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# Enhancing Scientific Argumentation Skills in High School Physics: A Blended Learning Approach with Project-based Instruction

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***ABSTRACT***
*This empirical investigation delves into the application of blended learning within project-based instruction (project-based blended learning), within the framework of physics education for eleventh-grade students in a high school setting. The primary aim is to unravel the repercussions of this teaching model on the students' proficiency in scientific argumentation, particularly in the domain of optical instruments. Employing the non-equivalent control group design, the study enlists two classes: the experimental and the control group at a senior high school in Bandar Lampung, Indonesia, encompassing a total of 60 students during the academic year 2022/2023. Quantitative evaluation of scientific argumentation skills was conducted through tests, while qualitative insights into student reactions were garnered via an open-ended questionnaire. The findings underscore a noteworthy enhancement in the scientific argumentation abilities of the experimental group (n-gain: 0.69) as opposed to the control group (n-gain: 0.40), with the test of mean differences yielding a significance level (2-tailed) of 0.00. Qualitative scrutiny of the data also brought to light a more pronounced positive reception from students in the experimental cohort, lending support to the potential refinement of the project-based blended learning model for the augmentation of students' scientific argumentation aptitude.*

## INTRODUCTION

Argumentation is the process of reinforcing a claim through critical thinking, relying on evidence and logical reasoning. In the context of physics education, argumentation plays a crucial role, providing students with opportunities for group discussions and expressing opinions that determine the extent of their understanding of concepts, skills, and scientific reasoning abilities [1]. Through argumentation activities in the classroom, students not only learn physics but also have the chance to practice scientific methods when defending or challenging ideas [2]. Additionally, students engage in providing evidence, data, and valid theories to support their opinions on an issue. In recent years, the significance of argumentation in education has been widely emphasized [3].

Proficiency in scientific argumentation is crucial in the scientific thinking process; however, the scientific argumentation skills of students remain relatively deficient. Research conducted by Larrain et al. [4] suggests that the limited ability to engage in scientific arguments is a result of students lacking sufficient knowledge to substantiate their claims. Therefore, effective instructional strategies are needed to enhance students' capabilities in this area. One such strategy is project-based learning (PjBL) incorporating argument mapping and online laboratory components, which has demonstrated positive results in improving the students' argumentation skills [5].

Scientific argumentation skills can be improved through physics education. Based on research conducted by Riwayani et al. [6], the PjBL model can enhance scientific argumentation skills both qualitatively and quantitatively. Soparat et al. [7] suggest that the stages in PjBL can develop students' reasoning, thus enhancing scientific argumentation. However, the use of PjBL in education has yet to be integrated with technology. Hence, there is a need for an engaging learning system that utilizes technology.

In the educational landscape, technology plays a crucial role in implementing diverse instructional systems, with Blended Learning standing out as a method that integrates face-to-face classroom instruction with online learning. A study by Misbah et al. [8] revealed learners' positive perceptions of blended learning, highlighting its potential effectiveness. Ustun & Tracey [9] emphasize the importance of selecting the appropriate instructional model for an efficient learning process. Therefore, incorporating technology, particularly through Blended Learning, holds promise for optimizing the educational experience for both educators and learners.

Agusdianita's [10] study suggests that a synergistic integration of Blended Learning and PjBL (known as project-based blended learning, PjBBL) holds the potential to foster meaningful learning experiences. Building on this notion, Dai et al.'s [11] research underscores the effectiveness of PjBL within a Blended Learning framework, showcasing discernible advancements in the independent learning capabilities of participating students. Furthermore, Alamri's [12] investigation asserts that the incorporation of PjBBL significantly influences student learning outcomes. Complementing these findings, a study by Odja et al. [13] reveals that the combination of problem-based learning and blended learning notably enhances the problem-solving skills of middle school students, particularly in the domain of light physics.

Consequently, this study aims to address the research question: Can the implementation of a blended learning approach within the context of problem-based instruction enhance students' argumentation skills in high school physics? By synthesizing insights from these diverse studies, the research endeavors to contribute to the understanding of how the strategic integration of instructional methodologies can positively impact students' learning experiences and outcomes in the field of physics education.

