what makes each speedboat different?

Yes, the difference is: the first speedboat has a sail from end to end, the second speedboat has one sail, the third speedboat has a sail in front, the fourth speedboat has no sail, the fifth speedboat has a pentagon shape, the sixth speedboat has a long triangle shape, the seventh speedboat has no roof, the eighth speedboat round shape

- Try to think of as many solutions as possible. What kind of energy is used in each speed boat ? and what are the most important components in the design you choose?

There's a sail, a dynamo and a paddle

Fig. 3. Determining solutions (translated).

TABLE VI: FIFTH-GRADE PELALAWAN STUDENTS' ABILITY TO DESIGN A BOAT

Levels	Categories	Number of Students
1	Beginner Stage	-
2	Upper Beginner Stage	-
3	Developing Stage	5
4	Advanced Stage	12

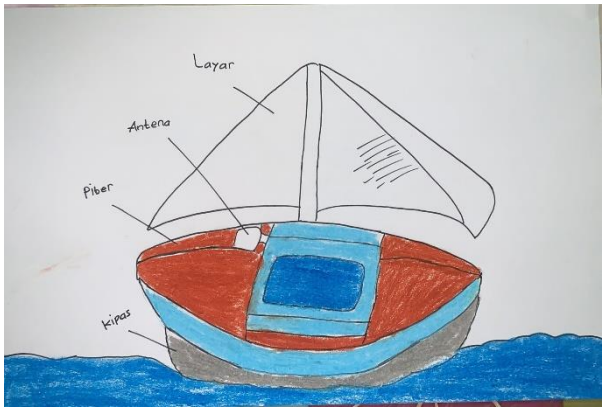


Fig. 4. A students' design sample of the developing category (translate notes: *layar* means sails, *antena* means antenna, *piber* means fiber, *kayu* means log).

Fig. 4 shows a sample of a student's design with a score of 3. The design was given a value of 3 because students proposed ideas with a drawing but it was not supported by how the tool could work.

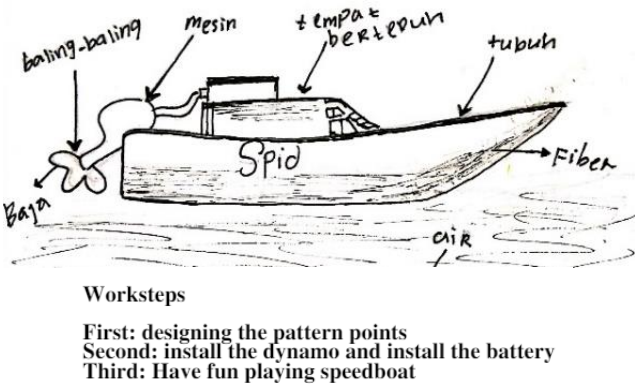


Fig. 5. An advanced-stage students' design sample (translation notes: *baja* means steel, *baling-baling* means propeller, *mesin* means engineering, *tempat berteduh* means shelter, *tubuh* means body, *fiber* means cable, *air* means water).

Fig. 5 shows an example of an advanced-stage student's design. The design was given a value of 4 because there was a machine with a dynamo and a cable that was made to explain how the system worked, and the given ideas would work if they were stated and there was a step-by-step description of how they operated. Based on the following design sheet, the groups began to make different designs, proposed ideas by drawing, writing words, and also descriptions of each component. Researchers also observed that they drew the designs based on their experiences with real objects. Having this capability through EDP can help them develop a deeper understanding of their design functions and aims.

C. Third Meeting

The LKPD stage at the third meeting, students are asked to create and test the tools that have been designed. After testing and assessing the effectiveness of the boat made, students then recreate the design of the new boat. The design of the new boat is poured by students in the worksheet provided, this design is made in order to improve the boat after evaluation.

In the boat creation stage, it showed that the 17 fifth-grade students of Pelalawan Elementary School were classified as having the stage 3 and 4 ability to create flood disaster boats (see Table VII), and boats created can be seen on Fig. 6. Based on the design sheet, these groups began to prepare quite complete tools and materials and created boats that were quite suitable in accordance with the plans formulated at the previous meeting. In addition, these students tested the boat whether the created boat could operate and they were able to assess the effectiveness of the boat.

