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Students' Argumentation Skills towards Using Biology e-Worksheet based on Project-Argumentative Learning Model

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ABSTRACT

Purpose: The objective of this study was to implement the combination of learning model of project-based learning and argumentation driving inquiry to improve students' argumentation skills in learning science subjects. This model was called project-argumentative learning model and which was implemented using biology e-worksheet. **Method**: The study design used a Non-equivalent pre-post control group design involving 120 samples of junior high school students and 4 science teachers at junior high schools in South Lampung, Indonesia. **Findings:** The results showed that the average score of students' argumentation skill in the experimental class was higher (61.92) compared to the control class (22.96). In addition, the level of students' argumentation skill was also higher in the experimental class (level 3) compared to the control class (level 2). The results of the independent sample t-test also showed that there was a significant improvement (Sig. 0.00 < 0.05) of students' argumentation skill from the experimental class rather than the control class. Implications for **Research and Practice**: Argumentation skills scale is a valid and reliable research instrument. Students still could not reach level 4 to state claim, ground, warrant, and backing. Claim and ground written by students were better than warranting and backing which means claim and ground were well written but need clarifications, while warrant and background were still unclear. Future biology learning necessitates the use of technology like e-worksheets that combine with argument stages to improves students' argumentation skills. Level of argumentation skills eventually will affect argumentation habits of Indonesia students to be more logical and systematic.

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1. Introduction

Globally, communication takes place through various platforms and media, helping individuals to deliver thoughts and opinions convincingly. Communication is also viewed as a tool for exchanging and receiving various types of information, as well as a factor in personality development over the course of a person's lifetime (Abdikarimova, Tashieva, & Abdullaeva, 2021). One of the communication skills that support a person's career and education is argumentation skills. Argumentation skills involves the ability to construct logical and persuasive arguments, as well as to critically evaluate the arguments of others. Argumentation skills are also invariably important in 21st century education as they promote critical thinking essentially required in a rapidly changing and complex world.

A lot of research on argumentation skills has taken place in recent decades which has garnered growing interest and captivation and has revealed that most research analyze argumentation skills in connection with cognitive abilities (Cankaya & Aydogan, 2022), critical thinking skills (Gültepe & Kiliç, 2021), science process skills (Ping, Halim, & Osman, 2020), and written arguments (Evagorou, Papanastasiou, & Vrikki, 2023). The findings obtained from literature review indicated that students' argumentation skills improved more effectively through a learning strategy known as Argument-Driven Inquiry (ADI) strategy compared to conventional learning strategies (Hasnunidah et al., 2015) or cooperative learning strategies (Okumuş, 2021). The reason is that the frequency of counterargument as an argumentation strategy is the primary indicator of utilizing argumentation skills in a learning process (Crowell & Kuhn, 2014). Students get the chance to conduct investigations, gather and analyze data, engage in debate sessions with others, produce investigation reports, and participate in peer review during a laboratory inquiry while using the initial iteration of ADI model (Antonio & Prudente, 2021).

The application of the ADI model in science learning leads to the activities of investigating, arguing, writing, and reviewing worksheets. Worksheets that can be accessed online using gadgets are commonly called e-worksheets. Although the usage of such e-worksheets helps students become more engaged and successful by improving their engagement in class, but they also show concerns regarding understanding some scientific concepts (Celikler & Aksan, 2012). Hence to understand the scientific concepts require argumentation skills to solve the issues shown in the worksheet. While students attempt to solve those issues, their effort motivates, stimulates and enhances their critical thinking abilities (Ernawati & Sujatmika, 2021). In their efforts, e-worksheets can be used as a good guide in facilitating student learning activities and their creativity in implementing projects, as well as equipping students' knowledge and argumentation skills.

One of the breakthroughs of online learning of the subject of biology is the inclusion of multimedia in biology e-worksheets, which encourages students to learn and make various bioprocesses more exciting and to comprehend the issues more easily due to the usage of images and videos (Fina, Raharjo, & Purnama, 2022). Different types of biology e-worksheets were found in use during the Covid-19 pandemic and were pronounced as technological advancement in learning. Students could access these e-worksheets via the internet and fill them while working on projects at home and school environment. For this reason, e-worksheets as the ADI tool could complement project-based learning (PBL), which optimized students' argumentation skills and produce products through projects.

Argumentation skills assessment through ADI and any other instructional model such as PBL, have been applied by many researchers worldwide including the United States (Hosbein, Lower, & Walker, 2021), Thailand (Songsil et al., 2019), Netherland (El Majidi, Janssen, & de Graaff, 2021), Indonesia (Hasnunidah et al., 2020), Turkey (Demircioğlu & Ucar, 2012), and Oman (Al-Ajmi & Ambusaidi, 2022). All these studies have examined the argumentation skills at the university levels and found ADI helpful in their learning processes. However, there is a dearth of research of studies at junior high school level, in particular to examine learning media and project activity.

During the preliminary observation and prior to the conduct of this research, it was revealed that 20% of junior high schools in Lampung Indonesia showed that 40% of teachers used e-worksheets as a teaching material in the PBL process. However, 55% of these e-worksheets used by teachers were taken from the existing textbooks and were not the creation of the teachers' own argumentation skills related to the project in hand. Both the teachers and the students were unaware of the fact that a project in particular aimed to provide a product or process well-supported with persuasive arguments on the topic or issue in question. This typically involves researching the topic and gathering evidence from a variety of sources, as well as analyzing and evaluating that evidence to build a strong argument. However, teachers have not been able to integrate arguments and involve the participation of junior school students in conducting independent investigations and group discussions.