## METHOD

This research constituted an experimental study employing the nonequivalent control group design. The study comprised two groups: the experimental group which underwent blended learning within the context of project-based instruction, and the control group which experienced direct instruction. The population for this research includes all eleventh-grade science classes at SMA Negeri 15 Bandar Lampung for the academic year 2022/2023. The sampling technique employed in this study was a cluster random sampling. Consequently, the sample for this study includes 30 students for each the experimental and the control groups. The experimental and control groups underwent different instructional approaches: the experimental group engaged in blended learning within the context of project-based instruction, as illustrated in Table 1, while the control group experienced a traditional direct instruction model.

**Table 1.** Learning sequence for blended learning in a project-based instruction model

| No. | Phase | Activity | Learning Mode |
|---|---|---|---|
| 1 | Driving question | The teacher presents the entry event related to optical instruments to students and guide them to propose project's driving questions | Asynchronous online learning using Google Classroom |
| 2 | Preparation | The teacher organize students into small groups and facilitating them to explore the knowledge and skills required for project completion | Face-to-face learning |
| 3 | Project's planning | Students design a project plan and arrange their teamwork schedule | Face-to-face learning |
| 4 | Implementation and monitoring the progress | Students implement their project plan outside the classroom, and the teacher monitors their progress online | Outside of classroom and online |
| 5 | Presentation and discussion | Some groups present the results of their project and engage in discussions with their peers | Face-to-face learning |
| 6 | Evaluation and reflection | The teacher evaluates students' work and encourages them to reflect on their learning experiences | Face-to-face learning |

The research employed a test instrument as the data collection tool, comprising pretest and posttest with ten essay questions. This test instrument was designed to measure students' scientific argumentation skills in both groups before and after the learning process. The test questions were formulated based on indicators of scientific argumentation skills, encompassing claims, evidence, and warrants. Claims refer to students' ability to state assumptions or conclusions regarding a question. Evidence serves as the support for claims, while warrants indicate how the evidence supports the claim. Before being used for data collection, the test underwent validity and reliability testing. The validity test employed the Pearson correlation method, while reliability was assessed using the Alpha Cronbach's formula. Thus, the test instrument used in this research can be considered valid and reliable.

Quantitative data in this research are analyzed using n-gain to measure the improvement in students' scientific argumentation before and after the learning process. As a prerequisite for parametric testing, the n-gain data are analyzed using tests for normality and homogeneity. If the data are normally distributed and homogeneous, the independent sample t-test is utilized as a hypothesis test to determine whether there is a significant difference in the averages of the two independent samples. Subsequently, to assess the magnitude of the effect post-treatment, an effect size test is conducted. On the other hand, the qualitative data from questionnaire were analyzed with the protocol of thematic analysis. The obtained response data are in the form of written verbal expressions. The researcher then reads through the entire data to understand the context and gain a general overview. The next step involves identifying patterns or themes that emerge repeatedly in the data. These themes are grouped and labeled to attribute meaning to the findings. In the final stage, the results of the thematic analysis are presented in the form of tables or narratives.

## RESULTS AND DISCUSSIONS

*Quantitative Data*

The results of this study encompass both quantitative and qualitative data. To obtain quantitative insights, testing techniques, including a pretest administered before the initiation of the learning process and a posttest conducted upon its completion, were employed. The quantitative data extracted from both the experimental and control groups are depicted in the aforementioned table. Notably, the table reveals that the average posttest scores in the experimental group surpass those in the control group. Additionally, the n-gain was analyzed to assess the progression in students' scientific argumentation both before and after the learning process. The outcomes of the n-gain are delineated in the same table. Table 2 also highlights that the average n-gain value in the experimental group exceeds that in the control group, indicating a significant improvement in students' scientific argumentation throughout the learning process within the experimental class. This underscores the superior effectiveness of PjBBL compared to Direct Instruction.

