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## Analysis of Engineering Design Process (EDP) Skills Through the Application of STEM-PJBL Based LKPD for High School Students on Archimedes Law Material

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### ABSTRACT (9 pt)

**Keywords:**

Archimedes' Law  
EDP  
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*Engineering Design Process (EDP) skills are one of the skills that students must have in the 21st century. Engineering is one of the components that has an important role in training students related to the skill of designing solutions to life's problems. However, the facts show that there is still a lack of learning in schools that train and teach Engineering Design Process (EDP) skills that should be part of the physics learning process. The purpose of this study is to analyze Engineering Design Process (EDP) skills through the application of STEM-PjBL-based LKPD to Archimedes Law material. The research design used is a case study research design with research stages consisting of problem identification, literature search, determination of research objectives, data collection, data analysis and interpretation, and finally reporting. The results of the study show that EDP skills in the indicator of gathering pertinent information are categorized as good, while defining the problem, generating multiple solutions, analyzing and selecting a solution, and test and implement the solution are in the very good category. Based on the results of the research, it can be concluded that most of the Engineering Design Process (EDP) skills possessed by students are good.*

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### INTRODUCTION

The 21st century is a century with highly advanced technological developments. The adaptation process in the 21st century can be complemented by several skills that are very useful in the 21st century, including: critical thinking and problem-solving skills, communication skills, collaboration, creativity, and the ability to innovate. All of these skills can be acquired, one of which is through the learning process s (Aslamiah, et al., 2021). One of the must-have skills in the 21st century is the Engineering Design Process (EDP) skill, the EDP skill is a process that involves decision-making, done repeatedly by applying the concepts of science, mathematics, and design engineering to find alternative problem-solving in the form of solutions to achieve certain goals (Ulum M.B, et al., 2021).

EDP skills in education are in line with the function and purpose of science learning, which is able to improve students' scientific attitudes through a practical and scientific learning process goals (Ulum M. B, et al., 2021). EDP skills can be trained through science learning, developing countries are expected to be able to implement science learning that supports EDP skills (Nanang W et al., 2020). EDP skills are considered as a learning strategy that connects science and mathematics in addition to being able to overcome problems, cultivate creative thinking skills, formulate solutions and make decisions by considering alternative solutions to meet the obstacles and limitations faced (Xiangying X, et al., 2023). However, research conducted by (Nanang

W, et al., 2020) states that EDP skills are still applied minimally in secondary schools. The results of observations conducted in one of the schools in Bondowoso Regency show that EDP skills in high school have not been applied optimally. Research conducted by (Sophie A M McNair and Samantha J Hayward, 2023) states the importance of Engineering Design Process (EDP) skills applied at the secondary school level regardless of the interests and subjects studied.

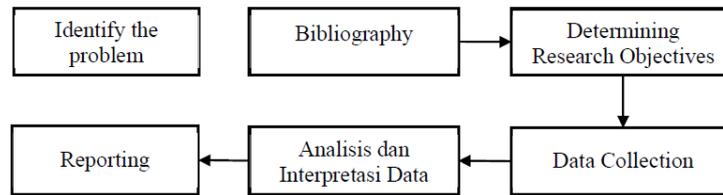
EDP skills can be trained using STEM-PjBL-based learning. STEM consists of four disciplines, namely Science, Technology, Engineering and Math. Learning that is integrated with STEM is able to train students in solving problems more thoroughly and completely (Tri Mulyani, 2019). PjBL learning that is integrated with STEM causes students to be more active in the learning process, so that students are able to recognize more deeply related to their knowledge. Research conducted by (S Sulista, et al., 2019) that STEM learning can be used as an alternative to learning that involves engineering design process skills to meet the demands of 21st century skills. Therefore, the application of STEM-PjBL-based learning is considered suitable for analyzing EDP skills because in STEM-PjBL learning the orientation is ultimately in the form of project engineering or design.

Research conducted by (Kurniahtunnisa, et al., 2023) shows that the STEM-PjBL learning model is highly effective in improving 21st century skills. This is also explained by stating that engineering design process skills can be developed using the STEM integrated PjBL learning model with the category of engineering skills owned by students, which is categorized as good. STEM-based learning is able to improve students' engineering skills. STEM learning has a positive impact on the engineering process by involving students so that students are able to develop their engineering skills (A N Rusmana, et al., 2021). Based on the description above and considering the importance of EDP skills in the world of education in the 21st century, it is necessary to apply STEM-PjBL in learning to train EDP skills. The purpose of this study is to analyze engineering design process skills through the application of STEM-PjBL based LKPD of high school students to Archimedes' Law material.

