LABORATORY BASED *INQUIRY LEARNING* APPROACH INTEGRATED WITH LOCAL WISDOM: *SYSTEMATIC LITERATURE REVIEW*

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ABSTRACT This article is a systematic literature review that aims to analyze the application of laboratory based *Inquiry Based Learning* (IBL) integrated with local wisdom in science learning, especially in physics subjects. This approach was chosen to improve students' critical thinking skills and science processes, through experiments that are relevant to the local cultural context. In this review, the *Systematic Literature Review (SLR)* method was used based on PRISMA guidelines. A literature search was conducted in major academic databases with keywords related to IBL, laboratory, and local wisdom, focusing on English and Indonesian articles published between 2014 and 2024. From the initial 450 articles, the screening process resulted in 35 articles that were analyzed in depth. The results showed that this approach can improve students' critical thinking skills by linking scientific concepts with local cultural contexts that students are familiar with. The integration of local wisdom in laboratory learning also helps develop science process skills, such as observation, experimentation, and data analysis, in situations that are more real and relevant to students. The findings suggest that science curricula should utilize the potential of local wisdom to create more contextualized learning and strengthen the link between theory and practice. This research provides insights for the development of more inclusive learning models based on local values to improve the effectiveness of science learning. In conclusion, laboratory-based IBL with local wisdom integration offers an effective and contextualized strategy in 21st century science learning that is adaptive and culturally relevant.

Keywords: *Inquiry Based Learning***,** *Laboratory***,** *Local wisdom***,** *Critical thinking skills***,** *Science process skills*

INTRODUCTION

The 21st century is one in which countries around the world interact with each other as if there were no geographical differences. Technology and science are developing rapidly. Globalization is increasing. Resources have the ability to flow freely and openly. The free entry of foreign labor into the country, the large number of imported goods that impact the domestic production system, and other factors. To achieve this, Indonesia must have the necessary abilities to live in the 21st century, which can be obtained through the education process (Mardianti, 2020; Redhana, 2019). The 21st century demands students' higher-order thinking skills (Septiani & Susanti, 2021).

In the 21st century, learning not only focuses on mastering content, but also requires students to develop critical thinking abilities and good science process skills (Akinbobola & Afolabi, 2010; Panjaitan & Siagian, 2020; Redhana, 2019). Critical thinking skills are needed to evaluate information analytically, solve complex problems, and make evidence-based decisions (Hasanah et al., 2023). On the other hand, science process skills, such as designing experiments, making observations, and analyzing data, are important for students to understand and apply the scientific method in everyday life.

Science process skills are important to build knowledge and apply in learning. In building knowledge, it is not only obtained through theory, but can also be obtained from experiments or activity-based learning (Logo et al., 2023). This is where science process skills can emerge because these skills contain scientific methods or steps in searching, obtaining new knowledge and developing the knowledge they have (Mardianti, 2020). These two abilities are an integral part of 21st century competencies that aim to prepare the younger generation to face global challenges and rapid technological developments (Trilling & Fadel, 2009).

Physics education in schools plays a crucial role in equipping students with essential skills (Jayadi et al., 2020). The objective of physics learning, as outlined in the 2013 curriculum framework, is to ensure students master fundamental concepts and principles of physics, develop the skills necessary to expand their knowledge, and cultivate confidence as a foundation for further education. Additionally, it serves as a basis for supporting scientific advancement and technological development (Abidin, 2014; Jayadi et al., 2020). Physics learning is viewed as a cognitive process aimed at developing students' ability to comprehend concepts, principles, and laws of physics. Consequently, the learning process must incorporate effective and efficient strategies and methods. To achieve this, students should be guided to discover and construct physics concepts independently. This approach is expected to foster and enhance their critical thinking skills (Nasution, 2018; Syafriati, 2017).

