JPPIPA 10(12) (2024)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Implementation of Project Based Learning based on Local Wisdom in Port Numbay Papua and its Impact on Students' Critical Thinking Skills

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Received: August 10, 2024
Revised: November 08, 2024
Accepted: December 25, 2024
Published: December 31, 2024

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DOI: 10.29303/jppipa.v10i12.9671

Abstract: The education sector bears a significant duty to nurture a generation prepared for the period of Society 5.0; thus, systematic initiatives to foster analytical, critical, and creative thinking are essential. We refer to this cognitive approach as higher-order thinking Skills (HOTS). This research aims to develop science instructional materials using a project-based learning approach, rooted in the local wisdom of Port Numbay, and assess its influence on students' critical thinking skills concerning Earth's structure and surface content. We conducted Research and Development (R&D) on the 4D model, transforming it into a 3D format without a dissemination phase. The research sample comprised seventh-grade pupils from public junior high schools in Jayapura City. Five validators approved the developed physics teaching materials. We utilized a quasi-experiment with a randomized pretest-posttest control group design to assess the impact of the teaching materials. The research findings indicated that the created teaching materials positively influenced student outcomes, revealing significant disparities in critical thinking skills between students utilizing the developed materials and those employing traditional teaching methods. The designed instructional materials facilitate student learning transitions and enhance critical thinking skills due to their inherent ability to stimulate creativity, originality, and independence in scientific learning.

Keywords: Critical thinking skills; Papuan local wisdom; Project-based learning

Introduction

Along with the times, technology has now become the basis of human life in economics, politics, culture, and arts, including the world of education. Every effort is made to adapt to the new era. The notion of Society 5.0 is a concept that has become part of the strategic plan chosen by Japan through the idea of a "Basic Policy on Economic and Fiscal Management and Reform" (Topcuoglu et al., 2024). Society 5.0 presents solutions to address the issues stemming from the Industrial Revolution 4.0, which is characterized by numerous disruptions indicative of a world increasingly marked by instability, uncertainty, complexity, and ambiguity (Sołtysik-Piorunkiewicz & Zdonek, 2021). Indonesia has entered a transformative phase of education towards Society 5.0, which requires its human resources to act as equilibrating agents in achieving economic advancement. This involves addressing diverse challenges associated with economic development and social issues, particularly in education. The education sector bears a significant duty to nurture a generation prepared for the period of Society 5.0; thus, systematic initiatives to foster analytical, critical, and creative thinking are essential. We refer to this cognitive

How to Cite:
Risamasu, P. V. M., & Pieter, J. (2024). Implementation of Project Based Learning based on Local Wisdom in Port Numbay Papua and its Impact on Students' Critical Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, *10*(12), 10917–10925. https://doi.org/10.29303/jppipa.v10i12.9671

approach as higher-order thinking Skills (HOTS) (Putranta & Supahar, 2019).

A country can achieve prosperity if the country has several entrepreneurs of at least 2% of its total population, while one of the conditions for being a developed country is that the ratio of the number of entrepreneurs reaches at least 14% of its total population (Chrysnaputra et al., 2021), Contemporary progress necessitates that students possess both soft and robust abilities. People often refer to hard skills as intellectual intelligence, which encompasses the competencies needed for a profession, including both general and specialized knowledge. Emotional intelligence, commonly known as soft skills, refers to the capacity to develop and improve students' performance, encompassing psychological, emotional, and spiritual competencies. Academic institutions can cultivate these skills through education.

Education should focus on equipping human resources to compete and possess high-quality competencies (Lamri & Lubart, 2023), asserted that soft skills and hard skills encompass all attributes that facilitate the execution of hard skills. In addition to personal success, these two skills can benefit the community and environment. To overcome the lack of hard skills and soft skills, the government launched an independent curriculum in 2020. The independent curriculum prioritizes a learning framework that fosters students' higher-order thinking Skills (HOTS) (Poláková et al., 2023). Afifah et al. (2019), clearly stated that HOTS is a prerequisite in the 2013 curriculum. The execution of the 2013 curriculum, focused on higher-order thinking skills (HOTS), necessitates that students possess the ability to resolve the challenges they encounter (Fitriani & Sari, 2019). The qualities of HOTS include problem-solving skills, creative thinking, critical thinking, the capacity to articulate opinions, and decision-making abilities (Widana, 2017).

