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# Enhancing Creative Thinking in High School Physics through Project-Based Learning Integrating Local Wisdom and STEAM for Quality Education

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**ABSTRACT**

***Objective:*** *The main goal of this study is to examine the impact of applying a Project-Based Learning (PjBL) model, grounded in local wisdom and integrated with a STEAM approach, on improving students' creative thinking skills in high school physics education. This objective aligns with the Sustainable Development Goals (SDGs), especially those focused on quality education.* ***Method:*** *This research employs a literature review methodology utilizing qualitative descriptive methods. It analyzes various national and international journals related to project-based learning based on local wisdom, published within the last five years.* ***Results:*** *In the research, work and project-based learning becomes discovery significantly enhances students' understanding of physics concepts. The study demonstrates that PjBL fosters deeper learning, allowing students to develop not only their comprehension of physics but also essential skills such as problem-solving, creativity, and teamwork in real-world contexts. Moreover, integrating local wisdom within the PjBL framework increases students' interest in cultural preservation and enhances their scientific literacy through hands-on project activities.* ***Novelty:*** *The novelty of the research lies in the unique integration of local wisdom into the PjBL STEAM framework, an area that remains relatively underexplored in existing literature. By combining these elements, the study contributes to innovative teaching methodologies aimed at improving academic outcomes while promoting cultural awareness and appreciation among students. This approach offers a fresh perspective on aligning educational practices with global educational goals, all while fostering the creativity and critical thinking skills essential for the 21st century.*

## INTRODUCTION

Learning activities must be designed to address specific needs, including those based on the characteristics of regional wealth, such as local culture and traditions. This requirement is affirmed in the Law of the Republic of Indonesia No. 20 of 2003 concerning the National Education System, particularly in Chapter X, Article 36, paragraph (1), letter (d), which states that schools are mandated to implement an education model grounded in the local potential found in each region (Law No. 20 of 2003 Article 36 paragraph 1). Local potential, often referred to as local wisdom, customs, or regional habits, plays a crucial role in shaping educational practices. Various methods can be employed to implement local wisdom-based education in schools, one of which is to apply a learning model that centers on student participation, such as Project-Based Learning (PjBL) (Syakur et al., 2020). PjBL is a student-centered learning model that emphasizes contextual learning and is specifically designed to address and solve complex problems (Priantari et al., 2020).

With the integration of a local wisdom approach into the PjBL framework, a more meaningful and relevant learning experience can be created with an impact that can be received by students in encouraging understanding and enriching students' culture and heritage. Based on the results from the Program for International Student Assessment (PISA), Indonesia's ranking is low, ranking 70th out of 78 countries surveyed in 2018

(OECD, 2020). Additionally, in the innovativeness map of the Global Innovation Index (GII) published by the World Intellectual Property Organization (WIPO) in 2021, which includes an education component, Indonesia was ranked 87 out of 132 countries (WIPO, 2021). These rankings highlight a consensus among nations that education is a critical factor for progress. The quality of education in a country often serves as an indicator of its overall advancement; a nation with poor educational outcomes risks falling behind in global competitiveness (Nur & Kurniawati, 2022). In response to these challenges, national education reform through the independent learning policy has been initiated as a government effort to enhance educational quality. This policy aims to grant each educational unit the independence to innovate, allowing them to adapt the learning process to better align with local culture, wisdom, and the surrounding socioeconomic and educational infrastructure. By fostering this flexibility, the independent learning policy aspires to create a more responsive and effective educational system that meets the diverse needs of students across Indonesia.

The Sustainable Development Goals (SDGs) build upon the framework established by the Millennium Development Goals (MDGs), which consisted of eight goals and achieved significant success. The SDGs were formulated to further enhance the quality of life within communities, comprising 17 goals aimed at addressing various global challenges. In Indonesia, the achievement of the SDGs over the past six years has not been as positive as hoped. To effectively implement sustainable development in education, four key strategies have been identified: ensuring equal, inclusive quality education while supporting lifelong learning opportunities for all. By focusing on these strategies, there is optimism that this programmatic approach will lead to improved educational quality in Indonesia, addressing existing disparities and fostering a more inclusive and effective learning environment for all students. The successful realization of these goals is essential for advancing Indonesia's educational landscape and contributing to overall national development.

Physics should serve as a subject that explains observable phenomena through human experience, rational thinking, and experimentation, making it accessible and relevant to students' lives (Makhmudah et al., 2019). However, many students struggle with physics and do not grasp its practical benefits, leading to disinterest and a lack of appreciation for the subject (Jurfrida et al., 2021). To address this issue, physics education should incorporate learning materials that relate to students' daily activities, ensuring that the knowledge gained is meaningful and integrated within their cultural context. By connecting physics concepts to real-life experiences and local cultural elements, educators can enhance student engagement and foster a deeper understanding of the subject. This approach not only makes physics more relatable but also empowers students to appreciate its relevance in their everyday lives.