A dire need was therefore felt to initiate a study that would integrate ADI with PBL in order to construct a Project Argumentative learning model for the junior school level students. As its name indicates, this model would be helpful to explore a specific topic or issue using a combination of project and argumentation skills of the students. It was seen as a research opportunity to be carried out a strategy that would integrate two learning models to improve argumentation skills using e-worksheet. This study would also investigate how to make an improvement of argumentation skills through implementation of project argumentative learning model using e-worksheet for junior high school students.

2. Literature Review

- *Argumentation Skills*

Argumentation skill refers to the ability of students to construct and present logical and well-supported arguments. It involves being able to identify and evaluate evidence, to use critical thinking, and to present ideas clearly and persuasively. Science education requires students to possess argumentation skills because it involves students in challenging scientific procedures to create and validate knowledge claims. They need to analyze data on a certain topic which requires an argumentation process prior to sharing their analysis and findings with others (Hasnunidah et al., 2014). Developing argumentation skills in students can help them become more effective communicators and problem-solvers, both in their academic and professional lives. Due to the fact that the learning strategy is used to train students' argumentation skills, which are based on the amount of practice, infusion learning strategies can help students improve their argumentation skills (Tristanti & Nusantara, 2022).

Arguments created by students and lecturers in science classes are compiled to support statements that have already been made, which is a crucial component of scientific

reasoning (Dorfner et al., 2018). Argumentation skills can be expressed and evaluated in oral and writing (Antonio & Prudente, 2021). The analysis of the students' oral arguments revealed that all groups participated in discussion and presented strong arguments, emphasize the contribution of technology media based on argumentation exercises to the development of students' argumentative and critical thinking abilities (Demircioglu, Karakus, & Ucar, 2023). The Toulmin model can be used to analyze arguments and identify any weaknesses or flaws in the reasoning. It can also be used as a guide for constructing clear and logical arguments. The model consists of six components: claim, grounds, warrant, backing, qualifier, and rebuttal (Larson, 1959).

- *Project Argumentative Learning Model*

Combination of PBL and ADI is known as project-argumentative learning model (PALM), which has eight steps using both online and offline methods as presented in Figure 1 (Hasnunidah, Maulina, & Ismi, 2022). Step 1 is providing fundamental references and asking questions which students discuss in groups; Step 2 requires students to design a project and plan the procedure of making a bio product which would answer the experiment question. Step 3 and 4 are creating a schedule to finish the project and implementing the plan to produce products such as tempeh, yogurt, fermented cassava, and others. Step 5 requires student groups to construct product argumentation based on Toulmin model which include claiming, grounding/data, warranting, and backing.

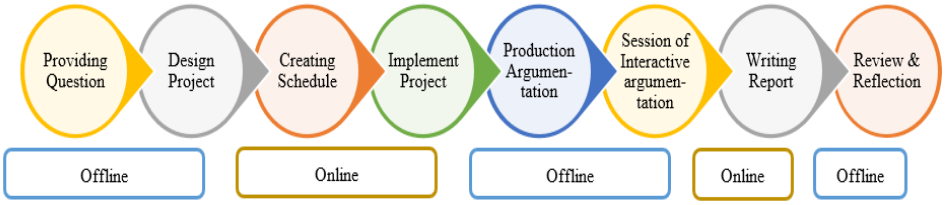

Figure 1. *Project-argumentative learning model syntax*

In the next step, Step 6, students face the interactive argumentation session as a part of evaluation. Step 7 is writing the project report online using teleconference apps. This step needs a presentation in small groups. Group members test the results of the project by comparing the results with other groups so that they know the accuracy of the observations. Finally, the Step 8 is a review and reflection activity that discusses the learning experience and concludes the concepts obtained during the learning process.

PBL techniques encourage conversation and the sharing of knowledge, which raises student involvement while teachers must support students by answering their questions (Almulla, 2020). PBL has enormous potential to provide an engaging learning experience for students in studying science materials. PBL is an instructional approach that focuses on students working on real-world, authentic projects to learn subject matter and skills. Students' comprehension and understanding of real projects have improved after active PBL intervention (Torres, Sriraman, & Martinez Ortiz, 2021). It is believed that PBL is a potential strategy for enhancing student learning in higher education with an emphasis on student outcomes, empirical studies on PBL have been evaluated (Guo et al., 2020).

ADI is a teaching method that emphasizes the use of scientific arguments to develop students' understanding of scientific concepts and practices. ADI with scaffolding model is likely to be more effective at raising students' accomplishment levels in terms of the quality of their argumentation and require to maximize their contribution to scientific teachers and lecturers implementing the ADI learning model (Hasnunidah et al., 2014). When properly scaffolded, the ADI model can help students enhance their critical thinking abilities and reasoning skills (Hasnunidah et al., 2020). Teachers may apply this pedagogical strategy to teaching other Biology topics because of the positive effects of the metacognitive ADI approach on students' development of conceptual comprehension and reasoning abilities (Antonio & Prudente, 2021). Students engaged in activities of ADI with designing experiments, analyzing data, and constructing explanations to support their arguments. Another study's findings indicate that the ADI instructional technique was better than the conventional method in terms of enhancing argumentation quality, but it had little influence on attitudes (Demircioğlu & Ucar, 2012).