A key objective of science education, including physics, is to cultivate scientific thinking, enhance inquiry skills, and develop the ability to reason within a scientific framework (Council, 2012). Inquiry can be done through inquiry learning (Abdurrahman, 2017). Thinking skills in 21st century learning can be taught through inquiry (Maryam et al., 2020). *Inquiry* learning is learning that seeks to develop scientific ways of thinking. This learning model provides more space for students to learn more on their own, explore as creatively as possible in solving problems (Bilgin, 2009). Inquiry originates from the word to inquire, which refers to the process of actively engaging in questioning, seeking information, and conducting investigations (Yuniyanti & Sunarno, 2012). *Guided inquiry* is one type of inquiry where students investigate questions or problem formulations presented by the teacher using procedures designed by students themselves. Students try to explore their own knowledge and concepts with the guidance of the teacher (Bilgin, 2009).

Inquiry learning is inseparable from experimenting in the laboratory (Narang et al., 2022). Learning environments supported by laboratory activities play a vital role in enhancing students' science process skills and critical thinking abilities (Basak Erkacmaz et al., 2023). The inquiry-based laboratory approach is rooted in Bruner's student-centered teaching and learning theory. Through this approach, students explore principles, concepts, and generalizations by conducting experiments they design themselves, fostering continuous curiosity. In learning environments that adopt this method, students exhibit strong cognitive and affective characteristics, enabling them to conduct research, design experiments, formulate hypotheses, and construct knowledge independently. Additionally, this approach helps students develop essential scientific skills, such as collaborating in groups, sharing information, and engaging in critical questioning (Basak Erkacmaz et al., 2023; Erdem & Alkan, 2015). Laboratories enable teachers to effectively demonstrate theoretical principles through practical applications (Wardani et al., 2017).

In the context of Indonesian education, laboratory-based learning methods integrated with local wisdom are becoming increasingly important to improve the relevance of teaching materials and instill local values in students. Local wisdom, which includes values, norms, and knowledge unique to a region, provides a strong foundation for student character building, enriches learning, and supports environmental and social sustainability in local communities. This local wisdom based laboratory experiment can also add new knowledge for students (Ardiansyah & Fadliah Nur, 2024; Pamungkas et al., 2017; Sapitri et al., 2020). The integration of local wisdom in inquiry based learning in the laboratory has great potential to increase student learning motivation, enrich concept understanding, and strengthen the connection between scientific knowledge and daily life. In addition, this approach can also contribute to cultural and environmental preservation.

Although there have been many studies that discuss IBL, laboratory-based learning, and local wisdom integration separately, there are still limited studies that systematically review the integration of these three aspects in science learning. Therefore, a systematic literature review is necessary to analyze and synthesize various studies on the laboratory based Inquiry Based Learning (IBL) approach integrated with local wisdom. This review aims to provide a comprehensive understanding of its effectiveness, challenges, and best practices in implementation. Additionally, it serves as a crucial empirical foundation for developing learning models that incorporate IBL, laboratory activities, and local wisdom. The findings of this study are expected to make a meaningful contribution to the advancement of science education, ensuring it is both pedagogically effective and culturally relevant for students.

METHOD

The writing of this article uses a literature study. The method used in this article uses a Systematic Literature Review (SLR) approach with a focus on analyzing various literatures that discuss the implementation of laboratory based Inquiry Based Learning (IBL) integrated with local wisdom. This research design follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure the process of selecting and presenting literature is transparent and structured (Page & Moher, 2017). The stage applied to obtain research data is based on a review of previous research literature (Hudha et al., 2023). At the beginning of the review, the question was explained so as to indicate the objectives to be answered in the research. The database used for the criteria search along with the selection of studies is shown.

The main data sources were obtained from various academic databases, such as *Scopus*, *Web of Science*, *ScienceDirect*, *Google Scholar*, and Garuda. Search keywords included combinations of terms such as "Inquiry Based Learning," "Laboratory," and "Local Wisdom," and their Indonesian equivalents.

