



The argumentation of the students about plant biodiversity: Quasi-experimental research

**Luthfiana Nurtamara *, Sri Amintarti, Aulia Ajizah, Dewi Amelia Widiyastuti,
Noorhidayati, Amalia Rezeki**

Study Program of Biology Education, Faculty of Teacher Training and Education, Universitas Lambung Mangkurat, Banjarmasin,
South Kalimantan, Indonesia

* Corresponding Author Email: luthfiana.nurtamara@ulm.ac.id

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Abstract

Argumentation in science learning is crucial to form scientific explanations supported by strong claims with evidence and explanations. The study used two classes, namely the control class using the discovery learning model, using textbooks from the school, and the experimental group using the STEM PJBL learning model, assisted by teaching modules developed by researchers. The control class consisted of 35 students, and the experimental class consisted of 36 students. The research used a quasi-experimental research method with a posttest-only control design. Post-test results in the control group had an average of 24.28, and the experimental group 50.278. The statistical test used the Mann-Whitney U non-parametric test with a significance value of 0.000, which means that the P-value is less than the 0.05 significance level, so H_0 is rejected, so there is a difference in value between the control class and the experimental class on argumentation skills. The results of this research conclude that most students at level 1 are only able to make claims without being supported by data and reasoning. The low level of argumentation is caused by the lack of argumentation training and the lack of conceptual understanding of students, so it is recommended that science teaching be given argumentation training with contextual and constructivist learning models.

Abstrak. Argumentasi dalam pembelajaran sains sangat penting untuk membentuk argumentasi ilmiah yang didukung oleh klaim yang kuat dengan bukti dan penjelasan. Penelitian ini menggunakan dua kelas, yaitu kelas kontrol yang menggunakan model pembelajaran discovery learning dengan menggunakan buku teks dari sekolah, dan kelompok eksperimen yang menggunakan model pembelajaran STEM PJBL dibantu dengan modul pembelajaran yang dikembangkan oleh peneliti. Kelas kontrol terdiri dari 35 siswa dan kelas eksperimen terdiri dari 36 siswa. Penelitian ini menggunakan metode penelitian kuasi eksperimen dengan posttest-only control design. Hasil posttest pada kelompok kontrol memiliki rata-rata 24,28, dan kelompok eksperimen 50,278. Uji statistik yang dapat dilakukan adalah uji non parametrik Mann-Whitney U dengan nilai signifikansi 0,000 yang berarti nilai P-value lebih kecil dari taraf signifikansi 0,05, maka H_0 ditolak, sehingga terdapat perbedaan nilai antara kelas kontrol dan kelas eksperimen pada keterampilan argumentasi. Hasil penelitian disimpulkan bahwa kebanyakan berada di level 1 sehingga peserta didik hanya mampu membuat claim tanpa disertai data dan alasannya. Rendahnya nilai argumentasi disebabkan karena kurangnya pelatihan berargumentasi dan kurangnya penguasaan konsep peserta didik, sehingga diharapkan pembelajaran sains diberikan pelatihan berargumentasi dengan model pembelajaran kontekstual dan konstruktivis.

A. Introduction

Argumentation is an important component of science literacy for developing scientific explanations and theories (Erduran et al., 2005). Argumentation is a core component of science literacy (Kutluca & Ayd, 2017). Assessment of science literacy has been conducted globally by the OECD PISA shows that the literacy score of Indonesian students has decreased compared to the 2018 score. PISA results on science literacy in 2022 for Indonesian students are 383, which is lower than the previous year 2018 which was 396 and in 2015 which was 403 (OECD, 2023).

Research on argumentation has a central role in curriculum development research and educational research (Iordanou et al., 2019). Toulmin's argumentation emphasizes that argumentation is the key to making statements and opinions about a topic in daily life or in academic work (van Eemeren et al., 2014). Toulmin's argumentation pattern consists of a claim, data, backing, qualifier, and rebuttal (Dawson & Carson, 2018). Argumentation can be established through a process of discussion and debate to provide an explanation for a problem or issue, and can be determined by analyzing the argument structure of the written and spoken words (Dawson & Venville, 2013). The argumentation process facilitates learners to take knowledge from various sources and put it together in a reasonable and logical way, so that learners can gather a comprehensive knowledge and integrate knowledge from other individuals' perspectives (Songsil et al., 2019). The results of the preliminary study of the argumentation survey on students showed the low ability of students to construct structured arguments. Learners are only able to make claims without evidence and reasoning.