- *e-worksheet in science*

An electronic worksheet or e-worksheet for students is a digital version of a traditional worksheet that is used for educational purposes. It can be created using various programs, such as Microsoft Word, Google Docs, or a specialized education software. It is different from printed teaching materials which are not the best option for reaching students' needs because they tend to be informative but uninteresting and are unable to show sound, video, animation, or visuals that can clearly explain the idea being taught (Asrial & Ernawati, 2020). e-worksheet have several activities that involve discussing phenomena, open-ended presentations, formulating hypotheses, continuing experiments, analyzing experimental results to answer questions, and providing conclusions, the development of teaching materials in the form of worksheets can enhance students' higher-order thinking abilities (Romli et al., 2020).

e-worksheets can include interactive elements, such as fill-in-the-blank questions, multiple choice questions, and drag-and-drop activities. By utilizing a flipbook worksheet, digital eco-learning enables students to quickly become familiar with the environment without having to compromise their pedagogical and environmental literacy skills (Aliman & Mutia, 2021). Students can also be shared and completed electronically, making it easier for teachers to grade and for students to access and complete their assignments.

3. Methodology

- *Research Design*

The study utilized a quasi-experiment research design with pretest posttest with non-equivalent control group design. The quasi-experiment is a kind of mixed method research design where the researcher utilizes control and experimental groups, but the design may not randomly assign groups to any extent (Creswell, 2014). Participants in this study were divided into two groups (experimental and control). Pretest measures were taken for both groups before the intervention and posttest measures after the intervention.

- *Research Sample*

The research sample was identified from students studying at junior high schools in South Lampung district, Indonesia having the population of 35,475 students. In this study, two sub-districts, Katibung and Candiputo, were chosen based on the split method of learning after pandemic which split 50% of classes for offline learning every alternate week. The purposive sampling technique was used to get a sample of 120 students of third grade level, with 60 students each for experiment and control classes from two different sections. The Indonesian students require three years of junior high school after finishing six years of primary school. This limited sample was only representative as the purpose was to get insights into the broader population and reduce the need to include every individual.

- *Research Instrument and Procedure*

One pre-test and one post-test instruments were used to measure students' argumentation skills. Each test included 6 essay questions about biotechnology and 6 essay questions about ecofriendly technology. Questions were equipped with brief explanations, pictures, and opinions. Students were asked on each question to choose the most suitable opinion out of 4 choices, e.g., providing supporting facts, expressing reasons for supporting the opinion, and explaining theories that support the previous three answers. Each choice referred to Toulmin's argumentation analysis framework contained in the Toulmin's Argument Pattern (TAP).

The framework for the analysis of students' scientific argumentation was a kind of argumentation assessment rubric based on the completeness of the argumentation components. The argumentation assessment rubric was adapted from Hazeltine (Hazeltine, 2017), which analyzed the skills of students participating in writing argumentation and assessed their quality of argumentation according to conceptual and epistemic categories using the TAP.

In this research, the aim was to implement biology e-worksheet based on project-argumentative learning model which could improve students' argumentation skills. Biology e-worksheet used in this research was developed from previous study and adapted using project-argumentative learning (Hasnunidah & Abdurrahman, 2022; Hasnunidah, Abdurrahman, & Diawati, 2022). The experiment group used implementation of project-argumentative learning model with e-worksheet, while the control group used common learning method. Data were collected through argumentation skills questions, teacher and student' response questionnaire, and learning process observation.

- *Data Analysis*

Both the quantitative and qualitative data was combined for the purpose of analyzing simultaneously and to understand the research problems from the results of the analysis. The rationale of this data analysis design was that the shortcomings of one type of data would be complemented by another type of data. In this case quantitative data provided a way to generalize while qualitative data provided information about contexts and settings. Qualitative data comprising preliminary study data, expert test data, practicality test data, and student satisfaction data was analyzed using a descriptive qualitative approach. Through this analysis, an overview is made of the needs of teachers and students in learning, their problems, the availability of worksheets, worksheet components that need to be revised, the

level of validity and practicality of learning tools in the form of lesson plans, interactive e-worksheets, and the level of student satisfaction with e-worksheets generated interactive.

Quantitative data in the form of student argumentation skills collected form questionnaire was analyzed using descriptive statistics, to triangulate the overview results obtained from the qualitative data of students' argumentation skills. It was required that the results should meet the learning objectives until they reach certain criteria, otherwise the entire learning tool would be improved. The argumentation skills data were tested for normality and homogeneity and then an independent sample t-test was carried out. The results of the statistical test were then analyzed and interpreted according to the statistical table.

4. Results

After pandemic, the learning process in Indonesia school has been directed to implement PBL as a new policy by the Ministry according to the Prototype Curriculum for learning recovery program and students' character development. Accordingly, this research supported teachers to implement the new policy. The argumentation skills were tested for validation and reliability on other students who had studied biotechnology and eco-friendly technology materials. Validation result for biotechnology topic showed category valid for 4 questions and 2 questions were not valid, reliability test result was 0.67 with category reliable. For eco-friendly topic, validation result showed category valid for 4 questions and 2 question were not valid. These questions were revised according to the results before using them in research to obtain pre-test and posttest data.

