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The Feature of Project-Based Learning and Differentiated Instruction Practices in Biology Learning

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Abstract: This research aims to examine Biology teachers' views on the effectiveness of Project Based Learning (PjBL) in building a conducive learning environment that increases student involvement and socio-cultural awareness in Biology learning in Indonesia. In addition, this research aims to explore the methods used by Biology teachers in implementing differentiation in Biology education in the Indonesian context. The approach was taken with a sequential mixed methods strategy, which ensured comprehensive data collection. and the use of qualitative and quantitative methods starting with distributing questionnaires to 200 Biology teachers, followed by focus group interviews with eight volunteer educators. The results of the study state that Biology educators consider project-based learning as a useful teaching method that contributes to increased student engagement, increased social dynamics in the classroom, cultural appreciation, and effective implementation of strategies for differentiated learning. These findings have implications across multiple domains, including teacher professional development, academic administration, curriculum design, and decision-making processes. Furthermore, the insights gained from this research may extend beyond the boundaries of Biology education, attracting interest from stakeholders in a variety of academic disciplines.

Keywords: Biology learning; Differentiated learning; Project-based learning

Introduction

Differentiated instruction and project-based learning have recently captured the focus of instructors and educators, primarily because of their essential position in establishing dynamic learning environments. As a sovereign nation, Indonesia's leaders and government institutions have emphasized the need to educate a well-rounded citizenry, capable of dealing with the difficulties of contemporary life and contributing effectively to global society. Therefore, various educators in Indonesia have taught the application of educational practices that focus on creating a learning environment that encourages interaction, collaboration and critical thinking. These elements are seen as important foundations for achieving educational excellence in the country.

It is important to see the teacher's perspective regarding the benefits of implementing an organized project-based learning model in Biology learning. The goal is to create an interactive learning atmosphere that supports skill development while integrating social, cultural, and academic enrichment. Furthermore, this research seeks to effectively accommodate differentiated

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learning, encourage student-centered learning and assist teachers in facilitating student skill development. This inquiry is particularly relevant in the Indonesian context, where the country is actively pursuing ambitious national goals and participating in international educational efforts aligned with 21st century learning principles.

In Indonesia, there is broad consensus on the need to improve the education system and value teamwork and hands-on learning as fundamental components in building and acquiring knowledge (Kreher et al., 2021). Therefore, educators and researchers in Indonesia have put forward many recommendations that underline the urgent need to change teaching methods, with an emphasis on implementing PjBL. Indonesia's goal is to build an effective educational environment for its population, in line with the demands of a society that continues to develop, a knowledge-based economy. Realizing this goal requires the integration of various factors, including critical thinking, reasoning, problem solving, and project-based learning.

If we break down the issues mentioned above and consider Indonesia's National Agenda, it is clear that Indonesia is currently in a continuous and urgent effort to keep up with contemporary teaching and learning trends in order to contribute to national educational progress. educational outcomes. Therefore, there is an urgent need to explore and implement appropriate approaches that can improve the overall educational process. This goal can be realized by encouraging a more dynamic and student-focused learning atmosphere. In this context, this research seeks to contribute to the body of knowledge that supports strategies that are aligned with Indonesia's national and global initiatives, which underscore the nation's commitment to realizing and facilitating this educational progress.

Additionally, integrating Project Based Learning (PjBL) and differentiated instruction is critical to meeting the diverse needs of students as they strive to achieve educational goals. As a result, there is an urgent need to introduce innovative teaching approaches to replace traditional methods.

Based on the background of these problems, this research aims to examine Biology teachers' views on the effectiveness of Project Based Learning (PjBL) in building a conducive learning environment that increases student involvement and socio-cultural awareness in Biology learning in Indonesia. Apart from that, this research also aims to explore the methods used by Biology teachers in implementing differentiation in Biology education in the Indonesian context.

Method

Research Method and Setting

The research approach is based on the theoretical framework and research questions. To effectively answer the research questions, a sequential mixed methods strategy was used, starting with the distribution of a questionnaire to 200 Biology teachers and continuing with focus group interviews with eight volunteer educators. Integrating qualitative and quantitative methods provides deeper insights (Creswell, 2014).