STEM-based learning PjBL can be used as an alternative solution to improve argumentation skills. Based on research by Khoeriah et al. (2023) shows that the application of STEM-based learning instruments can improve students' reasoning skills and research by Fajrina et al. (2023) recommends applying PjBL to improve the results of written argumentation skills in students. Based on the results of a literature study by Feziyasti et al. (2025), the effects of the implementation of STEM PjBL on biology learning on critical and creative thinking skills have moderate to high effectiveness, so that it can be used in learning biology, especially on biodiversity and plant species.

Argumentation can be trained in science learning on the topic of biodiversity in Indonesia. Teaching about biodiversity in science education is an important urgency to emerge literacy competence in biodiversity (Katili et al., 2021). Biodiversity is defined as the variety of life at the genetic, species, and ecosystem levels (Yli-Panula et al., 2018). Biodiversity decline has become a major issue today, along with climate change, tropical deforestation and pollution (Krueger, 2000). Biodiversity Education is very essential to be provided in these schools near

important biodiversity hotspots (Børresen et al., 2023). The urgency in this research is to promote plant diversity and provide an effective learning experience to enhance students' argumentation about biodiversity.

Learning about biodiversity in schools is very limited in learning biology at school and only provides a general description of biodiversity, while the specific description of biodiversity around the daily environment of students is not included in the learning book. Researchers have been developing teaching materials to introduce plant biodiversity in South Kalimantan with the title "Teaching Module Biodiversity of Exotic Fruits Plants of South Kalimantan based on STEM-PJBL for Phase E Students" (Nurtamara et al., 2024). The purpose of this study was to determine the effect of applying the STEM PJBL learning model on the topic of Plant Biodiversity in South Kalimantan to train student's argumentation skill. Learning to introduce biodiversity can be done using a project-based learning model by providing questions or problems and defining projects that are carried out to encourage students to learn the learning objectives (Katili et al., 2021).

B. Material and method

The research conducted used a quasi-experimental method. The study used two classes, namely the control class and the experimental class. The quasi-experimental method is research that cannot randomly put subjects into experimental treatment, so researchers use groups that are collected in classes (Ary et al., 2010). The research was conducted for 3 weeks in July until August during the Even semester of the 2023/2024 school year in a Public Senior High School in Banjarmasin. The participants of this study were X grade of science students using 2 intact classes in one of the public high schools in Banjarmasin. One class was selected as an experimental class of 36 students, and the other was selected as a control class of 35 students. The research instrument used written argumentation posttest questions consisting of five essay questions to identify students' claims, evidence and reasoning. During learning activities, arguments spoken by students were also observed and recorded using an observation sheet by the observer, so the data obtained were in the form of written and oral argumentation.

The procedures of this research are experimental class was treated by applying the teaching module of biodiversity of South Kalimantan Flora using the STEM-PJBL learning model and the control class used a discovery learning model using textbooks from schools that did not contain the biodiversity of flora in South Kalimantan. The learning process was observed while discussing and asking questions to record the arguments made by the

students. After the learning was given a post-test in the control and experimental classes. The post-test scores obtained were tested for normality and homogeneity tests for normal data and homogeneous data. If the data is not normally distributed and homogeneous, the Mann-Whitney U non-parametric test is conducted. Non-parametric statistical results are used to determine whether or not there is a significant positive effect of STEM PjBL-based teaching modules on students' argumentation skills

C. Results and discussion

The first argumentation can be identified in the first learning step of STEM PJBL, namely the Reflection Step. At the Reflection stage, learners are asked to analyze why Indonesia is a mega biodiverse country. Learners are also asked to analyze the differences in biodiversity at the gene level, species level and ecosystem level in the South Borneo environment and provide arguments regarding the concept of biodiversity levels. The result of argumentation at the reflection stage is that students reveal the problem and problem formulation, but many students in expressing the problem are only limited to claims, and the teacher must provide follow-up questions so that students are able to reveal data and reasons in determining problems in learning.