Widana (2017) similarly expressed that the attributes of higher-order thinking Skills (HOTS) encompass analyzing, evaluating, creating, problem-solving, and critical thinking abilities. Consequently, educators must become proficient in instructing students to comprehend and resolve intricate issues. Higher-order thinking skills are necessary for subjects in the natural sciences. The science education approach prioritizes direct experiences to cultivate capabilities, enabling students to investigate and comprehend their natural environment. Kaushik et al. (2019), argues that ontology, epistemology, and axiology examine the nature of natural sciences through three dimensions: science as a process, science as a product, and science as a scientific attitude. If educators and educational stakeholders effectively execute the initiatives of the Indonesian government, particularly regarding national education standards and curriculum, then students in Indonesia should possess significantly elevated higher-order thinking skills, especially in scientific disciplines.

The reality that occurs in schools today shows that students' HOTS abilities in science subjects are still not optimal. This can be proven through data from the 2021 Program for International Students Assessment (PISA) survey, Indonesia is ranked 74th with a score of 371 in the reading ability category and 71st with a score of 396 in the science performance category (Serevina et al., 2019), This data certainly proves that Indonesia is still one of the countries with the lowest scores. Apart from PISA, the low HOTS ability of students, especially in science subjects, was also found in the research results of Maulina et al. (2022), that at the junior high school level in Bandar Lampung City, students' HOTS ability was relatively low, this was measured through the completion of scientific literacy questions. contains cognitive levels C4 (analyzing) and C5 (evaluating). Furthermore, research conducted by Sara et al. (2020), stated that there were no students' HOTS abilities in the very good category, 4% in the good category, then there were none in the sufficient category, 4% in the poor category, and 92% in the very poor category, so it still shows the low level of students' HOTS abilities.

The Project Based Learning (PjBL) Model is an effective learning framework for enhancing students' Higher Order Thinking Skills (HOTS) (Guo et al., 2020). The PjBL model is a pedagogical approach that encourages students to engage with, investigate, and contemplate a problem, thereafter analyzing it as a means to devise a solution. Additionally, Pratiwi et al. (2024), asserted that the PjBL model engages students in problem-solving aligned with the steps of the scientific process, hence fostering the development of students' higher-order thinking skills (HOTS). The PBL approach also has a big goal: to improve students' ability to apply ideas to new or real-world problems, encourage self-directed learning, and bring together higher-order thinking skills, motivation to study, and competencies (Sukackė et al., 2022).

Project-based Learning (PJBL) is an educational model that emphasizes the fundamental concepts and principles of a scientific discipline, engages students in problem-solving activities and other significant tasks, offers opportunities for autonomous learning, and culminates in the production of valuable and realistic outcomes. As stated by Boss and Kraus (Chang et al., 2024), project-based learning (PJBL) is an educational paradigm that prioritizes student engagement in addressing diverse open-ended problems and utilizing their knowledge to develop specific authentic products through project work. Utilizing PJBL enhances students' problem-solving capabilities and fosters the development of higher-order thinking skills (Suharno et al., 2022).

Papua is a region rich in natural and cultural resources. This cultural richness has a significant impact on individuals' daily lives, particularly in the field of education. Numerous studies indicate that the utilization of local community knowledge in Jayapura yields favorable outcomes in students' scientific process skills (Pieter & Risamasu, 2024). Furthermore, research by Risamasu et al. (2024), Yuendita et al. (2024), shows that only a small portion of the local wisdom of the people in Papua is included in physics learning. This indicates that there are broader chances to integrate local potential and riches in Papua into physics education in schools through project-based learning, aimed at enhancing students' scientific process skills and creative thinking abilities. The author is unaware of any instructional resources derived from the local wisdom of Pot Numbay that promote students' critical thinking skills. This research seeks to provide teaching materials utilizing a project-based learning approach grounded in the local wisdom of Port Numbay and to evaluate its effect on the critical thinking abilities of high school students in Jayapura City.

Method

This study utilized research and development (R&D) techniques to create a product and assess its efficacy. This research pertains to the 4-D development model (Yu et al., 2025), which encompasses four stages: define, design (planning), develop (development), and disseminate (distribution). In this study, the researcher executed only three stages: define, design, and develop. We evaluated the efficacy of the developed teaching materials on seventh-grade junior high school students in Jayapura City, using both an experimental group and a control group during the 2023/2024 academic year. Five expert validators, including two Physics Education lecturers from FKIP Cenderawasih University and three senior, certified Physics teachers from high schools in Jayapura City, subsequently reviewed the developed teaching materials using a questionnaire instrument. The acquired data is quantitative and derived from the validator's evaluation of the questionnaire.