So the use of both methods is essential for a robust analysis. Following Creswell's recommendation, this study adopted a three-phase approach. The first phase involved collecting quantitative data through a questionnaire. However, some aspects, such as the impact of PjBL on cultural and social awareness, needed to be explored further because the survey was not in-depth enough. Therefore, the second phase involved focus group interviews with experienced teachers to gain more detailed insights. The third phase involved integrating and analyzing both data sets to produce comprehensive conclusions. In this framework, the use of qualitative and quantitative methods provides complementary data sources, whether applied simultaneously or sequentially (Moreira dos Santos et al., 2024).

This study involved 200 teachers from various schools in Padang, Indonesia, where PjBL was implemented. Data were collected through surveys and focus group interviews, with questionnaires distributed to schools. For qualitative data, eight Biology teachers from one school were interviewed to obtain first-hand information about authentic experiences with PjBL.

Participants

The participants of this study consisted of 200 Biology teachers from various schools implementing PjBL in West Sumatra, Indonesia, with diverse cultural and linguistic backgrounds (see Table 1). All participants were experienced Biology teachers who had no difficulty understanding the questionnaire. The majority of respondents were female teachers, totaling 107. The teachers came from various cities, including Padang, Bukittinggi, Solok, Payakumbuh, Pasaman, Pariaman, Dharmasraya, and Padang Panjang. Their teaching experience ranged from 6 to more than 10 years. Only eight teachers participated in the interviews.

Table 1. Respondents' personal data

Years of experience		Gender	
6-10 years	More than 10	Male	Female
87	113	93	107

Source: own elaboration

Sampling

To understand teachers' perspectives on Project-Based Learning (PBL), the researchers selected schools in West Sumatra that actively implemented PBL and had first-hand experience. Schools that fully complied with the Ministry of Education curriculum were excluded. Field visits were conducted to assess teachers' familiarity and experience with PBL, and schools that regularly implemented PBL were selected for questionnaire distribution. Focus group interviews were then conducted with 20 volunteer teachers, with eight specifically selected for their experience and contributions. Purposive sampling was used because of its effectiveness in obtaining reliable input on PBL. According to Tongco, this method can be more effective than random sampling in certain circumstances, especially when randomly selected participants may not have the required expertise (Tongco, 2007).

Research Instrument

This study used a 5-point Likert scale questionnaire as the primary tool. Since it was difficult to find a survey that suited the research objectives, the researchers developed their own questionnaire to measure educators' views on cooperative education techniques and their effectiveness. The development of the questionnaire involved several stages, including discussions, consultations with PjBL trainers, and reviews from university educators to refine relevant items. The final questionnaire had two sections: demographic data and 20 research items, with a reliability of 0.93 assessing the Reliability of the questionnaire through Cronbach's alpha. The second method was a focus group interview, which was based on the results of the questionnaire to develop further questions. The interviews focused on three main areas: the role of PjBL in interactive learning, students' awareness of socio-cultural aspects, and the implementation of differentiation in Biology classes. The interview questions were designed to ensure relevance and simplicity, following Kvale's (2008) guidelines, and were refined based on feedback from teachers.

Data Collection

A total of 200 questionnaires were collected from Biology teachers in various schools in West Sumatra, Indonesia. Three research assistants helped distribute and collect the questionnaires, especially from distant schools. After that, focus group interviews were conducted in one of the large educational institutions, involving eight Biology teachers divided into two groups, with interview sessions lasting more than 40 minutes. Discussions were conducted in Indonesian, and qualitative data were analyzed through annotation, coding, and repeated theme checks to identify correlations with the questionnaire results. Furthermore, conclusions were drawn based on the problem statement, questions, and research objectives.

Data Analysis

Quantitative data underwent analysis utilizing Version 21 of SPSS acquire statistical descriptions, specifically focusing on the average of every item. This redundancy, and allowing for quicker consolidation or combination of ideas (Kvale & Brinkmann, 2013). Merriam emphasizes the role of technology in simplifying data analysis, noting its usefulness in both individual and collaborative research efforts (Merriam, 2018).

For qualitative information analysis, The investigators adopted The Patton qualitative content analysis model, which involves interpreting and making sense of by connecting newly discovered data to the study questions. They stressed the importance of balancing interpretation and description, viewing them as complementary elements that provide depth and meaning, clarifying contexts and details (Patton, 2012).