**Table 2.** Statistical descriptive of scientific argumentation

| Parameter | Experiment | | Control | |
|---|---|---|---|---|
| | *Pre-test* | *Post-test* | *Pre-test* | *Post-test* |
| Number of sampel | 30 | 30 | 30 | 30 |
| Minimum | 20 | 70 | 30 | 50 |
| Maximum | 50 | 90 | 50 | 78 |
| Average | 34.93 | 80.53 | 39.27 | 64.27 |
| Standard of deviation | 8.66 | 5.73 | 6.72 | 7.64 |
| n-gain | 0.69 | | 0.40 | |

The normality test was conducted on the n-gain data from both classes, and the results are documented in Table 3. Table 3 indicates that the significance value (2-tailed) is greater than 0.05, suggesting that the data can be concluded to follow a normal distribution. In addition to the normality test, a homogeneity test was also conducted to assess the homogeneity of variance in scientific argumentation data. The homogeneity test results show that the Levene's statistic is 1.950 with a significance value (2-tailed) of 0.168, which is greater than 0.05. Therefore, it can be concluded that the n-gain data from both classes exhibit uniform or homogeneous variance.

**Table 3.** Result of normality test

| Group | *Sig (2-tailed)* | Interpretation |
|---|---|---|
| Experiment | 0.200 | Normal |
| Control | 0.200 | Normal |

*Hypothesis Testing*

Analysis using the independent sample t-test aims to determine whether there is a significant difference in the mean scores of scientific argumentation between two unmatched groups. From the test results presented in Table 5, the significance value (Sig) for the experimental and control groups is 0.00, which is below the threshold of 0.05. This indicates a significant difference in the mean scores of students' scientific argumentation between the experimental and control groups, aligning with the proposed hypothesis.

Subsequently, the effect size test is employed to measure the magnitude of the impact of PjBBL on scientific argumentation skills. According to the documented results in Table 6, the Cohen's d value for the experimental group is 2.478, categorized as a large effect. Therefore, it can be concluded that the implementation of PjBBL has a substantial impact on enhancing students' scientific argumentation skills compared to the control group.

*Qualitative Data*

To obtain qualitative data, this study utilized questionnaires containing student responses after the implementation of the learning activities. Thirty students completed the questionnaires, providing both positive and negative responses, which are detailed in Table 4. The majority of responses expressed by students were of a positive nature. Through thematic analysis of the students' questionnaire responses, four types of positive responses were identified, while negative responses comprised only two types, with relatively low percentages.

**Table 4.** Qualitative data on students' response

| Aspect | Category | Sample of students' statement | Frequency (%) |
|---|---|---|---|
| Positive response | Easier to understand the materials | - "I find it easier to grasp the material because learning through projects is more effective for me compared to receiving explanations solely from the teacher" | 20 (66%) |
| | Enhancing communication skills | - "In addition to finding it easier to comprehend the material, I am also more confident in expressing my opinions/ideas regarding the project at hand"<br>- "I am more courageous in posing questions when there are aspects of the project that I have not fully understood" | 22 (73%) |
| | Increasing students' collaboration. | - "The positive thing of this learning experience is the ability to collaborate effectively within the team and appreciate each other's opinions"<br>- "The learning approach has made me actively engage in discussions with the team to successfully complete the project" | 16 (53%) |
| | Increasing students' creativity | - "This learning experience has spurred me to become more creative in producing excellent projects" | 20 (66%) |
| Negative response | Encountering challenges in team collaboration | - "Sometimes, it's challenging to collaborate within the team due to certain members being difficult to coordinate"<br>- "Some members do not actively participate in group work, leading to suboptimal outcomes in project development" | 6 (20%) |
| | Difficulty in communication | - "Limited involvement in the project creation process makes it challenging for me to express my ideas"<br>- "Difficulty in conveying ideas/opinions during project development arises from certain group members not appreciating the ideas/opinions of others" | 4 (13%) |

*Discussion*

The research results indicate that the implementation of PjBBL is effective in enhancing students' scientific argumentation skills. This is substantiated by the difference in the average n-gain test scores between the pretest and posttest in the experimental and control classes. The experimental class, subjected to PjBBL treatment, achieved an average n-gain of 0.69. Conversely, the control class, undergoing Direct Instruction model treatment, attained an average n-gain of 0.40. These findings highlight a more significant improvement in students' scientific argumentation skills in the experimental class compared to the control class.