The search was filtered to articles published within the ten-year period from 2014-2024 to maintain relevance to recent developments. The initial search related to the terms "Inquiry Based Learning," "Laboratory," and "Local Wisdom," on physics learning resulted in 450 articles. Subsequently, 450 journals were downloaded in RIS (Research Information System) format and imported into the Mendeley Reference Manager application. Once imported, the RIS files from each journal were consolidated into a single RIS file encompassing all journals. The final step involved processing this combined RIS file using VOSviewer software to generate a graphical representation of the bibliometric map. The second search was narrowed down to get the latest trends and research results of *"Inquiry Based Learning," "Laboratory,"* and *"Local Wisdom,"* in physics learning in physics learning which obtained 95 articles.

Inclusion criteria were set to include articles that addressed laboratory based IBL with local wisdom integration, in both English and Indonesian, and in the context of relevance to education in Indonesia. On the other hand, exclusion criteria were applied to articles that did not include practical applications or were not relevant to the context of IBL. The study selection process was conducted in several stages, starting with an initial screening based on title and abstract, followed by a full-text review for studies that met the inclusion criteria. Each stage of screening was recorded and presented as a PRISMA diagram to visualize the number of studies identified, excluded and included in the final analysis.

Articles that met the inclusion criteria and did not fall under any exclusion criteria were further reviewed based on specific characteristics or quality standards. In this literature review, the quality criteria focused on several aspects, including the description of the inquiry learning model, research design, objectives, sample or research participants, responses to research questions, research conclusions, variables, recommendations for future inquiry model development, and the educational levels targeted. Of the 95 articles included in the initial search in the database, an analysis was then carried out based on quality criteria so that 60 articles were eliminated and in the end 35 were selected for further analysis. The data extraction stages can be represented through the PRISMA method shown in Figure 1

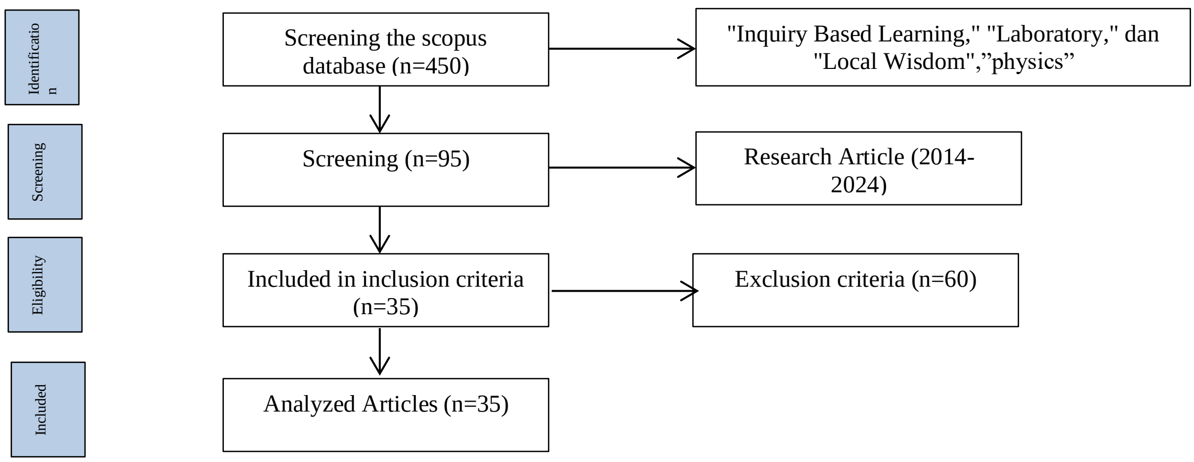

Figure 1. Prism Stages

Data extracted from each article included basic study information, research methods, main findings, and recommendations related to the implementation of laboratory based IBL with local wisdom. The data collected was then analyzed qualitatively to identify key themes related to the effectiveness, challenges, and potential for further development of laboratory-based IBL integrated with local wisdom.