Physics teaching often relies heavily on textbook content, which can lead to a neglect of integrating local culture and real-world applications. This oversight diminishes students' understanding of the subject's relevance in their lives. Given this context, there is a pressing need to develop more effective learning methods, including the ethnophysical approach. Ethnophysics explores the relationship between culture and the concepts of physics. It acknowledges that culture encapsulates a social heritage unique to the members of a society, which can be studied and understood through an examination of its practices and beliefs. Using the ethnophysical approach allows educators to establish connections between scientific concepts and the cultural context of the students, thereby enriching the learning experience. Unfortunately, this approach is not commonly applied in the classroom, resulting in a lack of contextual examples that resonate with students' local environments (Rosadi et al., 2019). By incorporating the ethnophysical perspective into physics education, teachers can provide students with relatable and meaningful examples, fostering a deeper understanding and appreciation of physics as it pertains to their own cultural experiences.

Project-Based Learning (PjBL) has the potential to enhance students' understanding of physics by actively engaging them in hands-on projects that cultivate critical thinking and problem-solving skills. However, PjBL is not widely adopted in physics education, which limits students' opportunities to apply their knowledge in practical situations (Komarudin et al., 2020). The Project-Based Learning model has been shown to positively influence students' conceptual understanding of physics. Additionally, the process of completing projects necessitates a structured approach to learning. One effective framework that complements PjBL is the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach. By integrating STEAM with PjBL, educators can create a rich learning environment that encourages students to explore and connect various disciplines while developing their understanding of physics in meaningful ways. This combination not only promotes deeper conceptual comprehension but also prepares students to tackle real-world challenges creatively and collaboratively.

The STEAM approach aims to integrate science, technology, engineering, art, and mathematics to foster creativity and innovative problem-solving skills among students (Annisa et al., 2019). However, the current implementation of STEAM in education often lacks depth, particularly in its artistic integration, which is crucial for nurturing creative thinking (Cholily, 2020). Incorporating the STEAM approach into physics education can also contribute to achieving one of the Sustainable Development Goals (SDGs), specifically Goal 4, which focuses on Quality Education. This goal can be more readily achieved when students are equipped with essential 21st-century skills (Kurniawan, 2023). Despite the potential advantages of STEAM, many educational institutions face challenges in fully realizing this outcome due to insufficient teacher training and limited resources (Kurniawan, 2023). To maximize the effectiveness of the STEAM approach in physics learning, it is vital to address these shortcomings and provide educators with the necessary support and training to effectively integrate all components of STEAM into their teaching practices.

Studies indicate that integrating local wisdom into STEAM education enhances contextual relevance, which significantly boosts students' motivation and understanding of physics concepts (Rosadi et al., 2019). This combination not only promotes student collaboration but also enhances their real-world problem-solving abilities (Sagala, 2019). Despite these positive outcomes, there are limitations regarding teacher readiness to effectively implement this integrative approach. Many educators lack the necessary training to meaningfully incorporate local culture into the curriculum (Annisa et al., 2019). Additionally, resource constraints often hinder the development of comprehensive projects that fully leverage the potential of STEAM education. To overcome these challenges, it is important to provide educators with adequate training and resources, enabling them to design and facilitate enriched learning experiences that connect local wisdom with STEAM concepts. This support can help create a more engaging and effective educational environment for students.

In summary, while there is a clear need for reform in physics education through culturally relevant approaches, such as ethnophysics and STEAM-based Project-Based Learning (PjBL) models, a significant gap remains between educational ideals and current practices. Addressing this gap is crucial for enhancing student engagement and improving educational outcomes in physics. By integrating local cultural elements into the curriculum and adopting innovative teaching methods, educators can create a more meaningful and impactful learning experience for students. This transformation is essential for fostering a deeper understanding of physics concepts and ensuring that education is relevant to students' lives and contexts.

Project-Based Learning (PjBL), when integrated with local wisdom and the STEAM approach, aims to enhance students' creative thinking skills. This initiative aligns with the targets of Sustainable Development Goal 4, which emphasizes the significance of inclusive and quality education. By collecting and compiling findings from various studies, this article seeks to provide a comprehensive insight into the implementation of project-based learning based on local wisdom combined with the STEAM approach. The goal is to improve students' creative thinking skills specifically within the context of physics learning in high school. Through this analysis, the intention is to identify common patterns and recommendations that can support the development of the PjBL approach in physics education moving forward (Abdullah, 2021). By doing so, educators and policymakers can better understand how to incorporate these strategies effectively in their teaching practices, ultimately leading to enhanced educational outcomes for students.