The efficacy of learning in the experimental class is attributed to the successful implementation of PjBBL. This approach elevates student engagement across various stages of project development, including formulation, design, completion, presentation, and evaluation. These findings align seamlessly with the research conducted by Suana et al. [14], highlighting the positive impact of the PBBL model on enhancing students' creative thinking abilities. The study underscores the transformative potential of PjBBL in reshaping conventional teaching methods, particularly in cultivating creative thinking skills amidst complex global issues like climate change. Furthermore, PjBBL encourages active student participation in group discussions, fostering collaboration in designing and investigating project outcomes. This student-centered approach creates a dynamic learning environment, enriching their educational journey through hands-on involvement in scientific projects.

Student involvement in each stage of the PjBBL process in this study can stimulate the enhancement of students' scientific argumentation skills. This improvement is attributed to the learning process utilizing the PjBL model, which incorporates stages that facilitate students' understanding of the learning material through the creation of projects. According to Mihardi et al. [15], projects in PjBL can cultivate students' argumentation skills based on evidence acquired throughout the learning process. In this study, the scientific argumentation test questions focused on optical devices, particularly magnifying glasses and cameras. The pretest and posttest items in this research align with the primary indicators of students' scientific argumentation according to Toulmin, i.e claim, data/evidence, and warrant [16]. The n-gain achievement graph for scientific argumentation indicators is presented below.

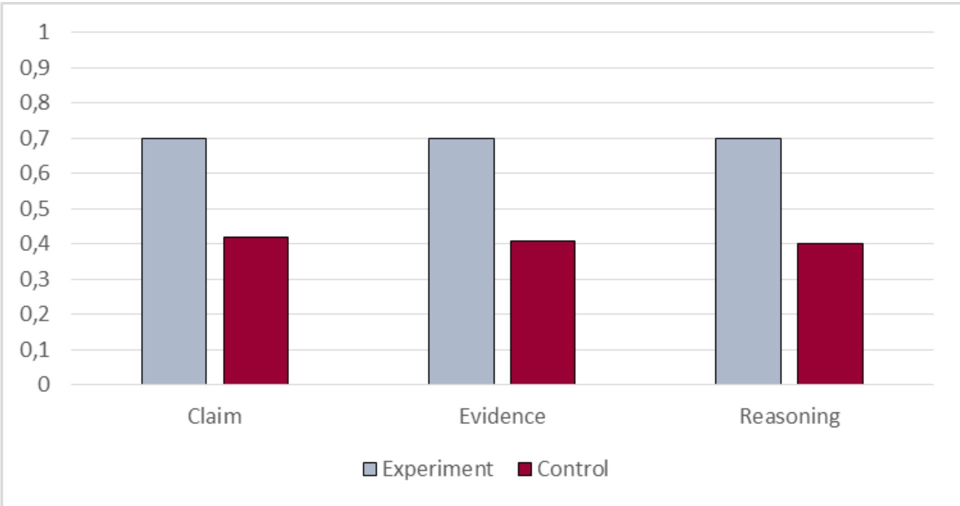


***Fig 1.*** *N-gain for each scientific argumentation indicator*

The above figure illustrates the results of the n-gain analysis for each scientific argumentation indicator. Based on the graph, all three indicators show improvement in both the experimental and control classes. However, in this study, the experimental class experienced a significantly higher increase compared to the control class. This is attributed to the learning process in the experimental class using the PjBL model, which includes a learning stage with prompting questions that can stimulate students to be more active in the learning activities. During this stage, students are given the opportunity to generate ideas and thoughts expressed in the form of questions through extensive and diverse thinking processes. Thus, at this stage, students can pose questions or respond to questions in the form of arguments (claims).

In expressing opinions or arguments, it is essential to be supported by data, facts, or evidence. Based on the graph, the evidence indicator also demonstrates improvement. This is attributed to the PjBL process, which involves project completion stages such as designing, planning, and implementing the project. The implementation of the project in this research aims to substantiate or investigate arguments through the outcomes of the project. Therefore, this stage requires students to engage in group discussions, study literature, create and investigate project outcomes to discover data, facts, or evidence that can be used to support and investigate arguments through project results.

In addition to claims and evidence, the reasoning indicator also experiences improvement. This enhancement is due to the PjBL process, which includes stages of presentation, discussion, evaluation, and reflection. In this stage, students discuss their arguments and then present them. Through discussion, students find it easier to comprehend the material concepts, enabling them to provide more detailed explanations to reinforce arguments and evidence. Following the presentation and discussion, students can evaluate arguments and draw conclusions about the validity of their claims.