Table 2. Implementing Project-Based Learning to Promote Learning

Description	Maximum	Minimum	Median
Regardless of my students' academic ability, aids in their journey	5	1	4.12
Gives my children the opportunity to learn in a stress-free environment	5	2	4.15
Improve my disciples' the capacity to participate in various conversations	5	2	4.29
Gives my disciples' the chance to engage in fruitful learning	5	2	4.31
Develops an interactive and captivating learning environment	5	2	4.41
Creates s a comfortable atmosphere for my kids to learn in	5	2	4.45

Decision was influenced by the observation made by Yu and An because "Against extreme scores, the median is more resilient" (Yu et al., 2016). Furthermore, employing medians enables researchers to distinguish between random fluctuations and structured changes. Robson and Reed also advocated for the use of the median over the mean due to its simplicity of computation, expeditiousness in acquisition, and the reduced degree of variability it presents in representing the data (Robson & Reed, 1999). The resultant analyzed outcomes were set up into tables to help with the interpretation and discussion of significant findings.

The qualitative information gathered farthest from the center groups were originally arranged in tables to make a comprehensive examination of the entire dataset simultaneously. Following this, A structure was created to systematically categorize and organize the information into patterns or themes that corresponded with the study's objectives and research questions, as recommended by Denzin et al. (2014). The investigators followed Brinkmann and Kvale's recommendations to steer the conversations effectively, allowing for the identification and categorization of additional themes and ideas. They utilized the emphasizing feature Utilizing Microsoft Word for classification various ideas and subjects, annotating their accordingly. The illustration enabled by computer technologies assisted in the analysis

Result and Discussion

Ethical Considerations

Question 1 underscores how PjBL fosters active student participation and communication. Referring to the initial dataset analyzed from assessments, Figure 1 and Table 3 illustrate that teachers acknowledge and value the concept of "enhancing engagement." This reaffirms the interactive environment facilitated by PjBL (Beier, 2019; Bell, 2010; Burks, 2022; Hernáiz-Pérez et al., 2021; Husin, 2016; Pearlman & Thomas, 2000; Warin, 2016). It also underscores the dynamic nature of the learning environment where PjBL is applied, promoting the exchange of ideas, thoughtful discussions, collaborative goal-setting, and collective efforts to achieve these goals. Consequently, the median score reflects that PjBL supports learning and development within an environment that accommodates students' varying levels and needs while prioritizing their emotional safety and well-being. Notably, engagement appears as a more significant direct benefit of PjBL compared to learning outcomes or academic progress.

In general, findings from the interviews corroborate those obtained from the questionnaire, particularly regarding student engagement. Teachers provided extensive insights into how the learning process becomes more captivating and involving when PjBL is effectively implemented. One teacher highlighted that "in a PjBL classroom, students feel motivated and engaged as they interact with their peers." Some highlighted the interactive nature of PjBL settings, emphasizing the active participation and sense of responsibility it cultivates in students. Existing literature describes PjBL environments as promoting collaboration, interdependence, communication, and interaction (Azmi & Festiyed, 2023; M. M. Capraro, 2013; Edmunds, 2017; Grant, 2002; Kingston, 2018; Mahasneh & Alwan, 2018; Sarjani et al., 2023; Siswono et al., 2018; Tsybulsky & Muchnik-Rozanov, 2023; Turgut, 2008; Ummah et al., 2019; Yanti et al., 2023). Additionally, PjBL has a significant impact on learning motivation, relationships, and psychological well-being (Ariwibowo et al., 2018; Brungel, 2020; Jacques, 2017; Ma et al., 2023; Saad & Zainudin, 2022; Santos et al., 2023; Zulyusri et al., 2023).

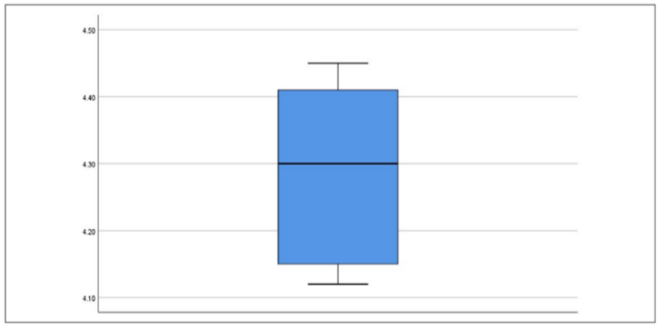

Figure 1. Spreading about data of "project-based learning as a means for learning engagement." Source: own elaboration.
Notes. 4.30 is the median. About 25% of the values are below Quartile I, which is 4.15. Approximately 75% of the values are higher than 4.15, with quartile 3 = 4.41. The lowest = 4.12. The highest = 4.54.