In this study, researcher design worksheets according to a learning model was designed to be interactive and was accessed online. e-worksheet was validated in content, systematics, and language by 3 experts in their fields and 1 science teacher. Furthermore, the e-worksheet was revised according to expert advice so as to produce an e-worksheet that is in accordance with PALM to improve students' argumentation skills. The implementation of PALM in learning used e-worksheets which uploaded pdf format and Indonesian language on liveworksheets.com website, e-worksheets link can be shared with students. Researcher and teacher fills in the answer key hence feedback is directly received by students via email or their accounts.

Table 1

Analysis of the quality of argumentation of contextual and epistemic aspects

	4	3	2	1
Claim	Claims are easy to distinguish and well written	Claim is well written, but could use some clarifications	Claims are not too good and need to be developed	Claims are indistinguishable or non-existent
Grounds	Ground is clear, compact, and efficient	Ground is easy to identify, but needs some clarification	Ground is unclear and needs development	Ground is not displayed or is irrelevant
Warrant	Warrants are well written, easy to identify and connect claims and grounds efficiently	Warrants can be clearly identified, but need some clarification	Warrant is unclear, but there is something linking claim and ground	Warrants do not link claims to ground or are not easily identifiable
Backing	Backing supports warrants	Backing supports the warrant, but can use some clarifications to show the relationship as evidence	Backing is in favor of the warrant, but the relationship should be clearer	Backing that supports the warrant, but cannot be identified or does not support the warrant

However, this study used only four criteria on the argumentation skills test which were claim, ground, warrant, and backing in order to adjust with students' argumentative experience, as presented in Table 1.

The e-worksheets were designed for 3 meetings. The e-worksheet-1 for the first meeting contained components of introduction, objectives, determination of research questions, argumentative production, interactive argument sessions, designing project planning, compiling schedules, and concluding. It was different from the design of e-worksheet-2 for the second meeting which contained instructions for preparing a project report. For the third meeting, e-worksheet-3 consisted of components for project report presentation and peer assessment.

Before implementation, researchers and teachers discussed and practiced the PALM using e-worksheet for five days. During argumentative session, observations were done to learn more about the students' oral argumentation abilities. To support the observational data, audio-visual recordings were also made. This finding can be used to understand the complexity of the evolving argumentative discourse pattern. The quality of the student's reasoning was determined by how complex the interaction path was in the argumentation discourse. Over the course of three meetings, the learning process was observed and recorded for each group and individual student.

The learning steps of the content section included giving references, figuring out fundamental questions, developing arguments, having argumentation sessions, designing projects, creating schedules, implement project plan, compiling reports, testing outcomes, and evaluating experiences. Three sections of e-worksheets consisted of introduction, content, and closing based on PALM using a blended learning strategy. Introduction on cover contained core competencies, fundamental competencies, accomplishment indicators, and learning objectives. Figure 2 displays the example of e-worksheets pages.

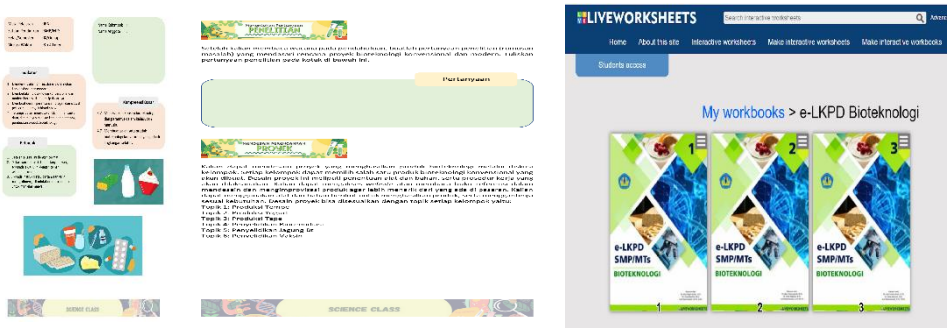

Figure 2. *e-worksheet of project-argumentative model learning*

It was ensured that each e-worksheet complied with aspects like an ideal format, appearance, and the applicability of the e-worksheet with project-based argumentative syntax with a blended learning approach. The conformity with argumentation skills and the validity of interactive e-worksheet creation was also examined. With a cover, foreword, table of contents, bibliography, availability of basic skills and indicators, and room to enter answers on interactive e-worksheets in live worksheets, the development's e-worksheet had successfully met the first requirement.

The next stage of this study was a limited trial to find out the practicality given to learners outside the product implementation research sample with 120 students from South Lampung senior high schools, Indonesia. The implementation of interactive e-worksheets on biology topic with project-based argumentative models implemented in blended learning was tested using observation instruments. The last phase of this development research was field trials. This test was administered using a blended learning strategy that involved using interactive biotechnology, e-worksheets, and environmentally friendly technology with students. The experimental and control classes each comprised two classes of students during the field trial phase. To ascertain whether the produced items were effective, field tests were conducted. The efficiency of employing electronic worksheets was evaluated based on student activities and evaluations of students' argumentation abilities on pre- and post-tests. A normality test, homogeneity test, and independent sample t-test were then performed using the pre and post-test results.