## **RESEARCH METHOD**

This research is a type of qualitative descriptive research. The research design used in this study is the case study research design (Jhon W.C and J. David C, 2018). The case study in this study is the lack of Engineering Design Process (EDP) skills possessed by students. The location of this research is in one of the high schools in Bondowoso Regency, namely SMAN Tamanan which was held in the even semester of 2024 or 2025. This study used one of the XI classes of SMAN Tamanan, which was selected using the Purposive Sampling technique, namely class XI C consisting of 32 students. This research sample was selected based on the considerations of the physics teacher of SMAN Tamanan, namely that the class is relevant for carrying out STEM-PjBL learning because the class has never applied project-based learning. In addition, Engineering Design Process (EDP) skills have never been trained to students, so this urgency is the focus and goal of this research. This study uses research steps in accordance with (Jhon

W.C and J. David C, 2018), namely there are six stages of qualitative research presented in Figure 1



**Figure 1.** Research Procedure

The data collection techniques according to (Sugiyono, 2017) are: first, documentation, in the form of photos and videos during learning, and student work in the form of LKPD. Second, interviews, the type of interview used is structured interviews. Interviews in this study were conducted to students before the research and to teachers after the research. Third, observation, observation activities are carried out, namely observation of student activities to determine Engineering Design Process (EDP) skills based on EDP indicators. The observation activity involved five observers and each observer held an observation sheet.

The data analysis method used in this study is a data analysis technique according to Mile and Huberman, namely the data analysis process is carried out interactively and continuously until the analyzed data is saturated (Sugiyono, 2017). The steps for data analysis are as follows. First, data collection is carried out by documentation, interviews, and observations. Second, data reduction, the same findings in the three data will be classified or categorized into patterns. All data sources that have been detailed will then be selected and selected, data that does not focus on Engineering Design Process (EDP) skills will be discarded. Fourth, the presentation of data, the results of data reduction of documentation, interviews, and observations are presented in the form of narrative texts supported by relevant literature. Finally, drawing conclusions and verification, after the data is presented in the form of a narrative, new credible findings will emerge. These findings can be in the form of descriptions or descriptions of problems related to students' EDP skills that were previously not visible.

## RESULTS AND DISCUSSION

This study aims to analyze Engineering Design Process (EDP) skills through the application of STEM-PjBL-based LKPD in Archimedes Law material. The learning process includes five stages of STEM-PjBL learning, namely reflection, research, discovery, application, and communication. The data of this study is the result of observation of Engineering Design Process (EDP) skills in the form of observation sheets and student worksheets (LKPD). Engineering Design Process (EDP) skills consist of five indicators, namely: define the problem, gather pertinent information, generate multiple solutions, analyze and select a solution, and test and implement the solution. Data from research observations conducted on 32 students are presented in Table 1

**Table 1.** Data on the Observation of Engineering Design Process Skills (EDP)

Engineering Design Process (EDP) Skill Indicator	Number of Students (%)			
	Very Less	Less	Good	Very Good
<i>Define the problem</i>	3,13	12,50	43,75	40,63
<i>Gather pertinent information</i>	0	15,63	43,75	40,63
<i>Generate multiple solutions</i>	0	12,50	53,13	34,38
<i>Analyze and select a solution</i>	0	15,63	43,75	40,63
<i>Test and implement the solution</i>	0	9,38	46,88	43,75

Based on Table 1 shows that most students have good and excellent EDP skills. EDP skills in each indicator meet the category of good and consistently excel, this is shown in the generate multiple solutions indicator with a total of 87.51% and test and implement solution indicators with a total of 90.63%. The EDP skills of students who show a category are very lacking, i.e. very low in almost all indicators. The data on the results of the student worksheet (LKPD) consisting of six groups is presented in Table 2

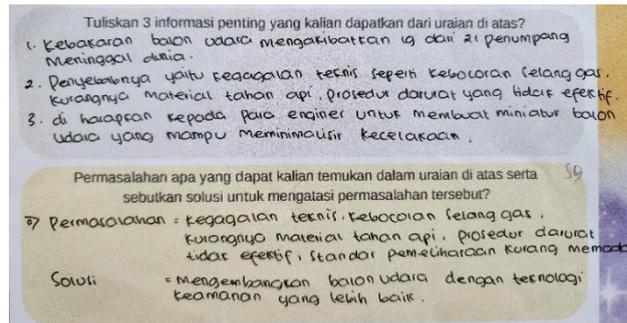
**Table 2.** Data on the Results of Assessment of LKPD Students by Group