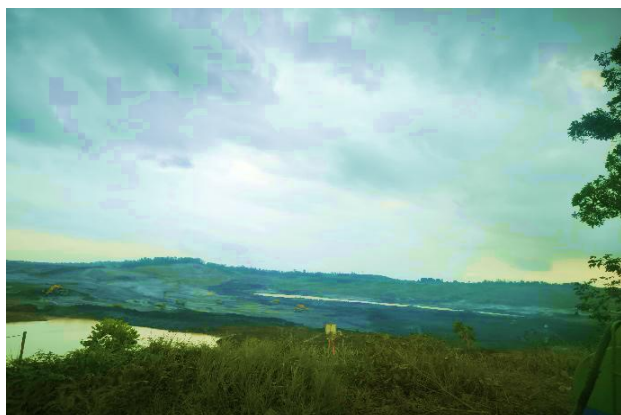


Figure 1 Land used for coal mining threatens biodiversity

Figure 1 presents the deforestation of land for coal mining that is shown in the learners' worksheet to create a problem solution for the threat of land deforestation against biodiversity. A triggering question is asked to learners about how different levels of biodiversity can be preserved if natural habitats are destroyed by coal mining. Biodiversity

loss is a threat that needs to be conserved, learners are asked to provide arguments about how plant conservation is conducted in situ and ex-situ in South Kalimantan. As a result, during the question-and-answer process in the reflection step, most learners could only make claims without being accompanied by reasons, so they needed help from the teacher to direct learners to make claims accompanied by reasons. The results of the analysis of students' worksheets show that some students have misconceptions about *Kebun Raya Banua* (Botanical Garden) as ex-situ conservation because it is still in the South Kalimantan region.

The second and third stages, namely the research and discovery stages, the investigation stage is used to help students find evidence that supports the statements made through literature studies from teaching materials prepared by the teacher in the form of reading materials and videos. In the Merdeka curriculum, teachers can facilitate various learning styles of students including visual by reading scientific literature, audio visual by providing links to learning videos and kinesthetic with outdoor practicum activities to identify various plants around the school environment assisted by plant identification applications. Research and discovery activities are recorded in the students' worksheets that have been completed. The research and discovery stage are used to collect information based on observations and literature studies that can be used to create evidence in argumentation. The results of the worksheet showed that students were still limited that they could only state their statement without the support of data and reasoning in using the information used to complete the project.

The fourth stage is application, a stage that invites learners to work in groups to present their findings in the form of posters regarding the level of plant biodiversity in South Kalimantan. The last stage is asking students to present the findings obtained during the learning process. The communication stage can provide opportunities for learners to state their arguments about the level of biodiversity and conservation efforts. Unfortunately, time limitations caused the absence of a debate process in presenting student arguments. The scoring of students' argumentation is conducted from the assessment of students' worksheets and post-test.

After the learning process, a post-test was conducted to measure students' argumentation skills. Post-test results are presented descriptively in Table 1.

Table 1 Descriptive statistics of argumentation skills of students

Argumentation score	Mean	Median	Variance	Max.	Min.
Control	24.28	30	178.15	60	0.00
Experiment	50.28	50	808.49	100	0.00

Table 2 Level of argumentation

Level	Description of each level of argumentation
2	The participant provides a coherent and logically consistent argument that includes explanations and reasons for his/her position (Claim with reasoning)
1	The participant provides a coherent argument but provides little or no elaboration in terms of the rationale for the position (Claim without reasoning).
0	Participant provides an incoherent response that provides no rationale for the argument (No clear claim)

Based on Table 1 showed that the value in the experimental class (50.28) was higher than in the control class (24.28). The maximum score in the control class was 60 and the maximum score in the experimental class was 100. A score of 100 means that students are able to compile coherent and logically consistent arguments that include explanations and reasons for their position (Claim with reasons). The minimum score in the control class and experimental class was the same at 0 which means that participants gave an incoherent response that did not provide a rationale for the argument (No clear claim).

A complete argumentation consists of claim, data/warrant, backing and qualifier which has level 4 argumentation quality (Cetin, 2014), because students in the study were only able to express claims accompanied by data so that this study only revealed the level of argumentation up to level 2. The post-test results show the overall class picture in both the control and experimental class; therefore, the distribution of the mean argumentation quality can be seen in Table 2 and Figure 2.

