



Analysis of Students' Argumentation Skill in Science Learning using Engineering Design Process

Devi Yustika, Pramudya Dwi Aristya Putra✉, Jekti Prihatin

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Universitas Jember, Indonesia

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Abstract

Argumentation skills are very important in science learning which is used to build opinions with rational evidence to draw conclusions through logical reasoning. This research is a qualitative research with a case study approach to identify students' argumentation skills using learning Engineering Design Process (EDP). The subjects of this study were 12 students, each consisting of six male students and six female students in grade 7 junior high school. The data collected are in the form of observation data, documentation and interviews during learning. The collected data will be reduced, analyzed based on indicators of argumentation skills and presented and then drawn conclusions. The results showed that students' argumentation skills in EDP learning were dominated by components claim by 87%, 47% data, and 33% warrant. This shows that students' arguments are not have been good, so they are only able to provide claims without understanding the underlying reasons and the existing data relationships as evidence to support claims. Experience aspects, science concepts, and user needs help students build solution designs during learning. EDP through a collaborative process has helped and expanded students' ideas and arguments in solving problems.

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INTRODUCTION

The world of education currently requires students to master various skills and life skills in the 21st century which are needed as provisions to face various global challenges (Widodo et al., 2021). One part of the skills in the 21st century is argumentation skills (Pitorini et al., 2020). Argumentation skills are needed by students to build a logical frame of mind by going through a scientific process (Jeong, 2020).

Argumentation skills encourage students to identify information, be able to understand differences of opinion and be able to provide different views with various data or facts to build and strengthen conclusions based on appropriate evidence (Songsil et al., 2019). Argumentation plays an important role in science learning as a means of negotiating, supporting, and evaluating ideas in understanding problems (Grooms et al., 2018).

Argumentation skills will be more effective when using a variety of practical problem-solving activities which can provide students with opportunities to observe phenomena, understand causes of phenomena, build hypotheses, analyze to make conclusions (Ajmi and Ambusaidi, 2022). The inquiry process is an important part of developing arguments through various questions and planning to construct student knowledge and present conclusions based on appropriate evidence (Songsil et al., 2019).

However, teaching argumentation in the classroom experiences various challenges, such as students having difficulty giving arguments based on scientific concepts (Ambarawati et al., 2021; Devi and Indriyanti, 2019). Learning needs to bridge this gap by helping students to recall previous knowledge, add new knowledge and represent it from their own point of view. In addition, most students do not understand the concept of arguing properly (Riwayani et al., 2019). Teachers must facilitate students with a clear set of instructions and information regarding the structure and components of argumentation (Faize et al., 2018). If this happens, it will hinder the process of developing knowledge in the appropriate science context.

Engineering Design Process (EDP) is a learning approach that is able to facilitate argumentation skills through real-world problem-solving activities (Putra et al., 2023; Sulaeman et al., 2021). EDP will develop student experience to define problems, present arguments, and make the right decisions through the integration of science, mathematics, and technology concepts (Guzey et al., 2018) through the EDP stages namely ask,

imagine, plan, create, and improve (Jolly, 2015). EDP allows students to plan, brainstorm, design, and re-evaluate the chosen solution system to make it more effective (Oanh, 2018).

EDP learning requires reflective thinking to produce the best decisions in solving problems (Putra et al., 2021). This can be done with collaborative activities between students in EDP learning to build argumentation skills by sharing ideas and solution ideas (Gülen and Yaman, 2019). Collaboration will help students to expand arguments by sharing knowledge or experience and refining ideas to understand problems (Hsu et al., 2018). Therefore, collaborative activities in EDP play an important role in supporting the development of student arguments.

Based on the description above, this study emphasizes the problem “How do students build arguments using stages Engineering Design Process (EDP) in science learning?” through the learning process small group discussion.

METHOD

This research is a qualitative research with a single case study method to explore students' argumentation skills through EDP learning in activities small group discussion (Yin, 2018). The research was conducted in class with the subject of Natural Sciences on the topic “Environmental Pollution” by providing a problem that must be solved by students by providing the right solution. EDP learning is a means for students to define problems and develop various solution ideas (Guzey et al., 2018). The EDP pattern will help students to think reflectively to produce better decisions in solving a problem (Putra et al., 2021). EDP activities in the classroom use the stages proposed by Jolly (2015) in Table 1.