Engineering Design Process (EDP) Skill Indicator	Number of Groups (%)			
	Very Less	Less	Good	Very Good
<i>Define the problem</i>	0	0	25,00	75,00
<i>Gather pertinent information</i>	0	66,67	0	33,33
<i>Generate multiple solutions</i>	4,17	16,67	16,67	62,50
<i>Analyze and select a solution</i>	5,56	0	22,22	72,22
<i>Test and implement the solution</i>	4,17	4,17	27,08	64,58

Table 2 shows that the EDP skills reviewed from the LKPD work meet the category of excellent in almost all indicators. However, there was a very significant difference seen in the gather pertinent information indicator which showed that 66.67% of groups were categorized as poor and no group was categorized as good, this suggests that information collection is a significant challenge. Meanwhile, the indicators Define the problem, Gather pertinent information, Generate multiple solutions, and Test and implement the solution showed a very positive trend, with the majority of groups in the good and very good categories. The very poor category showed a very low percentage across all indicators (maximum 5.56%), this suggests that most groups have strong EDP skills despite the need for significant improvement in generating some solutions or information collection indicators.

### 3.1 Define the problem

Students' EDP skills in the define the problem indicator are categorized as good. The first step in defining the problem is that students are directed to mention some important information from the case study, mentioning this important information makes it easier for students to identify the ongoing problem presented in Figure 2



**Figure 2.** Example of Define the Problem in the Reflection Stage

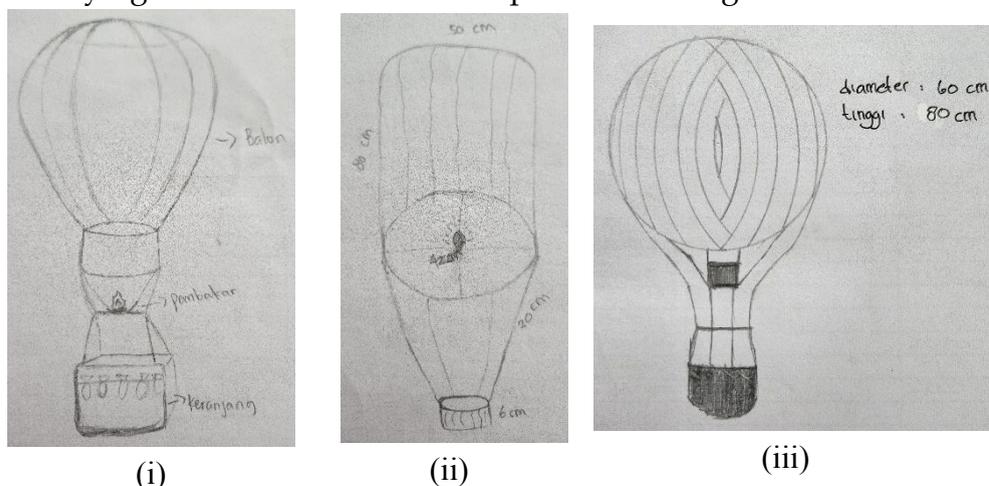
This is in line with research conducted by (Yuntawati, et al.,2021) that mentioning information can change the problem to be simpler so that it is easier to solve the problem. Students are able to define the problems that occur, namely the worst hot air balloon accident in the world caused by technical failures, such as gas hose leaks, fuel shortages and others. Based on these problems, students are able to propose possible solutions to overcome the problem of hot air balloon accidents, namely developing hot air balloons with better safety technology. The problem determining stage is the stage that is able to invite students to think more sensitively, comprehensively, and critically about a problem. Teaching problem-solving skills to students can encourage students to become more critical decision-makers in life (Zulqarnain M. and Ulum. F, 2022).Therefore, the definition of a problem stage is a crucial stage that influences the next stage of EDP.