## RESEARCH METHOD

This research adopts a descriptive qualitative approach, drawing on both international and national journals. The methodology begins with the selection of the research topic, followed by determining relevant keywords for journal searches in both English and Indonesian, using platforms such as SINTA, Semantic Scholar, Google Scholar, and Consensus journals. The research design employed is a literature review aimed at exploring perspectives from previous articles on the STEAM-based PjBL learning model (Hudha et al., 2020; Li et al., 2019; Suprapto et al., 2021). Data collection involved searching for articles in nationally and internationally accredited journals through online platforms, focusing on publications from 2019 to 2024. Out of the articles reviewed, 15 were selected for their relevance to the topic. These fifteen journal articles were then meticulously scrutinized and a critical appraisal was conducted to assess their contribution to the field. Following this, a literature review was performed based on the results of the critical appraisal. This method allowed for a clear and comprehensive description of the issues at hand. The data collected for analysis is presented in the results and discussion sections, ultimately leading to well-founded conclusions.

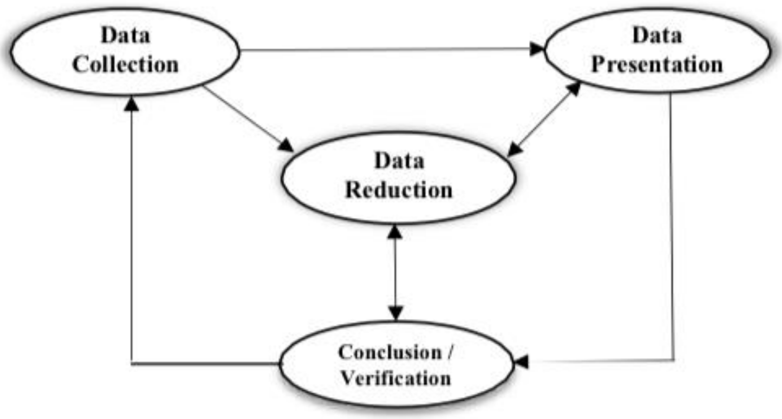


**Figure 1.** Qualitative data analysis diagram

According to Suliyanah et al. (2021), there are four stages of qualitative data analysis:

1. Data Collection: This stage involves gathering information through a review of previous journals or articles to meet the research objectives.
2. Data Reduction: Here, important points are summarized to provide a clearer overview of the collected data.
3. Presentation of Data: This stage involves organizing the findings into generalizations or descriptions, which can be conveyed through written descriptions or charts.
4. Conclusion and Verification: Based on the results of the data analysis, this stage concludes and verifies insights regarding STEAM-based PjBL learning and its impact on improving students' creative thinking skills in high school.

## RESULTS AND DISCUSSION

### *Results*

Each region has a cultural identity as a form of local wisdom that reflects its uniqueness. Almost every area boasts its own distinctive culture. Incorporating ethnophysics into learning is one effective way to leverage this cultural richness, as it connects physical knowledge with cultural insights. This approach not only shifts the focus from a traditional teacher-centered model to a more student-centered learning experience but also deepens students' appreciation for their culture. As highlighted by Atmojo (2012), such a contextual and meaningful learning environment can enhance engagement. Ultimately, ethnophysics aims to inspire students to explore physics concepts through the lens of their own cultural contexts.

Machado and Davim (2022) emphasize that education is crucial for successfully achieving the Sustainable Development Goals (SDGs). However, in Indonesia, education often relies on rote learning, leading to what is referred to as "Dead Knowledge," and lacks practical application in daily life, particularly in the realm of science (Makhmudah et al., 2019). Ethnophysics offers a unique opportunity to bridge this gap, with the plate dance serving as an effective medium for learning physics concepts. In the plate dance, dancers skillfully balance two plates in their palms and swing them rapidly. At the dance's conclusion, the plates are thrown to the floor, and the dancers perform on the fragments without injury (Citrawati, 2017). This traditional dance can be analyzed through various physics principles, including motion, equilibrium, Newtonian gravity, and sound. Each aspect of the dance provides a different angle for studying these concepts. Incorporating learning media based on local wisdom, like the plate dance, can create a fresh and engaging approach to teaching physics, which students often find challenging (Wandansari, 2015). By connecting physics lessons to cultural practices, educators can foster a more meaningful learning experience.

The incorporation of local wisdom into physics education can be illustrated through the Toancak Kite, prevalent in Kotanyar Village, Paiton District, Probolinggo Regency. Tobacco farmers in the area often engage in kite flying, a practice that requires skillful control, especially in strong winds. The physics of kite flying is rooted in the principles of lift, which occurs due to differences in airspeed and resulting pressure variations. Moreover, local wisdom is also reflected in traditional musical instruments such as the Gong, Kentongan, Bamboo Flute, Sasando, and Drum. These instruments connect to the physics concept of sound waves, providing another avenue for exploring physical principles through cultural expressions. By learning from social phenomena and local problems, students can enhance their science literacy, making education more relevant and engaging. This approach not only supports the understanding of physics concepts but also enriches students' appreciation for their cultural heritage.