The validation sheet for instructional materials evaluates numerous characteristics, including cover, drawings, structure, content, and language utilized. We analyzed the research data on a Likert scale ranging from 1 to 4. We collected data on the validation of the prepared instructional materials and the application of the learning tools using a questionnaire instrument, analyzed them using descriptive statistical techniques, and computed percentages using the following formula:

$$P = \frac{\sum x}{\sum xi} \times 100\% \quad (1)$$

Information:
P = percentage
$\sum x$ = total number of respondents' answers
$\sum xi$ = aggregate quantity of optimal ratings for a single item

The guidelines used to provide meaning and decision-making regarding product validity and implementation (product feasibility) are presented in Table 1.

Table 1. Five Guidelines for Absolute Scale Feasibility Conversion

Score range (%)	Qualification
90– 100	Highly valid
75 – 89	Valid
65 – 74	Enough
55 – 64	Less
0 – 54	Very less

The criteria for success in the product feasibility test (product validity and suitability) is if it reaches a minimum score of 75% (valid) with minimum qualifications. If it is below the minimum score, it needs to be revised again. Next, validation and reimplementation are carried out. This is done continuously until the minimum good criteria are met. We employed a t-test to assess the impact of teaching materials grounded in Port Numbay's local wisdom on the critical thinking skills of students in both the experimental and control classes. The SPSS 23 software facilitates the computation of the t-test. Additionally, we conducted an N-gain analysis between the experimental group and the control group to assess the impact of the generated instructional materials on students' critical thinking abilities:

$$g = \frac{S_{Post} - S_{Pre}}{S_{Maks} - S_{Pre}} \quad (2)$$

Information: g = normalized gain; S_{max} = maximum score of tests; S_{Post} = posttest score; and S_{Pre} = pretest scores. The high and low normalized gain values can be classified in Table 2.

Table 2. Normalized N-gain Category Values

N-gain Velue	Categories
g > 0.70	High
0.30 ≤ g ≤ 0.70	Medium
g < 0.30	Low

Result and Discussion

The product of this development research is the production of science teaching materials for class VII SMP which is a combination of Port Numbay local wisdom in science learning using the local wisdom of the Enggros and Tobati tribes in Jayapura on the surface of the earth, namely explaining the concept of the earth and the structure of the earth's layers. The activities carried out at each stage are as follows: The define stage is the stage for establishing and defining learning conditions under this research and development (operational definition). From the various analyses carried out at the Define stage, the final result obtained is a guide to the preparation and guidance of teaching materials that will be developed. The design stage aims to design learning tools and the final result of this design stage is the production of a blueprint or initial draft of the product (learning tools that accommodate Port Numbay's local wisdom in science teaching materials). The produced instructional materials encompass: competency standards (KI), basic competencies, indicators, learning objectives, content descriptions, learning summaries, practice questions, answer keys, and bibliography. In the development stage, we create a developmental product through two phases: expert evaluation and modification, and developmental trials. The ultimate objective of this development phase is to create a refined learning tool following changes informed by expert and practitioner feedback, as well as trial data.

Regarding the science process skills evaluation instrument, the validator practitioner provided notes that the images were selected by local wisdom found in the lives of the Port Numbay Papua Community as well as selecting images of the arrangement of the Matoa fruit (Pometia pinnata) which shows the structure of the earth's layers starting from the core to the surface layer of the earth. Apart from that, revisions were made to enlarge the image size so that it is visible and makes it easier for students to learn. Apart from that, notes from validator practitioners contain suggestions to pay attention to the typing in the manuscript layout, because there are still several typing errors found. Next, the research results section presents several results related to the development of teaching materials, which include validation based on feasibility instruments for media and content aspects as well as expert and practitioner responses to the products developed. Below is shown the cover and parts of the pages of the teaching materials resulting from the development research carried out.

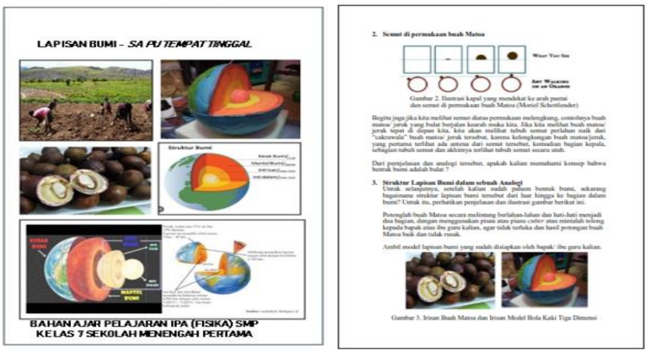

Figure 1. Display of developed teaching material

Table 3. Validation Result by Expert Judgment

Component	Mark		Mean	Qualification
	Val. I	Val. II	(%)	
Cover	91.67	100	95.83	Highly valid
Illustration	83.33	100	91.67	Highly Valid
Format	90	100	85	Highly valid
Content	95	90	92.50	Highly valid
Language	91.67	100	95.83	Highly valid
Mean			94.17	Highly valid

The validation results of the teaching materials indicated that content and material specialists responded favorably to the materials generated in this research. Subject matter experts conduct content evaluation on five components: cover, illustrations, format, content, and language. Subject matter experts conduct assessments by assigning a score ranging from one to four, specifically a score of 1-4. The analysis results reveal that content and material experts rated the quality of teaching materials as very good (90.67%), as illustrated in Table 3.