The findings of this research align closely with a study conducted by Riwayani et al. [6] which asserts that PjBL enhances both qualitative and quantitative scientific argumentation skills in SMA Negeri 1 Prambanan Yogyakarta. Another study by Soparat [7] suggests that student projects based on PjBL stages can foster students' reasoning, thereby improving their scientific argumentation skills. In a study conducted by Setiono [17], the implementation of PjBL is found to enhance scientific argumentation skills among pre-service students at the University of Bengkulu in the language skills course. Despite these similarities, the key distinction lies in the instructional approach employed. The mentioned studies utilized a fully face-to-face learning system, while the current research embraced a blended learning system.

The strengths of this PjBBL research lie in its ability to cultivate students' responsibility in project completion, providing ample opportunities for them to make decisions in project creation, and yielding tangible products presented within the class. Additionally, the Blended Learning system facilitates easier access to online learning materials, enables discussions with teachers and peers outside face-to-face sessions, and offers a more flexible learning schedule [14].

Despite the inherent advantages of PjBBL, several challenges arise during its instructional process. These challenges include the occasional necessity for guidance and supervision to navigate each learning step, as teachers consistently observe student activities to assess the attainment of learning objectives. Additionally, researchers must carefully consider the time allocation needed for each learning topic. In the existing literature, scholars have extensively identified challenges during implementation, particularly categorizing them into three main areas: technological literacy and competency, technological sufficiency challenges, and technological operational problems [18]. Within the learning model, issues emerge, ranging from the complexities of designing learning activities to the substantial time and effort invested in assessment and controlling activities. Moreover, students' unfamiliarity with the new model poses an additional hurdle [19].

Another layer of complexity in PjBBL implementation arises from challenges highlighted in external studies. For instance, a study by Ozdamli &Turan [20] emphasized that existing challenges were further compounded by internet connectivity and communication issues. This finding aligns with the observations made by Hursen [21], who specifically identified internet connection problems and insufficient technological devices as significant obstacles in the implementation process. Thus, while PjBBL offers promising educational benefits, addressing these challenges becomes imperative for its effective integration into the learning environment.

## CONCLUSION AND SUGGESTION

The results of this study significantly indicate that the implementation of PjBBL is effective in enhancing students' scientific argumentation skills, as supported by the independent sample t-test with a significance value of 0.00. The implications of these findings are highly relevant for educators, providing insights into designing more effective teaching strategies to improve the quality of the learning process. Therefore, it is recommended that the PjBBL approach be more widely integrated into the physics education context in schools. Furthermore, the qualitative data analysis indicates a predominantly positive response from students to the PjBBL approach, showcasing improvements in material comprehension, communication skills, effective collaboration, and creativity. However, some students faced challenges in team collaboration and communication, emphasizing the importance of better team management and communication facilitation in implementing this approach.

Recommendations for future research could focus on developing a more specific and tailored model of

PjBBL to meet the students' needs. Additionally, research could explore the impact of technology use in the context of physics education, particularly through the Blended Learning approach. Further studies might also evaluate the long-term effects of implementing PjBBL on students' scientific argumentation skills.

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## REFERENCES

[1] Erduran, S., & Park, W. (2023). Argumentation in physics education research: Recent trends and key themes. *The international handbook of physics education research: Learning physics*, 16-1.

[2] Pols, C. F. J., Dekkers, P. J. J. M., & de Vries, M. J. (2023). Integrating argumentation in physics inquiry: A design and evaluation study. *Physical Review Physics Education Research*, *19*(2), 020170.

[3] Wess, R., Priemer, B., & Parchmann, I. (2023). Professional development programs to improve science teachers' skills in the facilitation of argumentation in science classroom—a systematic review. *Disciplinary and Interdisciplinary Science Education Research*, *5*(1), 9.

[4] Larrain, A., Howe, C., & Cerda, J. (2014). Argumentation in whole-class teaching and science learning. *Psykhe*, *23*(2), 1-15.