Table 2

Descriptive statistical test results regarding students' argumentation skill

Group Statistics	Class	N	Mean	Std. Dev	Std. Error Mean
N-Gain	Experiment	60	61.924	8.656	1.117
	Control	60	22.960	9.560	1.234

Before testing the hypothesis, prerequisite tests were first carried out, namely normality and homogeneity tests. The results of the normality test of the argumentation skill data with the Sig value > 0.05 indicated the study data was normally distributed. The effectiveness of interactive e-worksheets in improving argumentation skills was also seen from the results of obtaining pre-test scores with student post-test. In addition, the n-Gain value (Table 2) and the percentages show the differences in the experimental class as a class treated for the implementation of learning using interactive e-worksheets and control classes using learning that teachers usually applied. The data used to determine the improvement of argumentation skills through a project-based argumentative learning model with a blended learning approach was the n-gain percentage data of argumentation skills scores collected from the experimental class and the control class.

In the calculation results of the experimental class statistics group (Table 2), the average value of the percentage of n-gain for the experimental class was 61.92 which was included in the category of quite effective. The results showed that the project-based argumentative learning model through a blended learning approach was quite effective in improving students' argumentation skills on biotechnology materials and environmentally friendly technology. In contrast to the average n-gain percentage score in the control class, which was 22.96 and which fell into the ineffective category, it meant that the conventional methods commonly used by teachers in teaching were not effective in improving students' argumentation skills.

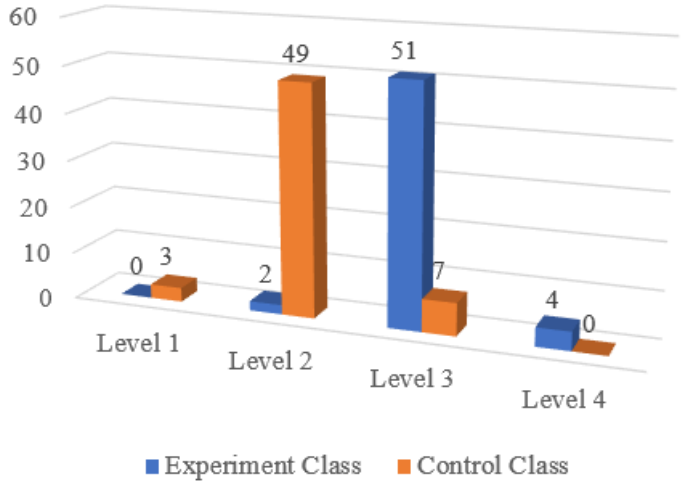

Figure 3. *Argumentation level of students from experiment and control class.*

The increase in argumentation skills can also be seen based on the level showing that there is an increase in the level of student argumentation in the experimental and control classes, but the percentage of student skills in the experimental class was more at level 3 which is higher than the control class (Figure 3). The results showed that none of the learners in the control class could reach level 4. This shows that in the control class, students have been able to give their opinions (claims) well, write evidence (ground/data) and provide justification (warrant) and provide support (backing), but still need to use some clarifications.

Table 3

Independent sample t-test results

Independent Samples Test	Levene's Test		t-test for Equality of Means			
	F	Sig.	t	df	Sig. (2-tailed)	Std. Error
Equal variances assumed	1.367	.245	23.401	118	.000	1.665
Equal variances not assumed			23.401	116.85	.000	1.665

In Table 3, the results of the independent sample t-test showed a significance value on the Levene Test of 0.245 > 0.05 which means that the data of the experimental class and the control class are homogeneous (Table 3). At the output value of t-test for equality of means it is known that the value of Sig. 0.000 < 0.05 which means there is a significant difference between the use of project-based argumentative models and conventional methods to improve students' argumentation skills. The results of the t-test also suggest that there is a significant improvement in students' argumentation skills through a project-based argumentative learning model with a blended learning approach.

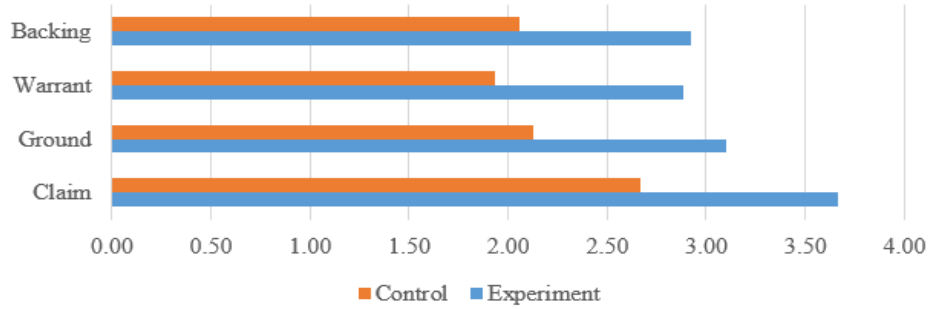

Figure 4. *Average score of TAP components from experiment and control class*

This study analyzed the ability of students to construct arguments using the TAP, specifically focusing on the components of claim, ground, warrant, and backing. The findings indicated that the majority of students were unable to effectively reach level 4 in terms of each component (Figure 4). While students demonstrated relatively better proficiency in formulating clear and concise claims and grounds, there were notable deficiencies in their construction of warrants and backings, which remained unclear and lacking in coherence.