Several relevant studies have explored local wisdom-based learning in the context of physics education. For instance, Firdiani (2019) conducted research on physics learning derived from the traditional art of dongkrek. Another study by Husin et al. (2019) focused on identifying physics concepts within the woven local wisdom of South Central Timor Regency. Additionally, Oktaviana et al. (2017) developed physics modules that integrate local wisdom related to the production of Lala oil, which aims to enhance character development. Research by Usmeldi (2016) examined the creation of research-based physics learning modules utilizing a scientific approach to boost students' science literacy. Furthermore, Nadia Fitri Insani et al. (2018) investigated the implementation of community science and technology learning models to enhance students' science literacy skills in physics education. These studies highlight the importance of integrating local wisdom into curricula, offering rich, contextualized learning experiences that resonate with students and foster a deeper understanding of physics concepts.

Various materials in physics education can be taught through the lens of local wisdom. Topics such as fluids, waves, rotational dynamics, temperature and heat, and the balance of rigid bodies have been effectively incorporated into this approach (Safitri, 2016). Specific applications have included research and module development focused on Temperature and Heat, exemplified by the preparation of Kandangan dodol (Wati et al., 2017), as well as Batik Lumbung and Tofu Tamanan (Agustin et al., 2018), and Rumah Umekbubu (Husin et al., 2018). Integrating culture-based learning methods has the potential to foster a more active, student-centered learning environment (Novitasari et al., 2017). This approach not only enhances students' understanding of physics through real-world contexts but also promotes engagement by connecting academic concepts to their cultural heritage.

Utami et al. (2024) highlight that many teachers still struggle to prepare learning tools that effectively implement the STEAM approach and connect learning topics to everyday life, particularly in ways that align with the Sustainable Development Goals (SDGs). Integrating the STEAM approach with SDGs in physics education offers a robust framework for fostering students' creative thinking skills (Prihatiningsih, 2024). Currently, some teachers continue to rely on conventional teaching models, where they enter the classroom, present the material, and students passively listen and complete exercises and assignments. In contrast, a number of educators have started using Project Based Learning (PjBL) and cooperative learning models. The PjBL approach is particularly suited to an independent curriculum, emphasizing innovative learning where students take center stage while teachers act as facilitators and motivators. However, the adoption of the PjBL model has been limited due to a lack of qualified guides or textbooks on its implementation. This barrier prevents many educators from fully integrating this effective instructional strategy into their classrooms, hindering the potential for enhanced learning experiences.

The interdisciplinary STEAM approach enables students to grasp scientific concepts within a broader context, while the Sustainable Development Goals (SDGs) provide a relevant framework to address global needs. Research by Indahwati et al. (2023) indicates that integrating independent learning with the STEAM approach significantly enhances students' critical thinking skills, supports the achievement of the 2030 SDGs, and prepares students to be agents of change in sustainable development. The synergy between STEAM and the SDGs allows science education to focus on cultivating creative thinking skills, which are beneficial for students in both academic settings and real-life situations (Utami et al., 2024). This integration not only enriches students' learning experiences but also empowers them to apply their knowledge and skills in addressing contemporary challenges, making education more relevant and impactful in the context of sustainability.

Observations during learning activities reveal that students respond enthusiastically to the tasks set by their teachers. When engaged in project creation, students demonstrate a wealth of creative ideas. Project-based learning (PjBL) allows students to produce tangible outcomes, actively involve them in problem-solving, and facilitates a deeper understanding of concepts. Interviews with students indicate that this project-focused approach makes it easier for them to grasp materials and encourages the development of their creativity. They appreciate being able to explain how concepts apply to daily life, moving beyond theoretical knowledge. These findings align with previous research by Fitriyah et al. (2021), which demonstrates that integrating STEAM and PjBL fosters innovative learning strategies capable of generating creative and critical solutions to problems. Moreover, the PjBL STEAM learning model significantly enhances students' interactions and boosts their creative thinking abilities, particularly in understanding physics concepts (Rohman et al., 2021). Students express happiness and motivation when learning through the PjBL STEAM model, believing it supports their comprehension of physics materials (Lestari, 2021). In this learning environment, the teacher's role as a facilitator is essential. They guide students to explore deeper solutions to problems, encouraging them to discover answers independently (Dewi et al., 2021). This dynamic not only promotes engagement but also empowers students to take ownership of their learning journey.

***Discussion***

In this study, students' conceptual understanding is categorized using the following assessments: understanding (P), partial understanding (PS), partial misconception (MS), misconception (M), and not understanding (TP), based on the framework established by Dhiasari (2006). The percentage of students' science literacy in each category, as assessed during the pretest and posttest, is illustrated in the accompanying figure. This categorization allows for a clearer analysis of students’ progress and highlights areas where further instruction may be needed. By comparing the results from the pretest and posttest, educators can evaluate the effectiveness of their teaching methods and the impact of specific learning strategies on students' comprehension of scientific concepts.