Other educators also emphasized the sense of participation that students experience while working within their groups. One teacher remarked, You can plainly sense the uplifting force in the classroom; disciples' actively Utilize cooperative education strategies inside of an atmosphere of constructive dialogue, exchange, and evident participation. This aspect is crucial for the success of the PjBL approach. According to this perspective, the active participation and liveliness of learning are direct outcomes of arranged properly PjBL, where pupils receive assistance and direction in implementing PjBL strategies systematically. Consequently, this fosters language acquisition, as interaction becomes an integral part of the learning process, leading to spontaneous and less stressful language learning experiences due to the low affective filter provided by the PjBL environment. In support of this notion, numerous research studies have highlighted PjBL as a method that improves learning outcomes and fosters a secure learning environment (Beier, 2019; Dewi & Arifin, 2024; Hasanah et al., 2024; Hernáiz-Pérez et al., 2021; Kingston, 2018; Niemiller et al., 2021; Pun, 2012; Wirawan et al., 2023).

Several studies have highlighted the positive impact of PjBL on motivation and involvement the learning (Jääskä et al., 2022; Lam et al., 2010; Pan et al., 2023; Wu & Wu, 2020; Zouganeli et al., 2014). These investigations underscore the role of PjBL in fostering increased engagement and motivation among learners

(Held & Mejeh, 2024; Nordahl-Pedersen & Heggholmen, 2022; H. Park & Hiver, 2017; Xu, 2024; Zhang & Dai, 2024). In summary, the findings discussed indicate that implementing PjBL in a Biology classroom fosters a sense of ownership in students' learning journeys, encouraging them to put in greater work in respective initiatives and tasks, depending on the earlier mentioned outcomes of the investigation and insights from The discussions related to Research Question 1, it is evident that teachers affirm the constructive learning environment fostered by PjBL for all learners.

Further research corroborates the engagement aspect of PjBL. Studies have affirmed the efficacy of PjBL in fostering motivation and involvement the learning classrooms (Ripollés & Blesa, 2024; X.-Y. Wu, 2024; J. Yu et al., 2024). The interactive environment cultivated by PjBL promotes engagement and enhances social skills (Fajrina et al., 2020, 2023). Consequently, PjBL is closely associated with factors contributing to student success (Platje et al., 1994). It's noteworthy to highlight that intrinsic motivation, stemming from the sense of contribution and collaboration, is one of the sources of the engagement felt within PjBL settings. Additionally, the feeling of collective responsibility fostered by PjBL, along with a sense of ownership of learning, contributes to the engagement factors (R. M. Capraro et al., 2013; Descovich et al., 2013; Masaguni et al., 2023; Puti et al., 2024; Susanti et al., 2022).

Table 3. Project-Based Learning as a Means of Augmenting Cultural and Social Awareness (Source: Own Elaboration)

Description	Maximum	Minimum	Median
Develops my kids' capacity for teamwork	5	2	409
Develops my students' social responsibility	5	3	4.19
Maximizes my students' capacity to learn in a culturally sensitive manner	5	3	4.19
Helps my students to exhibit collaboration and kindness	5	2	4.28
Helps my students to exhibit collaboration and kindness	5	2	4.32
Is a crucial ability for the academic and social success of my students.	5	2	4.38
Assists my kids in becoming into more gregarious people	5	3	4.50

Project-Based Learning as A Means of Augmenting Cultural and Social Awareness

The results of the questionnaire suggest that educators view PjBL as a teaching method that enhances the social and cultural consciousness of pupils while also improving their interpersonal skills. This is facilitated by PjBL through interactions with peers from various cultural backgrounds, involvement in diverse settings, and the development of abilities in sharing knowledge, ideas, and peer coaching. As shown in Figure 2 and Table 4, the greatest median result was for the object "helps my students become more sociable individuals," which strongly backs the focus concerning the second study query on comprehension of social and cultural aspects. Interviews further highlight educators belief in PjBL's effectiveness in boosting social skills of students, although They think about its impact on cultural sensitivity to be less significant than its influence on social aspects.

The answers from the interviews align with the survey findings, with all educators discussing the positive influence of PjBL on Social and cultural competencies of pupils' awareness. One Educators' noted that "groups of students with varying abilities and cultural backgrounds work together towards common goals, building strong social bonds." This teacher elaborated on the cultural awareness fostered by PjBL, pointing out that students working in diverse cultural settings Develop your ability to be accepting and tolerant. Through collaboration on tasks and projects, students' social skills and cultural understanding are significantly enhanced.