[5] Jumadi, J., Perdana, R., & Rosana, D. (2021). The Impact of Problem-Based Learning with Argument Mapping and Online Laboratory on Scientific Argumentation Skill. *International Journal of Evaluation and Research in Education*, *10*(1), 16-23.

[6] Riwayani, R., Perdana, R., Sari, R., Jumadi, J., & Kuswanto, H. (2019). Analisis kemampuan argumentasi ilmiah siswa pada materi optik: Problem-based learning berbantuan edu-media simulation. *Jurnal Inovasi Pendidikan IPA*, *5*(1), 45-53.

[7] Soparat, S., Arnold, S. R., & Klaysom, S. (2015). The Development of Thai Learners' Key Competencies by Project-Based Learning Using ICT. *Online Submission*, *1*(1), 11-22.

[8] Misbah, M., Khairunnisa, Y., Dewantara, D., Haryandi, S., Purwasih, D., Muhammad, N., ... & Ibrahim, M. A. (2023). Students' Perception on Online Learning Experience During Pandemic (Covid-19). *JIPF (Jurnal Ilmu Pendidikan Fisika)*, *8*(1), 42-52.

[9] Ustun, A. B., & Tracey, M. W. (2020). An effective way of designing blended learning: A three phase design-based research approach. *Education and Information Technologies*, *25*(3), 1529-1552.

[10] Agusdianita, N., Karjiyati, V., Hasnawati, H., & Dalifa, D. (2019, April). The Influence of Project Based Learning Model in Thematic Learning by Using Scientific Approach on the Elementary School Students. In *International Conference on Educational Sciences and Teacher Profession (ICETeP 2018)* (pp. 100-102). Atlantis Press.

[11] Calculli, C., D'Uggento, A. M., Labarile, A., & Ribecco, N. (2021). Evaluating people's awareness about climate changes and environmental issues: A case study. *Journal of Cleaner Production*, *324*, 129244.

[12] Alamri, M. M. (2021). Using blended project-based learning for students' behavioral intention to use and academic achievement in higher education. *Education Sciences*, *11*(5), 207.

[13] Odja, A. H., Hasan, M., & Mursalin, M. (2022). The Effect of Problem Based Learning Applied With Blended Learning on Students' Problem Solving Skills. *JIPF (Jurnal Ilmu Pendidikan Fisika)*, *7*(3), 248-255.

[14] Suana, W., Wati, S., Distrik, I. W., Sagala, M. K., & Rinaldi, D. (2023). The Effect of Project-Based Blended Learning Model on Students' Creative Thinking Skills in Global Warming Topic.

*Jurnal Ilmiah Pendidikan Fisika*, *7*(3), 424-433.
[15] Mihardi, S., Harahap, M. B., & Sani, R. A. (2013). The effect of project based learning model with kwl worksheet on student creative thinking process in physics problems. *Journal of education and practice*, *4*(25), 188-200.
[16] Toulmin, S. E. (2003). *The uses of argument*. Cambridge university press.
[17] Setiono, P., Yuliantini, N., Wurjinem, W., & Anggraini, D. (2021). Kemampuan Argumentasi Ilmiah Mahasiswa Melalui Penerapan Model Pembelajaran Project Based Learning. *ELSE (Elementary School Education Journal): Jurnal Pendidikan Dan Pembelajaran Sekolah Dasar*, *5*(1), 101-111.
[18] Suana, W., Andra, D., Permadi, D., & Putri, N. M. A. A. (2023, May). A Systematic Review of Project-Based Blended Learning as an Innovative Teaching Model. In *4th International Conference on Progressive Education 2022 (ICOPE 2022)* (pp. 138-148). Atlantis Press.
[19] Nguyen, V. A. (2017). A peer assessment approach to project based blended learning course in a Vietnamese higher education. *Education and Information Technologies*, *22*, 2141-2157.
[20] Ozdamli, F., & Turan, B. (2017). Effects of a Technology Supported Project Based Learning (TS-PBL) Approach on the Success of a Mobile Application Development Course and the Students' Opinions. *TEM Journal*, *6*(2).
[21] Hursen, Ç. (2018). The impact of Edmodo-assisted project-based learning applications on the inquiry skills and the academic achievement of prospective teachers. *TEM Journal*, *7*(2), 446-455.