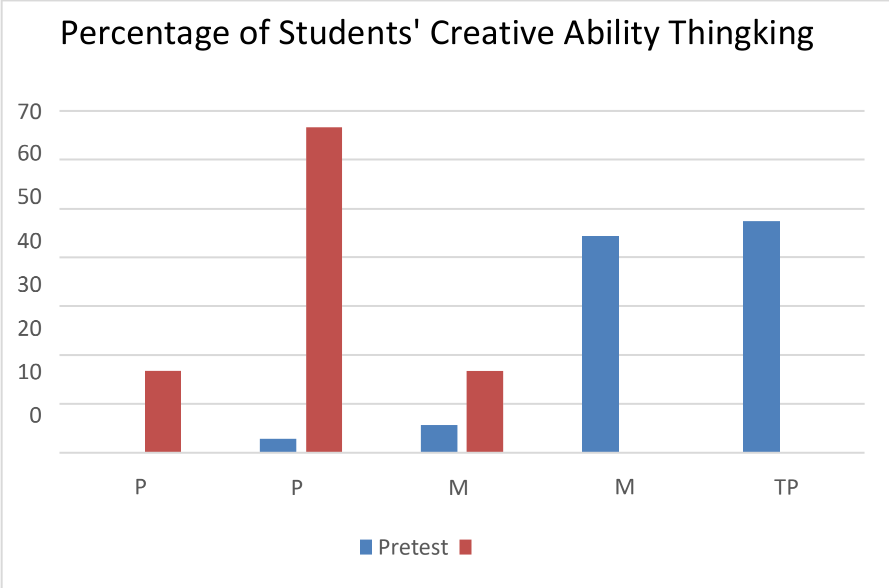


**Figure 1.** Percentage of students' creative ability thinking for each category in the pretest and posttest
(Source: Dewi et al., 2021)

After implementing the Project-Based Learning (PjBL) integrated with STEAM, the post-test results indicate notable changes in students' conceptual understanding, classified into three categories: comprehension (P) at 16.67% and partial comprehension (PS) at 66.66%. However, a small group of students remained in the partial misconception (MS) category, also at 16.67%. These findings suggest that most students are able to apply correct concepts to solve problems and can connect their understanding to other scientific concepts, although a few still hold misconceptions. These results are consistent with previous research, which demonstrated that students' conceptual understanding predominantly fell into the comprehension (P) and partial comprehension (PS) categories after being taught with PjBL integrated STEAM. In these categories, students actively engage in learning, as the group-based approach encourages collaboration. Each student participates in solving problems through project creation. Moreover, the STEAM-integrated PjBL approach enables students to readily apply what they have learned in their daily lives. The learning process becomes more engaging as students are required to think critically and collaborate with peers, fostering creativity and enriching their learning experiences through tangible projects (Na'imah et al., 2015). The following outlines the flow of activities involved in the project-based learning model integrated with local culture.