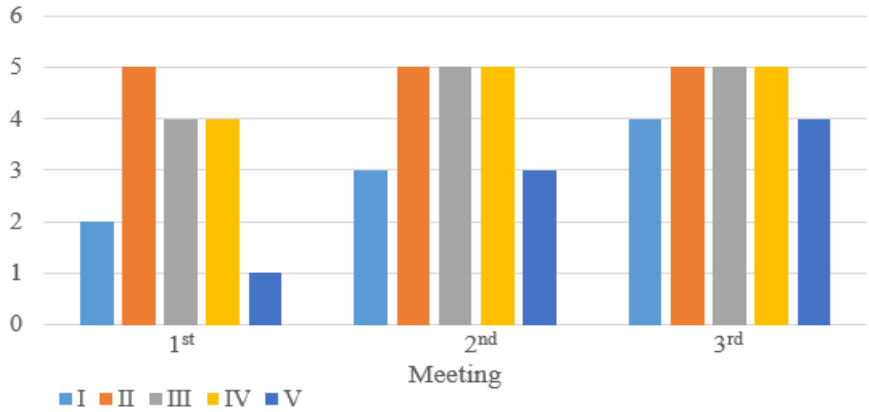

Figure 5. *Average Level of Quality of Argumentation in Conceptual and Epistemic Aspects*

Figure 5 illustrates the quality of students' argumentation based on the conceptual categories and the epistemic framework (Sandoval & Millwood, 2005) analyzed in this study. The conceptual aspect consists of two descriptors which are how students are individual able to express causal claims with a specific theoretical framework (descriptor I) and how individual able to guarantee claims with available data (descriptor II). Meanwhile, the level of epistemic aspects consists of three descriptors, namely how individual learners are able to cite sufficient data to support claim (descriptor III), how individual learners are able to write a logical explanation of a phenomenon (descriptor IV), and how individual learners are able to unify the right references when developing data (descriptor V).

The results of data analysis show the fact that the quality of students' arguments in the conceptual aspect is in the range of level 1 (0-20%) to level 5 (80-100%) which, in the epistemic aspect, goes only up to level 4 (60-79%). Based on the average level of argumentation quality in each descriptor, both in the control class and the experimental class, appears that descriptor I has the highest level while descriptor V has the lowest level.

The low level on the descriptor V (epistemic aspect) indicates that learners mostly have difficulty in unifying the right references when developing backing to support the claims or counterclaims they make. From the results of the analysis of the results of the discussion transcripts, it is known that very few students are able to develop adequate backing based on references. Based on the results of the comparison of the two categories of conceptual and epistemic aspects, it was found that the conceptual aspect had a higher average than the epistemic aspect in both the control and experimental classes. Nevertheless, the experimental class had a higher-level average than the control class on the epistemic aspect (experiment=3.60; control=2.33). This suggests that learners in the experimental class are more likely to cite sufficient data to support the claim and write a logical explanation of a phenomenon than learners in the control class.

Table 4

Results of student response questionnaires to the e-worksheet

Indicator	Percentage	Criteria
Attractiveness	90.78%	Very high
Usefulness	91.94%	Very high
Readability	90.83%	Very high

Student responses to e-worksheets obtained from questionnaires to determine the level of attractiveness, usefulness, and readability of e-worksheets. The response questionnaire data shows that the e-worksheet had very good criteria on indicators (Table 4). This showed that PALM-based e-worksheets were attractive, useful for project, and the language used is communicative.

5. Discussion

The research aimed to investigate the effectiveness of a project-based argumentative learning model, implemented through a blended learning approach, in improving students' argumentation skills on biology materials and environmentally friendly technology. The results obtained from the experimental class statistics group (Table 3) revealed that the average n-gain percentage for the experimental class was 61.92, categorizing it as quite effective. These findings suggest that the project-based argumentative learning model, combined with a blended learning approach, has a positive impact on students' argumentation skills. This aligns with previous studies that have emphasized the effectiveness of project-based learning and blended learning in enhancing students' cognitive abilities and academic performance (Shapiro, 2006). By engaging students in authentic projects and incorporating online learning activities, the research intervention was able to promote active learning, critical thinking, and collaborative problem-solving, which are essential skills for success in the 21st century workforce.

On the other hand, the control class, which utilized conventional teaching methods commonly employed by teachers, exhibited an average n-gain percentage of 22.96, falling into the category of ineffective. This finding highlights the limitations of traditional instructional approaches in fostering students' argumentation skills. Traditional methods, such as lectures and rote memorization, often prioritize passive learning and fail to stimulate students' active participation and critical thinking (Hattie, 2008). As a result, students in the control class did not experience significant improvement in their ability to construct and present arguments effectively.

The analysis of the data revealed an increase in the level of argumentation skills in both the experimental and control classes. However, there were notable differences in the distribution of skills levels between the two groups, with the experimental class showing higher percentages at level 3 (Figure 1). It indicates that students in the experimental class were able to demonstrate higher proficiency in argumentation compared to the control class. None of the students in the control class reached level 4, which suggests that although they were able to present their opinions, provide evidence, and offer justifications and support, they still lacked some aspects of clarity in their arguments. This is in line with research whose results show that learning with an argumentation model increases the lever of argumentation from 1 to level 3 (Marhamah, Nurlaelah, & Setiawati, 2017). These findings align with the research results discussed earlier, highlighting the effectiveness of the PALM in improving students' argumentation skills. The project-based approach likely provided students in the experimental class with opportunities for active engagement, collaboration, and critical thinking, allowing them to develop a deeper understanding of the subject matter and refine their argumentation abilities.