Table 4. Validation Results by Practitioners

Component	Mark			Mean (%)	Qualifications
	Prac. I	Prac. II	Prac. III		
Cover	91.67	100	100	97.22	Highly valid
Illustration	100	91.67	91.67	94.44	Highly valid
Format	95	91.66	95	92.22	Highly valid
Content	95	91.67	95	93.89	Highly valid
Langguagge	100	91.67	100	97.23	Valid
Mean				95.33	Highly valid

The results of the analysis show that the expert validator who validated the content and material responded in the very good category (94.17%), this indicates that the quality of teaching materials according to content and material experts is very good and can be used at this stage. Further research. Apart from being validated by experts, the teaching materials developed are also validated by practitioners who are secondary school teachers who teach science lessons. Furthermore, the results of validation by practitioners of the teaching materials developed are presented in Table 4.

The analysis of teaching materials validated by practitioners yielded an average score of 95.33%, placing it in the very good category. The validation value indicates that practitioners deem the developed Port Numbay Local Wisdom-based Project-Based Learning (PjBL) learning model suitable for use. The five validators corrected the revision notes, enabling the use of this learning material in school science education. Next, the researcher used a difference test (t-test) to determine whether the development of project-based learning model teaching materials, based on the local wisdom of Port Numbay, had a different impact on the critical thinking skills of students in the experimental group compared to the control group. The difference test (t-test) can be carried out provided that the data is normally distributed and homogeneous. Researchers used SPSS 23 to carry out normality tests and homogeneity tests. Table 5 below attaches the t-test results.

Table 5. Recapitulation of t-Test Results for Both Class

	t-test		
Class data	t	Sig.	Conclusion
Pre-test control and experiment class	0.17	0.86	There were no significant differences between the two classes.
Post-test control and experiment class	5.46	0.00	There are significant differences between the two classes.

The t-test results in Table 5 show a significant difference in the critical thinking skills of students in both courses that utilize project-based learning materials rooted in the local knowledge of Port Numbay for scientific instruction. Port Numbay's local expertise in its materials forms the foundation of the PjBL approach. Science instruction is superior to traditional teaching resources regarding Earth's Surface and Structure for seventh-grade students. We use normalized gain (N-gain) to calculate the percentage increase in students' critical thinking skills. Table 6 provides data on the percentage increase in N-gain associated with students' critical thinking skills.

Table 6. Percentage Increase in N-gain Student's Critical Thinking Skills

Class Data	N-gain (%)	Category
Experiment Class	53	Medium
Control Class	34	Low

The data in Table 6 indicates that the percentage increase in N-gain for students' critical thinking skills is greater in the experimental class utilizing project-based learning materials grounded in local Port Numbay wisdom, as opposed to the control class employing conventional textbook materials. The research findings indicated that the teaching materials utilizing the PjBL learning model, grounded in the local wisdom of Port Numbay (Jayapura), achieved a classification of very good. Expert validators assigned an average score of 94.17 for criteria including cover, illustration, format, content, and language, while practical validators provided an average rating of 95.33, also in the excellent category. Two premises theoretically underpin efforts to produce and test learning products grounded in the local expertise of Port Numbay Jayapura (Ahmer, 2020; Houston, 2014).

The primary point is that the ethnoscience-based learning paradigm significantly contributes to the efficacy of educational practices (Christiana & Rohaeti, 2024). This remark implies that ethnoscience, encompassing local expertise, ought to serve as a foundation for enhancing educational efficacy. Secondly, significant learning is the paramount component of education. This suggests that the learning process must connect the material with the context within the subject area, rendering learning more meaningful and engaging for students (Widana, 2017). Table 5 presents the outcomes related to enhancing students' critical thinking skills. We observed significant differences in critical thinking skills between the experimental group, which used the PjBL learning model based on local wisdom in Port Numbay, and the control group, which used conventional learning models.