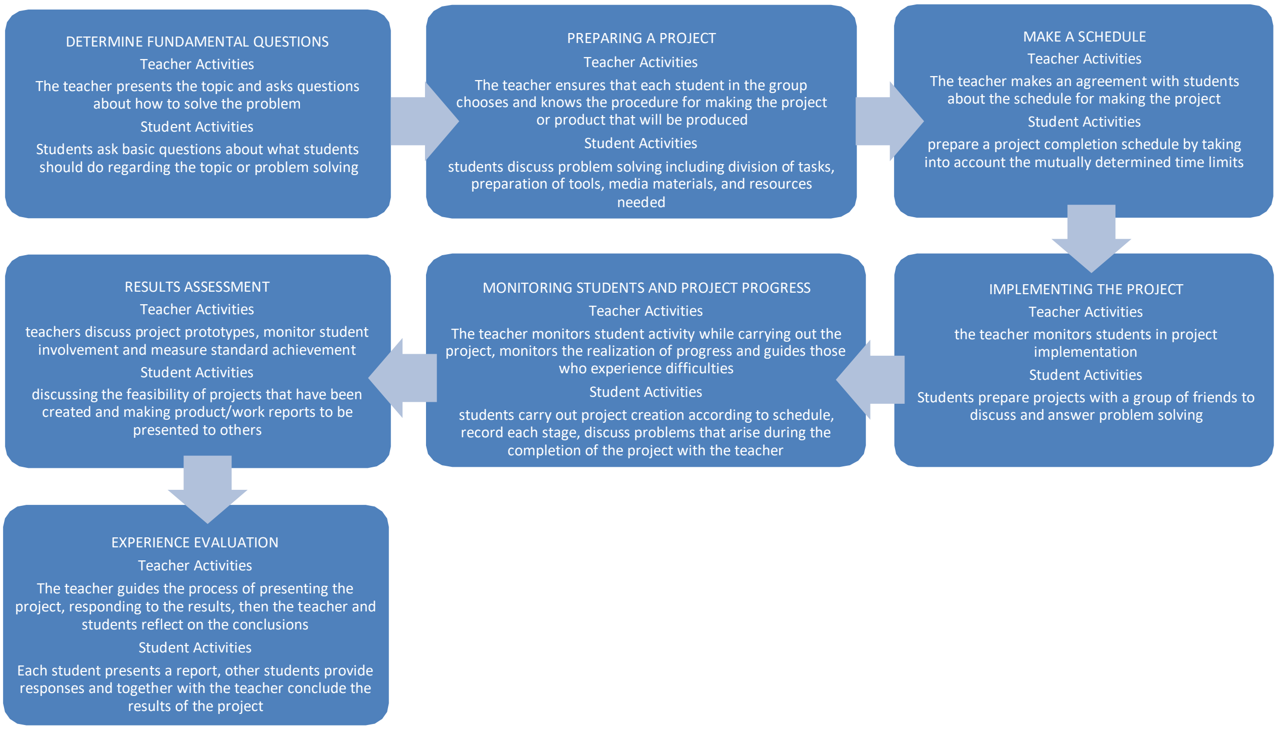


**Figure 2.** The flow of project-based learning activities integrated with local culture (Source: Trinova, 2013; Semaranatha et al., 2016)

In Figure 2, the learning flow of the local culture-integrated PjBL model is illustrated, demonstrating how it can be effectively applied to physics education in the classroom. The physics concepts taught are closely connected to local cultural elements, enabling students to grasp the material within a meaningful context. This integration helps to enhance students' understanding and engagement in the subject matter. Successful physics learning hinges on the collaboration between students and teachers to achieve educational goals. A key indicator of a student's interest in physics lessons is their level of participation in class and their comprehension of the material. Therefore, teachers must adapt their teaching strategies to reflect the local environment and the unique conditions of their students, fostering a student-centered learning atmosphere (Trinova, 2013; Semaranatha et al., 2016). By doing so, educators can create an engaging and responsive educational environment that promotes active learning and a deeper understanding of physics concepts.

A needs analysis and questionnaires conducted among several high schools in the Depok area revealed that only 23% of teachers understand Project-Based Learning (PjBL) and have successfully implemented it (Nugroho & Nurrita, 2023). However, there remains a significant gap, as the PjBL model has not been integrated with local culture. Many teachers are still struggling to fully grasp the principles of Project-Based Learning, leading to suboptimal implementation of PjBL steps during the learning process. Additionally, the lack of PjBL-based learning modules further hinders effective teaching practices. This deficiency in understanding and resources has a direct impact on student engagement and activity in the classroom. If the PjBL model integrated with local culture were applied in schools, it could significantly enhance various skills among students, including scientific thinking, critical thinking, problem-solving abilities, independent learning skills, science literacy, and the capacity to develop teaching aids and execute projects (Okyranida, 2021). Implementing this integrated approach could provide a more holistic and engaging educational experience, fostering essential skills in students that are vital for their academic and personal development.

Implementing a local culture-integrated PjBL learning model necessitates comprehensive teacher training focused on both the PjBL model itself and specific guidelines or teaching materials that connect local culture with project-based learning. Providing teachers with these resources will give them a clearer framework for developing their lessons. The concept focuses on the processes of observing, imitating, and modifying practices to enhance learning outcomes (Ministry of National Development Planning (PPN) / BAPPENAS, 2021). Moreover, it is important to note that, according to the data, 73.17% of teachers possess S1/D4 qualifications, while only 25.76% hold teacher certification. This indicates a pressing need to improve the quality of educators to meet educational goals effectively. By enhancing teachers' skills and knowledge through targeted training and resources, we can better equip them to implement innovative and culturally relevant teaching strategies that will ultimately benefit student learning and engagement.

The PjBL-Local Wisdom learning model significantly enhances students' abilities to conduct observations and investigations during project activities (Nurhikmayati et al., 2020). This model encourages each student to take responsibility for their tasks, fostering innovation and creativity as they engage with the projects. By integrating local culture into the learning process, students not only deepen their understanding of scientific concepts but also reconnect with aspects of local culture that may have been overlooked or forgotten. When learning is associated with engaging and relevant content, it can capture students' interest and create a sense of anticipation for what they will explore. This approach not only enriches their educational experience but also helps preserve and promote valuable cultural practices and knowledge.

Project-based learning (PjBL) focuses on enabling students to develop their knowledge and skills through a structured inquiry process, resulting in the creation of tangible products. This contrasts with traditional learning methods, which often emphasize rote memorization of theories. Through PjBL, students engage in meaningful exploration, allowing them to acquire knowledge and skills that are directly applicable to real-world situations. By working on projects, students not only learn theoretical concepts but also apply them in practical contexts, fostering a deeper understanding and retention of the material. This hands-on approach cultivates critical thinking, teamwork, and problem-solving abilities, ultimately preparing students for future challenges in both their academic and personal lives.