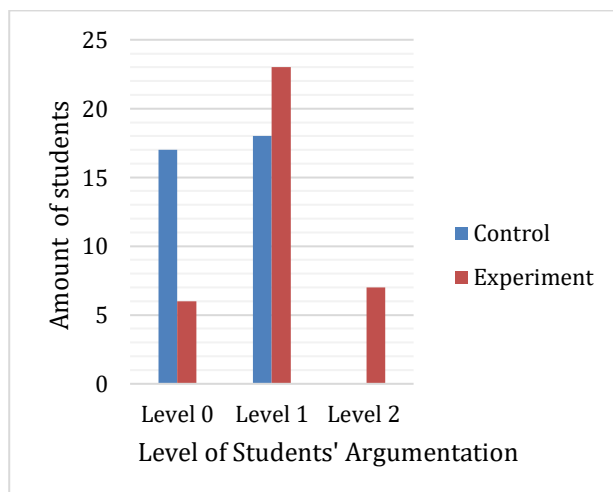


Figure 2 Students' argumentation quality level

Based on Figure 2, it is known that the average quality of argumentation in the control and experimental classes is at level 1. The lowest in level 0 in the control class was 17 people, and the experimental class was 6 people. Level 2 was only found in the experimental class, which was given an intervention in the form of applying the STEM-PJBL learning model using the teaching module for flora biodiversity in South Kalimantan. examples of learner-

derived arguments about in-situ conservation in Kalimantan are presented below:

- Level 2 = "In situ conservation can be conducted in the natural habitat (Claim). in-situ conservation is chosen because it is carried out in the place of origin of the plant species (Reasoning)."
- Level 1 = "In situ conservation, in the natural habitat (Claim only)".
- Level 0 = "ex-situ conservation (wrong claim) or didn't made claim".

The result of argumentation of student are low. The argumentation is still weak, possibly in the STEM-PjBL learning process that is implemented has not optimally encouraged students to provide and correlate data, evidence, or information to compose arguments that are meaningful and make reasonable logically. The research was limited to giving a post-test and assessing the opinions expressed during the lesson as well as those recorded in the learners' worksheets. The solution to explore students' reasoning skills, teachers need learning instruments that can recognize when students can express complex reasoning during learning (Dolan & Grady, 2010). In addition, interview instruments are needed to clarify answers and explore students' reasoning skills more deeply (Widodo et al., 2016).

Learning to build arguments is very important in science learning, because epistemic knowledge construction can be done by asking questions, observations, theories, hypotheses, and arguing; introducing scientific enquiry and conducting peer review, so that knowledge can be trusted (PISA, 2019). Learning in the experimental class was carried out by finding problems in accordance with the context of science to develop awareness, as presented in the student worksheet which provides the issue of loss of biodiversity in South Kalimantan due to land clearing for oil palm and mining. After finding the problem, participants formulate problem formulations, hypotheses, conduct literature reviews and observations related to plant biodiversity problems faced by compiling keywords for each problem and summarizing statements in the form of posters. Introducing learners to issues relevant to science content can help learners to contextualize science ideas and provide opportunities for learners to build effective arguments with their peers (Owens et al., 2017).

Table 2. Results of normality and homogeneity tests

Type of test	Class	P-Val	Results	
			Description	Decision
Normality	Control	0.006	P-value < 0,05	The data is not normally distributed
	Experiment	0.010	P-value < 0,05	The data is not normally distributed
Homogeneity	Control and experiment	0.002	P-value > 0,05	Inhomogeneous data

Table 4 Non-parametric statistical tests

	Argumentation score
Mann-Whitney U	240.500
Wilcoxon W	870.500
Z	-4.535
Asymp. Sig. (2-tailed)	0.000

After obtaining descriptive statistical data regarding argumentation skills, hypothesis testing was carried out to determine the effect of treatment on the experimental class compared to the control class. Before testing the hypothesis, it is necessary to test the normality and homogeneity of the data (Simatupang et al., 2024). Normality and homogeneity tests are presented in Table 3.