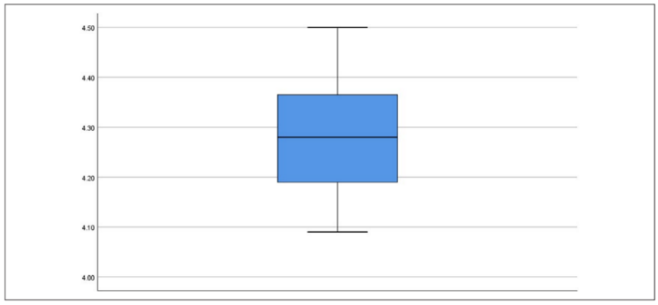

Figure 2. Spreading about data of "project-based learning as an enhancing factor for social and cultural undertanding." Source: own elaboration. *Notes*. 4.28 is the median. About 25% of the values are below Quartile I, which is 4.19. Approximately 75% of the values are higher than 4.19, with quartile 3 = 4.38. 4.50 is the highest. 4.09 is the lowest.

Earlier research on PjBL has observed positive social outcomes and advancements in communication skills (Breslow, 2015). Highlighting the significance of PjBL in improving cultural sensitivity, Fajrina undertook a study in Indonesia focusing on the cultural aspect within a Biology classroom (Fajrina et al., 2023).

In PjBL settings, a social environment emerges where diverse perspectives are embraced. Participants in PjBL develop friendly relationships as they interact, discuss ideas, exchange thoughts, and collaborate

towards group objectives. These participants come from various genders, races, styles, and abilities, fostering a sense of empathy among learners (Ariwibowo et al., 2018). Item 4 in Table 4, which addresses the element of compassion, aligns with the findings of Park and Kenny, illustrating How empathy promotes communication, education, and personal growth (Kenny, 2016; J. J. Park et al., 2018). It creates pathways of cooperation, kindness, acceptance, and constructive interconnectedness within PjBL environments.

In essence, the outcomes from both the interviews and surveys, alongside prior research, highlight the significance of social engagement and cultural comprehension fostered by PjBL in Biology classrooms according to teachers. These findings align with the theoretical frameworks supporting PjBL, as evidenced in Social constructionism, communicative competency theory, and sociocultural theories. Particularly notable is the cultivation of general awareness of social issues and sensitivity resulting from the structured connection facilitated by PjBL. Irrespective of their respective cultural upbringings, academic tiers, disparities, as well as passions, all students demonstrate heightened responsiveness and sociability through genuine interaction and collaborative involvement in cooperative projects, tasks, and activities.

Project-Based Learning's Function In Enabling Personalized Instruction

Research Question 2 explores the ways in which PjBL aids educators in executing personalized instruction. As shown in and all median scores are displayed in Table 5 and Figure 3 surpass four. The assertion receiving the median score with the greatest value was "enables me to serve as a guide to learning rather than a conveyor of information." In contrast, the assertion that received the median score that it lowest was "can adequately stimulate my high-achieving students." Nonetheless, all feedback highlights that PjBL strengthens distinction endeavors.

Support for this concept comes from the research conducted by Halimatusyadiyah, indicating that PjBL diminishes language learning apprehension in Biology classrooms (Halimatusyadiyah et al., 2022). Herlja further clarified that various PjBL frameworks accommodate the diverse needs and preferences of learners (Hrelja & Rye, 2024). Biology students commonly confront issues related to self-esteem arising from performance anxiety and apprehension of failure (Ito et al., 2024). The customization within a PjBL environment has the potential to reduce students' emotional barriers and strengthen their confidence, thereby encouraging them to participate more actively in assignments and projects (Fajrina et al., 2023). Corresponding with these findings, Hyojin's study reported that students exhibited heightened engagement, motivation, and a positive outlook on learning (H. Park & Hiver, 2017). Additionally, the outcomes imply that combining PjBL with personalized instruction can amplify students' inherent motivation.