### 3.2 Gather pertinent information

Gather pertinent information or collect some related information, in this indicator students are directed to find information related to problems from various library sources both from digital and print media. The gather pertinent information indicator is categorized as good because students are able to find information related to hot air balloon accident problems. The information obtained by students mostly leads to the working principles of hot air balloons, effective tools and materials for making hot air balloons and hot air balloon safety factors. Students look for this information through the web or other media such as Youtube, Google, and Instagram that have been presented in the student's LKPD. The process of gathering related information makes it easier for students to initiate effective and efficient solutions to solve problems. As well as making the problem simpler so that it is easier to solve the problem (Yuntawati et al.,2021). This is in line with research conducted by (Sukarno F.M, 2019) that the use of digital literacy in the classroom helps the problem-solving process run smoother because students get various solutions to overcome problems. Research conducted by (Abdurrahman, et al., 2023) states that STEM-EDP learning that utilizes the use of technology can expand teaching and knowledge more effectively than learning with traditional approaches such as providing web-based inquiry, and interactive technology.

### 3.3 Generate multiple solutions

Students' EDP skills in the generate multiple solutions indicator are categorized well because students are able to imagine and generate ideas to solve problems, namely making hot air balloons. Brainstorming/generating activities, designing ideas to produce products can help students develop their creativity skills (Simanjuntak, 2019). Students' creativity can make it easier to solve and answer problems (Simanjuntak, 2019). The ideas proposed by the students pay attention to the working principle of hot air balloons to the safety of hot air balloon work. The idea put forward by the students is about effective tools and materials, students compare several tools and materials that will be used to make hot air balloons. According to (Amelia S and Nugrahanta G.A, 2024). The process of selecting tools and materials in product design as well as the ability to collaborate with friends can improve the social intelligence possessed by students. Students think of some form of hot air balloon by considering the success of flying from a hot air balloon as presented in Figure 3



**Figure 3.** Prototype Design Examples in the Discovery Stage

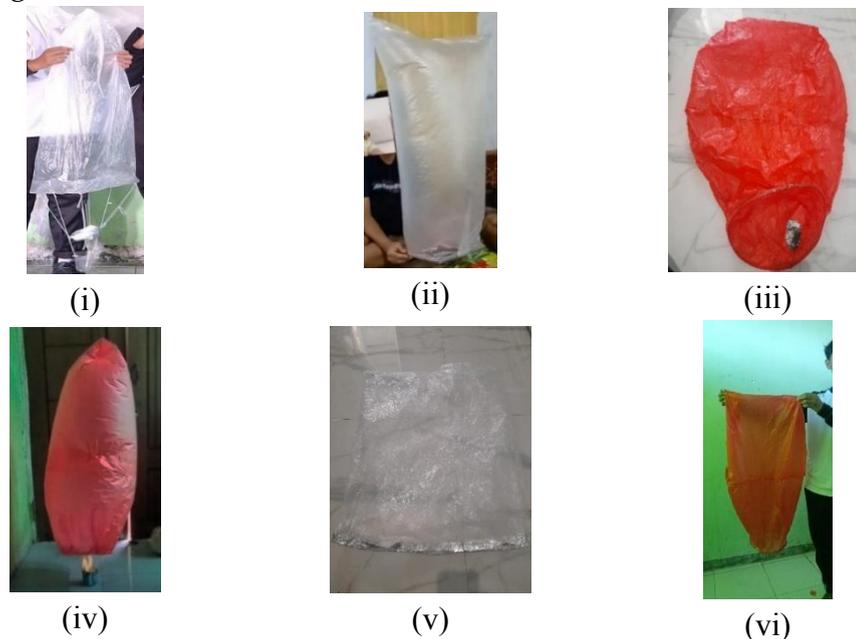
Students also consider the cost of choosing tools and materials and write steps to create an atmosphere by discussing between students in a group. Students contribute their ideas to then communicate and collaborate with each other, exchange ideas, work together, discuss, evaluate effective and efficient hot air balloon tools, materials, and forms. STEM-EDP activities are not only student-oriented, but also provide opportunities for students to exchange ideas, ideas (Sen, et al., 2021).

### 3.4 Analyze and select a solution

Students will choose solutions taking into account the quality of materials, production costs, manufacturing procedures, and design as well as easy-to-use tools and materials can also be considered for product success. The majority of students on this indicator are categorized as good. This is because students are able to estimate and consider the most appropriate solution from all the ideas that have been proposed in the solution activity. Based on their experience and knowledge, students make considerations in the selection of materials to be used, these considerations include material strength, fire resistance, and size. The majority of students choose crackers and plastic mulch materials for the hot air balloon material, for the fuel section students choose to use

paraffin and cotton instead of fabrics that tend to be heavy. Connecting students' initial knowledge and experiences to the context of the problem can help students find solutions (Zulqarnain M. and Ulum. F, 2022).