Table 1. EDP activities in class

EDP stages	Student Assignments
Ask	Students identify problems based on user needs
Imagine	Students reconstruct ideas to make some design solutions
Plan	Students choose the best solution to implement
Create	Students create and try out the selected solution designs based on supporting scientific data
Improve	Students assess the effectiveness of the design and revise the design if it is considered less effective

This research involved 12 grade 7 students at a junior high school in Jember Regency, consisting of six male students and six female students. Discussion activities in the EDP project were divided into two groups, each group consisting of three men and three women. Demographics of student participation will be explained in Table 2.

Table 2. Demographics of student participation

Characteristic	n	% Participation
7 th grade	12	100
Gender		
Men	6	50
Women	6	50
Science achievement level		
High	2	33
Medium	6	50
Low	4	17

The data collected in this study consisted of three data sources, namely the results of the EDP project worksheets, audio results from group discussions, and audio interviews with students. In the early stages students will define the problem by answering several questions attached in the worksheet about how to clean up microplastics in waters. The next EDP stages will help students in groups to discuss and exchange ideas and knowledge to produce solutions which are then written in worksheets. During the discussion, the researcher will record each student's conversation. At the end of the activity, interviews were conducted with each student to obtain the necessary supporting data regarding argumentation skills using the EDP stages.

The research results from three data sources will be analyzed and tested for validity using data triangulation techniques (Creswell, 2016). Analysis of all data was carried out by transcribing data, reducing data based on indicators of argumentation skills at each EDP stage, presenting data and making inferences. The indicators of argumentation skills are explained in Table 3.

Table 3. Indicators of Argumentation Skills

Indicator	Description
Claim	Statements or opinions that answer a problem
Data	Data and or observation results used to support claim

Warrant	Interpretation of how and why the data can support claim
	<p>The next argument component will be analyzed based on several aspects that build student arguments in class using interview data.</p> <p>This aspect helps students to convey ideas and ideas while solving problems. The aspects that build student arguments are presented in Table 4 below.</p>

Table 4. Aspects of student argument construction

Aspect	Description
Experience	Arguments are based on students' experiences in everyday life
Criteria	The student's argument refers to the solution criteria required by the user
Limitation	Student arguments are based on certain limitations of users in solving problems
Science concept	Students explain scientific concepts in arguments to solve problems
Engineering techniques	Students think about the right prototype design for problem solving

RESULT AND DISCUSSION

Argumentation skills in this study were analyzed based on the discussion process in two groups in solving environmental pollution problems in water areas. The analysis was carried out by assessing the discussion based on the argumentation component in the form claim, data, and warrant. Students are involved in the argumentation process to find solutions to the problems given and how to design test solutions so that problems can be resolved properly. The examples of group arguments that emerged during the discussion are as follows.

Group 1

Vignette 1

[S1]: Let's try using a magnet to pick up the trash, so later you need iron powder as a metal material that can attract each other like that (claim, data, warrant)

[S5]: Ow, yes it really makes sense too

[S3]: Do you use oil or ethanol then?

[S2]: Just cooking oil (claim)

[S1]: What do you think about burning ethanol later, ethanol is flammable (claim, data)

Group 2

Vignette 2

[S1]: Is it possible to use IPAL by treating waste water? (claim)

[S3]: But this isn't waste water, it's seawater which has trash and how do you get rid of the garbage.

[S2]: Uh, but so that the garbage is gone can it be filtered or not, if you go to sea you can usually use the help of ships (claim, data)

[S1]: Ow, yes, that makes more sense

[S4]: How about we make a tool like a pulley to pick up all the trash? (claim)

[S6]: Let's see first, it doesn't seem like it can be done because the criteria is that the water can't be lifted up so it has to be a tool where the water can't be carried along (claim, data, warrant)

The results of the analysis of the argumentation skills component as a whole from the two groups yielded percentages as presented in Figure 1.