Table 4. Project-Based Learning's Function in Supporting Differentiated Education (Source: Own Elaboration)

Description	Maximum	Minimum	Median
Push the classmates effectively who are above me	5	2	4.01
Provides opportunities for differentiated activities	5	2	4.12
Enables my children to react to tasks using their different intelligences	5	2	4.17
Helps people learn regardless of their aptitudes and preferred methods of learning	5	3	4.20
Allows me to give my pupils who are performing below level appropriate scaffolding.	5	2	4.21
Enables my pupils to generate innovative group projects	5	2	4.24
Allows me to switch from being an information provider to a learning facilitator	5	2	4.42

The insights gathered from the interviews support the conclusions drawn from an investigation. Educators confirmed that PjBL gives avenues for learners at different proficiency levels to effectively participate. For instance, one teacher elucidated that high-achieving students can support the learning of their peers through PjBL, while another emphasized that exposure to higher-order questions within PjBL settings can aid in the development of skills necessary to tackle such questions for lower-achieving students. In terms of highlighting the concept of differentiation, a teacher highlighted that PjBL encourages collaborative work on projects and tasks, which bolsters students' self-assurance and academic outcomes. Additionally, several teachers strongly advocated for PjBL 's role in facilitating differentiation, with others noting its positive impact on learners' self-esteem.

In PjBL settings, students receive activities tailored to their individual levels, fostering a sense of comfort and willingness to openly exchange answers with peers. The creation of mixed-ability teams allows students to offer each other assistance in a supportive learning atmosphere. Additionally, a teacher highlighted another advantageous aspect of PjBL, emphasizing its function as a stage for peer mentoring. Within the collaborative learning structure, personalized instruction benefits

both challenging high-performing students and aiding those who are still developing. Through the implementation of PjBL, high achievers view themselves as significant participants in the educational journey, while students who are still developing feel empowered by the assistance of their peers to advance and tackle challenges.

Engaging in PjBL environments boosts students' self-assurance and social abilities while directing their attention towards learning and academic achievements (Kingston, 2018). Students view the learning atmosphere as welcoming, inclusive, and secure, thereby alleviating apprehension and stress (Zulyusri et al., 2023). This supportive environment substantially assists students in their educational endeavors, encouraging them to aim for enhanced performance, thus promoting increased interaction and success.

In synthesis, the collective evidence based on the survey and interviews, prior research and a review of the literature emphasizes Biology educators' perception of PjBL as a valuable framework for implementing differentiation, effectively mitigating students' typical anxiety levels. Furthermore, PjBL fosters peer support and cooperation, facilitating advancement for learners irrespective of their individual learning levels, language proficiencies, or preferred modalities. These findings resonate with Indonesia's core educational objectives, cultural principles, and national initiatives, which prioritize collaboration, critical thinking, interaction, cultural sensitivity, and the cultivation of competent global citizens. Consequently, Indonesia is keen to embrace an educational approach capable of embodying, promoting, and instilling these principles in both present and future generations of students.

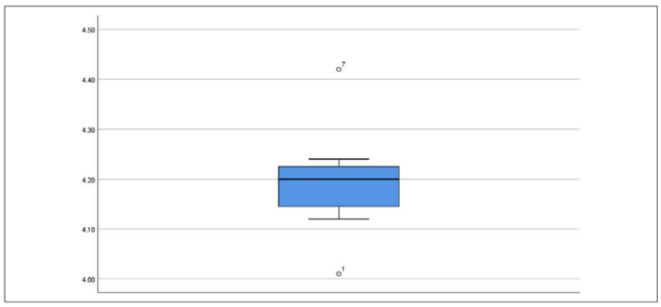

Figure 3. Spreading about information from "the role of project-based learning in facilitating differentiated instruction." Source: own elaboration.*Notes*. 4.20 is the median. About 25% of the values are below Quartile I, which is 4.12. Around 75% of the values are higher than 4.12, with quartile 3 = 4.24. 4.42 is the highest. 4.01 is the lowest.

Conclusion

Based on the analysis that has been carried out, it can be concluded that Biology educators consider project-based learning as a useful teaching method and contribute to increasing student engagement, increasing social dynamics in the classroom, cultural appreciation, and implementing effective strategies for differentiated learning. These findings have implications across multiple domains, including teacher professional development, academic administration, curriculum design, and decision-making processes. Furthermore, the insights gained from this research can go beyond the boundaries of Biology education and be able to attract interest from stakeholders in various academic disciplines.

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Author Contribution

Conceptualization, S. F and R. A. Methodology F. A. Validation H. H. Formal Analysis M. F. Investigation E. R. Resources A. M. P. Data Curation Z. Z. Review and editing A. K.

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Conflicts of interest

The authors declare no conflict of interest.

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