Project-based learning (PjBL) can be utilized to address challenges encountered in education and has been demonstrated to enhance students' critical thinking skills (Yusuf, 2023). Numerous prior studies indicate that individuals with deficient critical thinking skills might enhance their abilities when instructed through the PjBL learning model (Daniel, 2017). Subsequent studies demonstrated that project-based learning influenced students' critical thinking skills. The PjBL paradigm enables students to engage actively in their learning, fostering independence in analyzing and developing their concepts. According to recent studies, we can tailor project-based learning as an alternative educational methodology to both the learning content and the individual characteristics of students (Awamleh, 2024). We can adapt the PjBL model by incorporating learning media into its implementation.

Learning media can enhance students' comprehension of the teaching and learning process. Website-based learning tools, a contemporary development in education, are considered successful and engaging, especially when evaluation results are available before an examination. Science educators highly favor the implementation of a science domain-based learning model that incorporates local wisdom, as the findings of this research align with those of (Kamila et al., 2024). Gede Parma et al. (2020), asserted that science educators may readily embrace the advancement of learning methods rooted in indigenous Balinese culture. Alam et al. (2023), asserted that the use of big book media rooted in local wisdom during the learning process effectively captivates students' attention, as it aligns with the context of their everyday lives.

Gallois et al. (2015) Situated cognition theory, which posits that children acquire knowledge organically through engagement with authentic activities, context, and culture, aligns with several of the aforementioned research findings. Moreover, findings from Alam et al. (2023) Indicate that the use of a science education model grounded in local wisdom influences student academic performance. The t-test results show a significant difference in student learning outcomes between the science learning model rooted in local wisdom and the scientific approach learning model. The significance indicates that there are variations in student activities before and following the use of a science learning paradigm grounded in local wisdom. (Marginson, 2024; Collins & Stockton, 2018).

The initial impact of employing a science learning approach grounded in local wisdom on creativity is derived from the posttest outcomes. The assessment consists of descriptive questions that encourage students to think divergently, integrating many ideas pertinent to comprehending the learning material alongside the local wisdom of the prey system. The findings indicated that the post-test score in the experimental group surpassed that of the control group. The notable disparity in post-test average scores between the experimental and control classes stemmed from the impact of the student's learning process in the experimental class (Safitri & Purnamasari, 2024; Gusmaweti et al., 2023). Instruction in experimental courses that integrate educational content with local wisdom offers pupils a more expansive experience than previous scientific-pedagogical models. The notable disparity in posttest average scores between the experimental and control classes indicates that the Port Numbay local wisdom-based project-based learning model enhances students' critical thinking abilities, as PjBL prioritizes fostering creativity in project completion. This aligns with the creative, imaginative, and autonomous principles inherent in the project-based learning approach.

The application of the project-based learning model in science education, grounded in local wisdom in Port Numbay, allows pupils to enhance their creativity. Students engage actively in the learning process by employing a science education paradigm rooted in local wisdom through discussions and experimental activities. Moreover, Setiawan et al. (2017) showed that science modules grounded in indigenous wisdom might enhance students' scientific literacy. The findings of Leal Filho et al. (2018), George et al. (2023), Gutierrez et al. (2023), Kooli (2023), further corroborate research conclusions, indicating that the incorporation of local potential in scientific education enhances students' critical thinking abilities.

Conclusion

We can draw the following conclusions from the data analysis and subsequent discussions: The science teaching resources developed utilizing the Project Basel learning approach, grounded in the local wisdom of Port Numbay, are highly appropriate for deployment in educational activities within schools. The expert validation results indicate an average score of 94.17%, while practitioner validation yields an average of 95.33%, both classified as very good. There is a big difference between how well students in Port Numbay learn critical thinking skills using project-based learning materials based on local knowledge and those who learn these skills using traditional teaching materials in class VII science lessons about the structure and layers of the earth. The percentage increase in N-gain for students' conceptual mastery using project-based learning materials based on local knowledge in Port Numbay, Jayapura, was 54%, which is considered medium, while the percentage increase with conventional teaching materials was 34%, which is considered low.

Acknowledgments
The researcher would like to express his deepest thanks and appreciation to everyone involved in this research, junior high school students in Jayapura City, science teachers, validators, and all parties we cannot mention.

Author Contributions
Conceptualization; P. V. M. R., J. P.: methodology; P.V. M. R.; Validation; J. P: formal analysis.; P. V. M. R.: investigation.; J. P.; resources; P. V. M. R: data curation: J. P.: writing—original; P. V. M. R.: draft preparation; J, P.: writing—review and

editing: P. V. M. R.; visualization: J. P. All authors have read and agreed to the published version of the manuscript.

Funding
This research received no external funding.

Conflicts of Interest
The authors declare no conflict of interest.

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