Students also consider the price of the materials to be used, students choose materials that are easy to get and affordable prices. In addition to the quality and price of materials, students consider the procedure of making hot air balloons, students are looking for some information related to hot air balloon making. As well as students choose and consider the design of the hot air balloon, starting from the length, width, and diameter of the hot air balloon. As well as the size of the fire basket to be used, the size of the hot air balloon and fire basket affects the success rate of the hot air balloon. The size of the hot air balloon designed by the student averages 60 cm to 100 cm. Considering various aspects is a very appropriate step in analyzing and making it easier to find the right solution. The results of the prototype design of each group are presented in Figure 4



**Figure 4.** Sample Prototype Groups 1-6 in the Application Stage

### 3.5 Test and implement the solution

The majority of students are categorized well on this indicator because they are able to prototype hot air balloons, conduct hot air balloon trials, and make repairs and communicate their work. Students are already able to make hot air balloons from tools, materials, and designs that have been made beforehand. Students make prototypes with different shapes according to the ideas and imagination of each group. After the hot air balloon prototype was made, students conducted a trial, which is a test of flying a hot air balloon. The trial process is carried out with several procedures, namely students analyze how the hot air balloon works whether it is in accordance with the principles of Archimedes' law, then students calculate the lifting force of the hot air balloon. However, if a fault is found in the hot air balloon that causes the hot air balloon

to fail to fly, then the student makes repairs to the hot air balloon product. Research conducted by (Maulida, N.H, 2022) states that the prototype made needs to be evaluated and modified, this is because the prototype is an initial product that is still incomplete so it needs to be improved. The students' opinions and thoughts greatly contributed to the evaluation process as well as the development of the prototype (Sen, et al., 2021). The majority of student-made hot air balloons have a burning weight that is too heavy so that it is difficult to fly. The majority of students find that lighter weight will make it easier for hot air balloons to fly. The creation of a hot air balloon prototype is presented in Figure 5



**Figure 5.** Example of Project Creation at the Application Stage

During the test process, there was one group that successfully flew with a load, namely a group of two hot air balloons that managed to fly with a maximum load that could be transported  $\pm 2$  grams. This is because the size of hot air balloons made by students tends to be small, ranging from 60-100 cm. The next stage is for students to carry out the data collection process, namely calculating the lifting force of the hot air balloon and writing down the trial process and project improvements in the LKPD. As well as, factors that affect the work of hot air balloons, understanding related to Archimedes' law, obstacles experienced and efforts to improve products. Research conducted by (Chabalengula and Mumba, 2017) warns that prototyping is not the end goal, but rather by instilling other design skills such as discussion, argumentation, project evaluation, and data collection. The direct involvement of students in the prototype design process has a positive impact as research conducted by (Wijayanto, et al., 2020) project-based learning and STEM has a positive influence, namely being able to improve learning outcomes, students better understand the material concept because students are directly involved in the process of making projects. The next stage after the product trial process and data collection is completed, students communicate their products by making a presentation in front of the class. Students are able to make presentations, receive opinions and provide responses between groups. Effective communication occurs when the speaker and listener have a mutual relationship with each other (Simanjuntak, 2019). At the communication stage, students are able to use good and correct Indonesian.

EDP skills have a positive impact on the skills and knowledge possessed by students. Research conducted by (Abdurrahman, et al., 2023) shows that students who are involved in all phases of the Engineering Design Process (EDP) can improve their knowledge and skills mastery skills from both the material context and the learning unit. Research conducted by (Uzel and Bilici, 2022) explains that students' problem-solving skills can be improved through learning engineering design processes

and activities in STEM learning can also increase students' contribution in problem-solving skills in the real world. Learning that uses STEM approaches is significantly able to gain better conceptual knowledge related to engineering design process skills and students' thinking skills (Khamhaengpol, et al., 2021).

## CONCLUSION

Based on the description of the research results, it was concluded that students' Engineering Design Process (EDP) skills in the implementation of STEM-PjBL-based LKPD were categorized as good and very good. The difference can be seen in the indicators of collecting related information that are categorized as good. Indicators define problems, generate multiple solutions, analyze and select solutions, and test and implement solutions show a very positive tendency to meet excellent categories. The above shows that most students have quite strong EDP skills and need to improve the indicators of gathering related information to add more information in problem solving. The suggestion for further research is that the design and testing process of hot air balloon prototypes is hampered by time constraints, so it is necessary to extend the duration of the project so that students can complete all stages of EDP and overcome technical problems in depth. It is also recommended to conduct prototype trials in earnest because it can help students to identify problems and provide new insights for future project improvements.

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