TABLE VII: FIFTH-GRADE PELALAWAN STUDENTS' ABILITY TO CREATE A BOAT

Levels	Categories	Number of Students
1	Beginner Stage	-
2	Upper Beginner Stage	-
3	Developing Stage	5
4	Advanced Stage	12

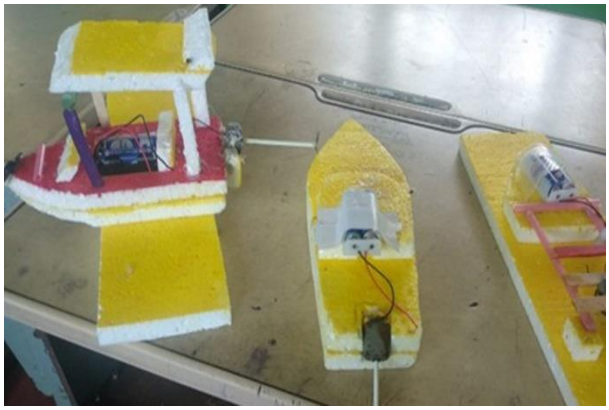


Fig. 6. Creating boats.

Furthermore, after these students assessed the effectiveness of the created boat, these students were asked to re-create a drawing of the new boat design along with the components and reasons why the design was different from the previous one on the design worksheet. Based on the design worksheet from one of the groups, this group wrote that they re-created the design because the previously created boat could not operate optimally. They reasoned that the propeller that they created was upside down. Based on this situation, the researcher concluded that students were familiar with the objects due to the experiences they had.

TABLE VIII: FIFTH-GRADE PELALAWAN STUDENTS' ABILITY TO RE-CREATE A BOAT

Levels	Categories	Number of Students
1	Beginner Stage	-
2	Upper Beginner Stage	12
3	Developing Stage	5
4	Advanced Stage	-

Based on the following design sheet, one of the groups provided a fairly in-depth explanation of why the problem occurred so that the product must be re-created and they drew a new design that was quite effective in solving the problem. Meanwhile, the other group gave a less in-depth explanation and the components of the new re-created drawing were incomplete. Recreating the boat with drawings can be seen following Fig. 7.

V. Discussion

The Engineering Design Process (EDP) is a new trend in science learning reform [62–64]. Through EDP, students can have good problem-solving skills that are useful for dealing with problems in their lives. EDP delivers a student-oriented, open, and constructivist learning [65]. In EDP, students are directed to be able to define problems, gather information, plan and evaluate solutions to obtain the best results. Engineering Design Process (EDP) is a learning process based on the power of designing solutions in solving problems [33]. The Learning Engineering Design Process (EDP) requires students to be able to critically analyse problems and design appropriate solutions. In Engineering Design Process (EDP) learning, students are required to conduct the learning process independently and teachers are only tasked with guiding students.

Some studies that apply EDP have benefited positively for students. Among them, research conducted by [66], found that the Engineering Design Process (EDP) conducted in the form of Tech for Kids (TFK) training activities can increase knowledge, mastery of technology, foster broad thinking skills, increase students' desire when learning, and increase student achievement in school. [67] also conducted research on Agriscience-based EDP learning models with STEM approaches. Based on the results of his research, it was found that this learning model had a significant effect in improving students' HOTS [68].

In this study, there is a significant development towards the process of engineering design on the understanding of disaster mitigation. In the first meeting, the participants seem to had the ability of identify the problems in the developing stage and advanced stage -mostly advanced stage, and the determining solutions seem in developing stage. In the second meeting, the participants seem to had the ability of design a "boat" (as the resolution of the problems) in the developing stage and advanced stage. Mostly of them were in the advanced stage. It became consistent until the third meeting when they need to re-create the "boat". When they were creating a boat, they were in developing stage and advanced stage. But when they asked to re-create the boat, it seem the ability went down to upper beginner stage and developing stage, and most of them were in the lesser level.