The Independent Learning Policy introduced by the Ministry of Education and Culture aims to ensure that high-quality education is accessible to all Indonesians, enhancing participation levels, improving learning outcomes, and promoting equitable education across different geographic and socio-economic contexts. To achieve the Sustainable Development Goals (SDGs) related to education quality and equitable learning opportunities, the strategies outlined in the 2020-2024 Strategic Plan provide a comprehensive framework (Ministry of Education and Culture, 2020). The government has identified several strategic steps, focusing on three primary objectives:

1. Optimizing Education Participation Rates: Ensuring that all individuals have access to education and encouraging greater enrollment in various educational programs.

2. Improving and Equalizing Education Quality: Enhancing the overall quality of education while addressing disparities between different regions and communities to ensure that all students receive a high standard of education.
3. Increasing the Relevance of Education: Aligning educational practices and outcomes with the needs of society and the labor market to better prepare students for their futures.

By prioritizing these objectives, the Independent Learning Policy aims to create a more inclusive and effective educational environment that supports the diverse needs of all learners in Indonesia.

The findings of this study align with previous research indicating that project-based learning effectively fosters creative thinking skills and enhances student motivation in experimental groups (Pan et al., 2023). The application of the STEAM project learning model in this study demonstrates that project-based learning can facilitate the integration of diverse knowledge and improve various skills among students (Gomez-del et al., 2022). Additionally, research on online project learning has shown it to be particularly effective in developing engineering design skills (Beneroso et al., 2022). Moreover, the implementation of STEAM projects has been found to significantly develop students' creative and critical thinking skills (Ju et al., 2022). Investigative activities within project-based learning frameworks also lead to notable improvements in students' creative thinking abilities (Albar et al., 2021). This study contributes to the body of research on creativity, demonstrating that students' product design skills can be enhanced through STEAM project activities (Malele et al., 2020). Furthermore, research indicates that students' cognitive abilities and creativity increase when utilizing STEAM modules (Thuneberg et al., 2018). STEAM learning practices inherently encourage students to engage in creative thinking as they work on product development (Katz-Buonincontro, 2018). Finally, the activities within this STEAM project reflect research on STEAM implementation, which emphasizes several key components, including inquiry-based questioning, project organization, process assessments, and product evaluations (Bui et al., 2023).

While integrating local wisdom into the PBL STEAM model shows promise for enhancing students' creative thinking, several challenges hinder its effectiveness. A significant limitation is the insufficient training and preparation of teachers to implement this interdisciplinary approach effectively. Many educators lack a thorough understanding of how to incorporate local cultural elements into their teaching practices, resulting in inconsistent application of the PBL STEAM model (Nisfa et al., 2022). Moreover, implementing project-based learning often demands considerable time and resources, which can pose challenges for schools with limited funding and support (Dewi, 2022). Additionally, there is a tendency for teachers to revert to traditional teaching methods under the pressures of standardized testing. This approach often prioritizes rote memorization over critical thinking and creativity, thereby stifling the very skills that PBL STEAM aims to cultivate (Agung et al., 2022). These factors create a disconnect between the theoretical advantages of the PBL STEAM model integrated with local wisdom and its practical implementation in classrooms. As a result, the potential for fostering creative thinking skills among students is ultimately limited, highlighting the need for targeted professional development, adequate resources, and a supportive educational environment to realize the full benefits of this approach.

A review of 15 articles examining the integration of Project-Based Learning (PBL) and STEAM with local wisdom highlights several unique findings that emphasize the effectiveness of this approach in enhancing educational outcomes. One significant observation is the consistent improvement in students' 21st-century skills, particularly in critical thinking, creativity, collaboration, and communication—commonly referred to as the 4 Cs. Research shows that incorporating local cultural elements into STEAM education not only makes learning more contextual and meaningful but also substantially enhances student engagement and motivation (Suprapto et al., 2021; Arfida et al., 2023). By linking academic content with students' cultural backgrounds, educators can create more relatable and impactful learning experiences, fostering a deeper connection between students and the material. This integration ultimately leads to more active participation and a greater likelihood of developing essential skills that are crucial for success in today's world.

Moreover, the studies emphasize that local wisdom is a powerful tool for making abstract physics concepts more tangible and relatable for students. By linking physics to local cultural practices, students are able to see the application of these concepts in their daily lives, leading to a deeper understanding and appreciation of the subject (Wati et al., 2017). Interestingly, the findings indicate that students exposed to ethnophysics education demonstrate a notable increase in their creative thinking and collaborative problem-solving abilities, both of which are essential skills for future success (Nisfa et al., 2022). This integration not only enriches the learning experience but also equips students with the skills needed to navigate complex problems in an increasingly interconnected world.