The increase in the level of argumentation from experimental class students get a higher increase due to the application of learning using interactive e-worksheets with a PALM with a blended learning approach that has a learning syntax to train students' argumentation skills. The level of argumentation in the experimental class has a higher value due to the investigation process carried out with the argumentation model (Lismawati, Hasnunidah, & Abdurrahman, 2021). In contrast, the control class, which relied on conventional teaching methods, did not achieve the same level of proficiency in argumentation. This further emphasizes the limitations of traditional instructional approaches in fostering advanced argumentation skills, particularly in terms of providing clarifications within arguments. In addition, the argumentation of students using the ADI learning model is significantly higher than the average n-Gain of student argumentation ability using conventional learning (Kadaritna & Tania, 2018). These findings underscore the importance of adopting innovative instructional approaches that actively engage students in constructing and presenting arguments. The project-based argumentative learning model offers a promising framework for enhancing students' argumentation skills, enabling them to develop higher-order thinking abilities, effective communication, and critical analysis.

The results of the Levene Test indicated that the data of the experimental class and the control class were homogeneous, with a significance value of 0.245 (> 0.05). This suggests that there were no significant differences in the baseline argumentation skills between the two groups prior to the intervention. t-test for equality of means revealed a significant difference in the argumentation skills between the experimental and control classes. The

significance value (Sig.) obtained was 0.000 (< 0.05), indicating a statistically significant difference. This finding implies that the use of the project-based argumentative learning model, implemented through a blended learning approach, resulted in a more significant improvement in students' argumentation skills compared to conventional teaching methods. Learning by applying the argumentation model has a significant influence on improving the argumentation ability of students (Marhamah et al., 2017). Learning also becomes more interesting with the use of e-worksheets and makes students become more active during the learning process (Celikler & Aksan, 2012). The application of this model in the experimental class allows students to write Claims well using several clarifications, arguments are easily identified through the presentation of data, can identify clearly and easily clarified (Warrant), and the backing created has supported the warrant by using several clarifications to show evidence (Backing).

These results provide strong evidence supporting the effectiveness of students' argumentation skills. The project-based approach, combined with the blended learning approach, created a more engaging and interactive learning environment, facilitating students' active participation, critical thinking, and collaboration. As a result, students in the experimental class experienced a significant improvement in their ability to construct and present arguments effectively. The analysis of the data revealed that a majority of students were unable to effectively reach level 4 proficiency in each of these components (Figure 4). The findings indicate that students demonstrated relatively better proficiency in formulating clear and concise claims and grounds, which are the foundational elements of an argument. However, there were significant deficiencies in their construction of warrants and backings, which are crucial for providing logical reasoning and supporting evidence in an argument.

In the experimental class, the increase level of argumentation of learners reached level 4. This shows that students have been able to write claims well, write evidence (ground/data) clearly, concisely, and easily identified, provide good justification (warrant) that is easy to identify and connect claims and warrants efficiently and provide backing that supports warrants. PALM activities provided opportunities for students to make an argument through project activities. This activity equips the concepts of students which are used as a basis for arguing. This is in accordance with the results of other studies that state that this learning model is seen as being able to facilitate students to understand the concept of science well, because the learning activities of the argumentation learning model emphasize the construction and validation of knowledge through investigation activities (Andriani & Riandi, 2015). In addition, argumentation skills can develop well in students if students are able to interpret concepts well (Squire & Jan, 2007).

The results of observations made to reveal students' oral argumentation skills during argumentative discussions show that the argumentation develops in the discussion describes the argumentation skills of students. The students' argumentation score range is 1-5, there is variation score of students' argumentation skills. The highest score can be achieved by students in the experimental class, while in the control class the highest score is only achieved level 4. The argumentation skills achieved by students in the experimental class with level 5 showed a more complex interaction pattern, the argumentation discourse developed with claims and counter claims equipped with more than one warrant and

backing. In addition, this score also develops rebuttal to the data, warrant or backing of other learners.

For instance, in their written arguments, students often presented well written claims and grounds, indicating their ability to express their main point and provide relevant evidence. However, further analysis revealed that these claims and grounds required additional clarification and development. Students struggled in linking the grounds to the claims through warrants, as well as providing sufficient backing to support their warrants. Consequently, the overall coherence and strength of their arguments were compromised.

In the epistemic aspect, the quality of arguments reached up to level 4 (60-79%). When comparing the average level of argumentation quality in each descriptor, it was found that descriptor I had the highest level, while descriptor V had the lowest level (Figure 5). The low level of argumentation quality on descriptor V (epistemic aspect) suggests that learners face challenges in unifying the appropriate references when developing backing to support their claims or counterclaims. The analysis of the discussion transcripts indicated that only a small number of students were able to develop adequate backing based on references. This finding highlights the need for explicit instruction and support in helping students effectively integrate and cite relevant references in their arguments.

In addition, argumentation skills are not only influenced by argumentation-based learning but also the level of student ability where students who have higher abilities are significantly different from students with low ability to complete arguments (Lin & Mintzes, 2010). However, argumentation strategies can improve learning outcomes in students with both high and low academic ability (Hasnunidah et al., 2015). Students are more engaged in online learning and make higher efforts to accomplish tasks when worksheets are used in remote education because they are more satisfied with their learning (Çelik, BAKI, & Ahmet, 2022).