We presumed that the dynamics that happened in this study were caused by the activities and the environment. The participants that went down to a lower level gave a less in-depth explanation, and the components of the new re-created drawing were incomplete. Thus, to make the students more creative and have the ability to solve problems, they need to focus on the goal and give more attention to the contents [7, 64]. And for the environment, this is similar to Larsen's study [50]. In Larsen's [50], the learning environment supports a positive effect on students' understanding and usage of the Engineering Design Process. Therefore, it is not only the students' attention but also the environment that supports the activities. Additionally, if those factors were combined properly, it would not only improve the understanding of the contents, but also the self-regulation and the level of determination. The proper use of the EDP stage can lead the students to have more self-determination in solving problems. It can affect students' ability to have a positive way of thinking and acting and also to make realistic choices so they can make a decision responsibly [69, 70]. In this context, the students are not only learning about disaster mitigation but also the determination to solve the problems by imagining if the real problems happened at any time.

VI. Conclusion

With the ability to design prototypes on disaster mitigation using EDP, researchers draw conclusions to answer the research questions. This study found that the activities using EDP were effective to help students to experience real learning and find components to solve natural disaster mitigation. In the aspect of identifying problems, determining solutions, designing, and creating prototypes, students are in the developing stage, and even most of the are in advanced stage. However, when it came to the last stage, which is re-creating prototypes with drawings, some students are went down to lower level than the previous stage. It can be concluded that students are fairly good at proposing ideas by designing boats using words, but lack of redesigning because some students do not write the step-by-step on the design sheet.

The researchers hope that this study can provide students with a better understanding of disaster mitigation and also improve the students' skills and lead them to be more active in producing solutions to solve problems in their environment. Teaching topics about simple machines such as boat with a design-based method enhances students' achievement and creative attitude without compromising their attitude towards the topic as they construct new knowledge through each step of the process appropriately. There needs to be an improvement in the learning implementation process through EDP which it is recommended that each activity is conducted individually. It is to better to identify the students' problem-solving design ability with the use of EDP in further studies. To the researchers, this recommendation can be a reference for further research related to disaster mitigation capabilities.

Appendix

Appendix 1.

STUDENT ACTIVITY SHEET

HOW TO MAKE A SPEEDBOAT

School : SDN 011 Sering Barat Pelalawan

Grade : 5th

Theme: Disaster mitigation

Learning : 1

B. BASIC COMPETENCIES
SCIENCE

Indicator :
3.1.1 Designing a speed boat manufacturing procedure

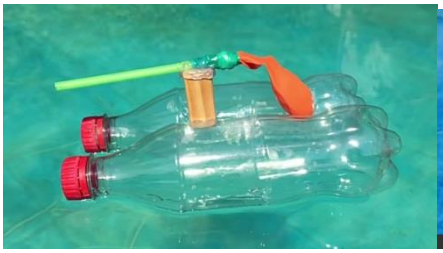
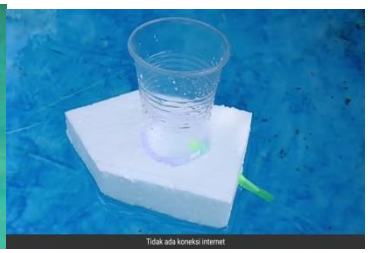
C.1.1 Designing a set of tools for making speed boats

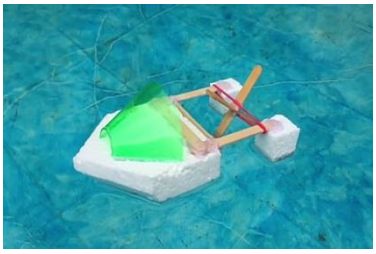
C. GOALS

1. With discussion and problem solving, students are able to design procedures for making speed boats
2. With discussion and problem solving, students are able to design a set of tools for making speed boats

D. ACTIVITY STEPS

Problem: When it rains, flood water overflows until my school is flooded so that my shoes, pants, backpack are wet all day long. Have you ever seen a speed boad or canoe? What is the shape? Take a look at the various examples of the following speed boat shapes.



Let's do the experiment and answer the questions!

1. Identify the problem
   - Determine the problem you are experiencing (who, what, where and how did you find more information about the problem).
2. Determine the Solution
   - Try to think of as many solutions as possible, no matter how crazy they may seem.
   - Once you have some ideas, what are the most important features in your chosen design? (material, cost, time, weight, etc.)
   - Based on your ideas and analysis, choose the best solution.
   - Why do speed bodies have different shapes?
   - What is the composition of the material for making the speed boat that you chose?

   What is the principle of making a speed boat?