Another unique aspect identified in the literature is the challenge related to teacher preparedness. Many educators find it difficult to effectively implement PBL STEAM approaches due to insufficient training and resources, which often results in inconsistent application across different classrooms (Utaminingsih et al., 2021). This gap highlights the critical need for professional development programs aimed at equipping teachers with the skills necessary to integrate local wisdom into their teaching successfully. By providing targeted training and resources, educational institutions can empower teachers to utilize the PBL STEAM model more effectively, ensuring that all students have access to a rich and engaging learning experience that connects academic concepts with their cultural contexts.

In summary, the integration of Project-Based Learning (PBL) and STEAM with local wisdom offers substantial opportunities for enhancing student learning experiences and outcomes. However, it also uncovers critical areas for improvement, particularly regarding teacher training and resource allocation. These findings offer valuable insights for educators and policymakers who seek to enrich science education through culturally relevant pedagogical strategies. Addressing these challenges will play a vital role in realizing the full potential of this integrative approach, ultimately fostering a more engaging and effective learning environment for students.

Several recommendations can be made to effectively implement the Project-Based Learning (PBL) STEAM model integrated with local wisdom. First, it is crucial to provide comprehensive training and professional development opportunities for teachers. This training should not only cover the theoretical aspects of PBL and STEAM but also include practical strategies for incorporating local cultural elements into the curriculum (Utaminingsih et al., 2021). By equipping teachers with the necessary skills and resources, they will be better prepared to create engaging, contextually relevant learning experiences that resonate with their students and enhance the overall educational experience. This approach will help ensure that the integration of local wisdom into PBL STEAM is both effective and sustainable in the long term.

Second, schools should cultivate a collaborative environment where teachers can share best practices and resources related to local wisdom. Establishing a community of practice among educators can facilitate the exchange of ideas and innovative approaches for integrating local culture into science education (Murtono & Shufa, 2022). Furthermore, schools should encourage partnerships with local cultural organizations and community members to enhance the authenticity of learning experiences. By collaborating with these partners, educators can provide students with rich, real-world contexts that deepen their understanding of both scientific concepts and local cultural heritage. This collaborative approach not only enriches the curriculum but also strengthens the connection between schools and their communities, fostering a more holistic educational experience for students.

In addition, it is essential to develop a curriculum that highlights the interdisciplinary connections between science, technology, engineering, arts, and mathematics (STEAM) while integrating local wisdom. This curriculum should incorporate project-based assessments that enable students to explore real-world problems through the lens of their cultural heritage, thereby fostering creativity and critical thinking skills (Adji & Shufa, 2024). By designing a curriculum that bridges academic concepts with local cultural elements, educators can create engaging learning experiences that resonate with students and encourage them to apply their knowledge in meaningful ways. This approach not only enhances students' understanding of STEAM subjects but also instills a sense of pride and connection to their cultural identity.

Finally, it is important to establish ongoing evaluation and feedback mechanisms to assess the effectiveness of integrating PBL STEAM with local wisdom. Collecting data on student engagement, understanding, and skill development will help educators refine their approaches and ensure that learning experiences remain relevant and impactful (Nisfa et al., 2022). By implementing these recommendations, educators can create more meaningful learning environments that not only enhance students' understanding of physics concepts but also deepen their appreciation of their cultural heritage. Continuous reflection and adaptation will enable educators to optimize their teaching practices and foster an enriching educational experience for all students.

## CONCLUSION

**Fundamental Finding:** The application of the Project-Based Learning (PjBL) model, especially when integrated with local wisdom, significantly enhances students' engagement and interest in cultural preservation. This approach encourages students to actively partake in their learning process by designing and solving problems, which nurtures critical and creative thinking skills. Incorporating STEAM disciplines within this framework creates a holistic learning experience that aligns with the principles of Sustainable Development Goal 4 (SDG 4), promoting quality education through innovative teaching methods. **Implication:** The findings suggest that implementing PjBL alongside local wisdom not only improves students' scientific literacy but also fosters a sense of cultural appreciation and responsibility. This integrative approach can serve as a model for educational reform, making learning more relevant and contextually meaningful. Educators and policymakers should consider adopting this model to enhance student outcomes in science education while simultaneously preserving local cultures. **Limitation:** Despite its advantages, several limitations exist in the implementation of PjBL integrated with local wisdom. A significant challenge is the lack of sufficient teacher training and resources, which are critical for effective implementation. Many educators may not be fully prepared to facilitate this type of learning, leading to inconsistent application across classrooms. Additionally, logistical issues such as time constraints and limited funding can obstruct the development and execution of project-based activities that involve local cultural components. **Future Research:** Future research should focus on creating comprehensive training programs for teachers to equip them with the necessary skills for effective PjBL implementation. Additionally, studies could examine the long-term impacts of this integrative approach on students' academic performance and cultural engagement. Exploring how different elements of local wisdom can be incorporated into various subjects beyond science would also provide valuable insights into expanding the applicability of this educational model.


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