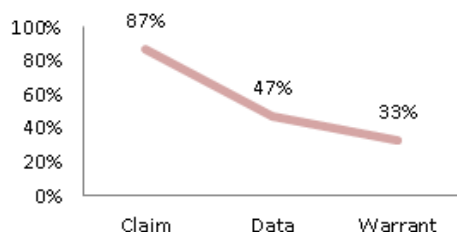


Figure 1. Percentage of the argumentation skills component

Based on the analysis in Figure 1, it shows that EDP learning can accommodate argumentation skills, although not all arguments that are formed are in accordance with good argumentation rules. Percentages show that 86% of students' arguments have been loaded claim. That is, students have been able to convey convey claim in every argument, though not all claim related or able to answer problems that can occur. Claim indeed it can be easily conveyed by anyone even without data or evidence. However, claim that is good needs to be based on evidence or data that are interconnected (Ping et al., 2020). Claim Imprecision can occur due to several things, namely students' lack of understanding of the topics discussed and low literacy skills. Wikara (2022) explains that understanding of a particular topic greatly influences the quality of student arguments due to the support of qualified data. Lack of understanding will cause problems, such as stu-

dents having difficulty conveying ideas, especially when ideas don't go well, and misconceptions occur due to not understanding the information read or heard (Chusinkunawut, 2020; Oktasari et al., 2019).

Unlike components claim, another component of the argumentation data and warrant has a lower percentage of 47% in components data and 33% warrant. The difference in the percentage of components that is quite significant indicates that students are only able to convey in their arguments claim without strong evidence and reasons to support it claim which are made. This shows that students' arguments are still not well formed. Students have difficulty conveying data or logical evidence to convince that claim what he did was right. Whereas, data and warrant become an important component to convince every claim logically and scientifically (Chusinkunawut, 2020). Difficulty of students in conveying data and warrant, this can happen because it takes good reasoning from students in processing the information obtained so that logical arguments are formed. According to Wikara (2022) data or evidence is indeed not easy to obtain, it requires good exploratory and reasoning skills to make logical reasons. In the interview sessions, students also admitted that they rarely expressed opinions, even though learning had facilitated this through discussion or group work. This can be one of the consequences that make students not argue well in class. Hence the percentage claim it is much higher here data and warrant.

The next argument component will be analyzed based on several aspects that build student arguments in class using interview data. These aspects include aspects of experience, criteria, limitations, scientific concepts, and engineering techniques. The results of the analysis are presented in Table 5.

Based on the results of the aspect of argumentation construction, it shows that during discussions, students get the opportunity to provide different perspectives in presenting arguments. Students predominantly rely on experience and scientific concepts to obtain and evaluate truth claim which are made. This shows that learning using everyday problems can help students construct and develop scientific arguments (Putra et al., 2021; Cynthia et al., 2018). In addition, the criteria and limitations in the problems presented make students develop ideas based on user needs. Knowledge related to user needs is an important part of designing and implementing solutions properly (Moore et al., 2014).

Table 5. Results of aspects of students' argument construction

Aspect	Amount	Sample transcript
Experience	9	"To clean up plastic waste, you can just use cooking oil, because the material is also easy to get"
Criteria	2	"If you use the pulley principle, you probably won't be able to, because the criterion is that the water shouldn't be lifted up, while the pulley can carry the water"
Limitation	4	"We have to make a simple tool, because the budget is not more than 50 thousand"
Science concept	10	"The wire can be used to lift the magnet later. And you need to buy iron powder too, so it comes with a magnet so it works well"
Engineering techniques	3	"Needles can be connected by thread to wire like a fishing rod"

The process of discussion and collaboration in solving problems has shown that the development of arguments is much broader because it can bring together various views and experiences from each student to produce the right solution ideas. Collaboration and discussion have helped students to share knowledge or experiences and refine ideas to understand problems (Hsu, et al., 2018; Choi and Hand, 2020). Although most claim not based on strong evidence, but students succeed in expanding ideas in learning. This explains that learning using EDP has been able to develop students' argumentation skills (Putra, et al., 2021; Sulaeman, et al., 2021).

CONCLUSION

Based on the results and discussion shows that EDP learning can accommodate argumentation skills, although not all arguments are formed in accordance with argumentation rules. The percentage of student argumentation components shows that students' arguments are not have been good, so they are only able to provide claims without understanding the underlying reasons and the existing data relationships as evidence to sup-

port claims. Aspects of experience and science concepts dominate the formation of student arguments. Criteria and constraints also help students construct solution designs. EDP learning through discussion and collaboration processes has helped and expanded students' ideas and arguments in solving problems.

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