3. Designing Models
   - What are the main materials needed to make a speed boat?
   - What tools are needed?
   - How to design a speed boat? what are the procedures? What materials do you need? Make a plan sheet.
   - How did you test the speed boat?

Tools and Materials

Tools : Materials

1. ..... 1. .....
2. ..... 2. .....
3. ..... 3. .....

Work steps :

1.....
2.....
3.....
4.....
5.....
6.....

Discuss the challenges together with the group.

What concepts were used in making this design?

What tools are used to drive the speed board?

- Why is the tool used?
- Why did you choose this tool as a driver?

4. Make a Model

Make a product according to the design you have designed and answer the following questions:

- What are the advantages of the design that you have made?

  1.....

  2.....

- What are the shortcomings of the plan that you have made?

  1.....

  2.....

5. Recreate the model with pictures

- How do you know if you need to redesign the model?
- Redesign the procedure for making the speed board that is made if there is something that needs to be improved.

Make a Speedboat

In this design, you will design the ideal canoe from your experience and observations of all launches. Each section of the canoe must include its name, the materials used in each section and its purpose.

Initial design:

Use the following table to make sure you include your design items

Part Name	Materials used	Goal

The bodies	√	

Discuss the design that you have made and note the inputs from the teacher and your friends for the improvement of the procedure?

Product redesign sheet (design the procedure for making a speed boat with the right composition of tools and materials)

Make an independent design below.

Final Design:
Work steps :

1. .....
2. .....
3. .....
4. .....
5. .....
6. .....
7. .....
8. .....
9. .....
10. .....

Discuss the design you have made, then present it?

Appendix 2

Questionnaire is an instrument used as a measuring tool to be able to determine the success of research by looking back at students' abilities. In the initial design, this test was given in the form of an essay so that students were more easily bored in working on the questions.

Stages of the EDP process	Question items
Identify the problem	• Name and explain the causes of the flood disaster • Name and explain the impact of the flood disaster • Make a brief description of the flood events that you have experienced
Determine the solution	• In the event of a flood disaster, what actions can you take? • What is the appropriate way to deal with the flood disaster?
Design a Model	• When a flood disaster occurs, your shoes and backpack get wet with water, how do you react to this condition? • What are the simple basic principles in your model?
Make a Model	• Try to describe the tools and materials as well as the stages of making the model you made • Describe the purpose of making the model using the material you choose.
Recreate a Model	• How do you know if you need to redesign the product?

Currently, education should be able to increase student interest in learning. For this reason, this test was developed

by giving tests in the form of coherent questions such as map pads that have been adapted to the cognitive level of elementary school students. This test will make it easier for students to solve problems because it is considered more practical and simple.

Rubric

The EDP assessment data that has been taken is then qualified through the engineering design process (EDP) assessment rubric. The rubric used in assessing the engineering design process capability is adapted through a research rubric (crismond and adams, 2012). The ideas in this study focus on 5 stages of EDP. Value data that has a scale of 1-4 are then averaged, analyzed and discussed with descriptions.

What factors affect the EDP learning process

1. Student Activities

The activities of the teaching and learning process become an important principle in the ongoing activities. Students are not only passive in listening to the teacher but a student must be able to be actively and genuinely involved in all stages of EDP activities such as identifying problems, determining solutions, designing products, making products to remaking 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 EDP stages and the method of delivery are one of the conditions for the 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 tools

Appropriate EDP learning tools are very important in an effort to achieve learning objectives. In addition, this learning device provides convenience for students in learning activities.

The application of EDP in primary schools has a relationship with the characteristics of the students themselves. Where elementary school students aged 7-12 years are still in the concrete operational stage, at this stage children are able to develop logical thinking, but are still limited to concrete objects, and are able to do conservation. So they show that in their thinking process they cannot be separated from the concrete world or things that are facts. At this stage students are more interested in factual and concrete everyday practical life. Their level of curiosity is higher and they want to learn. They will like to work in groups so the application of EDP from an early age should be implemented.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Putra, Mahdum & Mukaromah constructed the framework and theoretical background of the research. Ayub & Syaflita managed the administration affairs and conducted the experimental research and it was supervised by Mahdum, Putra, & Mukaromah. Suryana managed to proofreading the article's draft. All authors had approved the final version of the paper.

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