The data from the post-test results were tested for normality and homogeneity, showing that the data in the control class and experimental class had an abnormal and inhomogeneous distribution. Data that are not normal and homogeneous regarding argumentation level data and informal reasoning, so that non-parametric statistical tests are carried out to analyze the dependent variable (Venville & Dawson, 2010). The results of non-parametric statistical tests are presented in Table 4.

The results of the Mann-Whitney U test statistical test showed a significance of 0.00 which meant that the P-value was less than the significance level of 0.05, so H₀ was rejected, so there was a difference in value between the control class and the experimental class on the argumentation skills of students. Argumentation skills in experimental class students are better than in control class students, because the experimental class gets a learning experience using a teaching module for the biodiversity of flora in South Kalimantan with a PJBL learning model. Project-based learning involves learners and teachers finding solutions to questions in the lives around learners (Krajcik & Czerniak, 2018). Students' arguments are weak because students have not fully understood the concept of the level of biodiversity and its conservation efforts, especially in the South Kalimantan region.

At the genetic level of biodiversity, students are asked to make an argument regarding the genetic diversity of *Oryza sativa* cultivars in Banjarmasin such as Siam Mutira, Siam Unus, Karang Dukuh etc, at the species diversity level, students are asked to make an argument regarding the diversity of mango fruit species such as mango kueni (*Mangifera odorata*), Hampalam (*Mangifera laurina*), Kasturi (*Mangifera*

kasturi) and Hambawang (*Mangifera foetida*) and other local fruit plants, as well as plants such as ulin, meranti, galam and aquatic plants in Wetlands. There are many students in the control class who are unable to make an argument correctly because of their misunderstanding of the concept of biodiversity level and students do not recognize the plant species around them, because in the commonly used books the species introduced are not from their daily lives. In the argumentation about biodiversity conservation efforts, there are still some students who do not understand the difference between in-situ and ex-situ conservation.

Incorrect conceptualization causes students' argumentation scores are still weak. Poor conceptualization leads to low argumentation quality because the higher the learning outcomes of students, the higher the quality of their argumentation (Dianti et al., 2023). Understanding of scientific concepts is very important to provide data or scientific evidence that will be used in making arguments, one biological concept learned in one case can also be applied to overcome other cases in biology, so it is necessary to master biological concepts and practice argumentation skills that are accompanied.

The argumentation score in the control class (24.28) and the experimental class (50.28) is still on the low side, so it needs to be re-trained to students through learning activities that habituate critical thinking in regards to building science knowledge concepts through argumentation. The results of research on grade XI students in one of the high schools in Indonesia show weak student argumentation scores, students are only able to make arguments with claims and data, such as the results of the study of Hardini & Alberida (2022).

Education in Indonesia faces the challenge of how to improve scientific argumentation so that future generations of Indonesians become critical citizens who are able to respond to science issues with structured arguments with valid evidence and reasons for making decisions. Science education must change from providing knowledge to building knowledge through training in argumentation and decision-

making (Nurtamara et al., 2019). Teachers should be aware that if students are not taught how to think critically and build arguments to analyze problems and find solutions, it is feared that a generation will emerge that is difficult to make decisions quickly and accurately. The science curriculum has recommended science learning that integrates Nature of Science learning as a subject, where ideas are based on evidence, argumentation, and creativity (Forst, 2014).

D. Conclusion

Students' argumentation skills are still low, mostly at level 1. Students have provided a coherent argument but provide little or no elaboration in terms of the rationale for the position (Claim without reason). STEM-PjBL learning that was implemented for 3 weeks has not yet achieved optimal results to enhance students' argumentation skills. In order to improve argumentation skills, it is recommended that students are continuously trained by involving students in discussing, debating, and presenting concepts/solutions about problems in everyday life related to science. To improve argumentation skills, learners are encouraged to discuss, debate, and communicate concepts/solutions about problems in everyday life that are related to science. The problem of low argumentation level in students is caused by students not understanding the concept of biodiversity at the gene, species and ecosystem levels and their conservation efforts. the concept of biodiversity presented in the study is the flora that lives in southern Kalimantan, so that students are more unfamiliar because it is rarely shown in textbooks in schools, which are still generally characterized by the biodiversity. Conceptual understanding is crucial for building argumentation with strong claims that are based on evidence and conformance to theory.

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