Comparing the two categories of conceptual and epistemic aspects, it was observed that the conceptual aspect had a higher average level than the epistemic aspect in both the control and experimental classes. However, the experimental class exhibited a higher average level than the control class in the epistemic aspect (experimental class = 3.60; control class = 2.33). This suggests that learners in the experimental class were more likely to cite sufficient data to support their claims and write logical explanations of phenomena compared to learners in the control class. Students find the interactive e-worksheets on biotechnology and eco-friendly technology in PALM engaging and simple to understand. Additionally, the language is comprehensible and clear. The creation of instructional materials that are clear, accurate, and simple for students to understand is crucial, this is also the primary need for creating e-worksheets (Prastowo, 2019; Sadjati, 2012).

It is evident that students possess some foundational skills in constructing arguments, as evidenced by their effective formulation of claims and grounds. However, their ability to establish warrants and provide substantial backing for their claims needs improvement. These findings highlight the need for targeted instruction and guidance to help students develop a more comprehensive understanding concepts based on e-worksheet. Argumentation strategies proves to be more effective in dispelling misconceptions (Topalsan & Bayram, 2017).

6. Conclusion and Recommendations

This study showed that there are differences in the effectiveness of project-based argumentative learning models with blended learning approaches with conventional methods commonly used by teachers in improving students' argument skills. The use of e-worksheets makes it easier for teachers to display teaching materials and assignments and makes it easier for students to do assignments online anytime and anywhere so that it has a significant effect on student cognitive learning outcomes (Mispa, Putra, & Zaini, 2022).

The discourse pattern with high level achieved by students in the control class has the smallest percentage compared to low level. This shows that learners do not yet have the skills to argue well. Argumentation in learning for them is new as revealed from the results of the questionnaire. The low achievement of high scores for argumentation skills shows that students mostly have difficulty in developing more than one disclaimer that has clear data, warrants or backing against the arguments of other friends. From the results analysis of the transcripts of the discussion, it is known that very few students are able to develop rebuttal to the data, warrants or backing of other students. Most of the rebuttals submitted by learners are not based on clear rebuttals with adequate data, warrants, or backing. This shows that students in the experimental class have better argumentation skills than students in the control class.

Another pattern was also identified, namely that there was an increase in the average level of argumentation quality in epistemic aspects that were significant in learning in the experimental class, both in descriptors II, IV, and V, but this did not happen in the control class. The fact of an improvement in the quality of argumentation in this epistemic aspect can be understood as the impact of the learning strategies used. The phenomenon of low ability to compile data, warrants, or backing (descriptors of epistemic aspects) in the control class, which is at level (1-2) shows that the biggest difficulty in arguing is when developing data, warrants, and backing, especially when having to deal with claims from the opposing group. This fact is supported by the results of the analysis of the transcripts of the discussion it is known that very few learners can take enough data to guarantee their claim, provide a coherent causal explanation to explain a phenomenon, and combine precise rhetorical references when revealing about the data.

Students' argumentation skills after the application of the project-based argumentative-learning model with a blended learning approach to conceptual aspects are in the range of level 1 (0-20%) to level 5 (80-100%). Meanwhile, in the epistemic aspect only up to level 4 (60-79%). Most learners have difficulty in retrieving enough data to warrant their claim, providing coherent causal explanations to explain a phenomenon, and incorporating precise rhetorical references when revealing about the data. The results of the implementation of PALM with a blended learning approach according to the syntax that has been developed and using e-worksheets quite effective (61.92%) in improving students' argumentation skills. PALM with e-worksheet can improve students' argumentation skills significantly.

Student responses were collected through questionnaires to gather their perceptions of the e-worksheets. The results indicated that the e-worksheets were highly rated in terms of attractiveness, usefulness for the project, and communicative language. The findings

suggest that the design and presentation of the e-worksheets were engaging and visually appealing, as indicated by their high attractiveness rating. This is an important factor in keeping students motivated and interested in the learning materials. e-worksheets were also perceived as useful for the project, indicating that they effectively supported students' learning and application of argumentation skills within the project-based context. Furthermore, the e-worksheets were deemed to have a communicative language, implying that the language used in the worksheets was clear, concise, and easily understood by the students. This is crucial for facilitating effective communication and comprehension of the content, enabling students to engage with the materials and develop their argumentation skills. Positive responses from students regarding the attractiveness, usefulness, and communicative language of the e-worksheets indicate that they were well-received and considered effective tools in supporting students' learning and engagement within the project-based argumentative learning model.

The study suggests that while students demonstrate potential in constructing persuasive arguments, there is a clear need for further instruction and support to enhance their ability to articulate warrants and provide backing that strengthens the overall validity of their claims. By addressing these areas of weakness, educators can help students develop a more robust and effective approach to argumentation. Research findings highlight the potential of innovative instructional approaches, such as project-based learning and blended learning, in fostering students' argumentation skills. By providing students with authentic, real-world projects and incorporating technology-mediated learning activities, educators can create a dynamic learning environment that promotes critical thinking, collaboration, and effective argumentation.

Further research could explore the long-term effects of the project-based argumentative learning model on students' argumentation skills. Longitudinal studies could investigate whether the observed improvements in argumentation abilities persist over time and contribute to students' overall academic achievement. Additionally, investigating the transferability of these skills to other academic domains and real-world contexts would provide valuable insights into the broader impact of such instructional approaches. Consider diverse learning style, further study could recognize that students have different learning styles and preferences. To cater to a diverse range of learners, offer alternative formats or versions of the e-worksheets, such as audio recordings or interactive simulations, to accommodate different learning needs.

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