RESULTS AND DISCUSSION

The laboratory-based *Inquiry Based Learning (IBL)* approach integrated with local wisdom is a promising solution in improving students' critical thinking skills and science processes. This approach combines IBL principles that allow students to be active in experimental activities with relevant local contexts, so that learning materials become more meaningful. Local wisdom, which includes values, norms and knowledge typical of a region, provides a basis for learning that not only focuses on cognitive aspects but also character aspects, such as respect for local culture and environment.

Various studies have shown that the integration of IBL with local elements can increase student learning motivation, strengthen concept understanding, and facilitate the transfer of scientific knowledge into everyday life. This is important in 21st century education, where students are not only required to master knowledge, but also to develop higher order thinking skills that are adaptive and relevant to their environment. IBL has been shown to increase student engagement and support the development of critical thinking skills. Research by (Suhardi, 2020; Zhang, 2019) showed that this approach helps students to understand scientific concepts better, as they are directly involved in the research and experimentation process. The laboratory, as part of IBL, allows students to test their own hypotheses, collect data, and analyze the results.

Laboratories also provide an environment that allows students to conduct in-depth experiments. Based on the findings of (Arslan, M., 2021; Tan, W, 2020), , laboratory-based learning allows students to connect the theoretical concepts they learn with real practice. In this context, students' active involvement in experiments was shown to improve their understanding of scientific principles. (Tan, W, 2020) conducted experiments at the secondary school level using the IBL approach in science subjects. Tan reported that 95% of students who engaged in IBL-based learning showed improvement in their critical thinking skills, as measured using the Critical Thinking Disposition Inventory (CTDI). These results showed that students were able to better construct arguments, analyze experimental data, and consider various solutions to scientific problems.

In addition (Kilic, 2019) conducted a quasi-experimental study involving 200 high school students to measure their critical thinking skills after following IBL learning. The results showed a 30% increase in critical thinking test scores given to the experimental group who received IBL-based teaching, compared to the control group who followed traditional learning methods. The study also showed that students who learned through IBL were more likely to demonstrate the ability to evaluate information and make evidence-based decisions. Below is a table of findings relevant to this article:

Table 1. Search Results for Articles that Meet the Criteria

No	Author Name	Title	Journal	Citation	Journal Rank
1	(Gericke et al., 2023)	A Systematic Review Of Research On Laboratory Work In Secondary School	Studies in Science Education	69	Q1
2	(La Braca & Kalman, 2021)	Comparison of labatorials and traditional labs: The impacts of instructional scaffolding on the student experience and conceptual understanding	Physical Review Physics Education Research	22	Q1
3	(Kruse, 2022)	Comparing students' perceptions of the thinking required in inquiry-based and traditional laboratories	School Science and Mathematics	2	Q2
4	(Andersson & Enghag, 2017)	The Relation Between Students' Communicative Moves During Laboratory Work In Physics And Outcomes Of Their Actions	International Journal of Science Education	32	Q1
5	(Irwanto, 2019)	Using Inquiry-Based Laboratory Instruction to Improve Critical Thinking and Scientific Process Skills among Preservice Elementary Teachers	Eurasian Journal of Educational Research	44	Q3
6	(Nguyen, 2024)	The Impact Of Inquiry-Based Laboratories On Improving Pre-Service Teachers' Experimental Competency	International Journal of Innovation in Science and Mathematics Education	4	Q3
7	(Parmin, 2016)	Preparing Prospective Teachers in Integrating Science and Local Wisdom through Practicing Open Inquiry	Journal of Turkish Science Education	131	Q3
8	(Huang, 2022)	Effectiveness Of Inquiry-Based Science Laboratories For Improving Teamwork And Problem-Solving Skills And Attitudes.	Journal of Research in Science Teaching	20	Q1
9	(Baharom, 2020)	Integration of Science learning Apps based on Inquiry Based Science Education (IBSE) in enhancing Students Science Process Skills (SPS)	International Journal of Interactive Mobile Technologies (iJIM	32	Q3
10	(Adlim et al., 2018)	The Effect of Conventional Laboratory Practical Manuals on Pre- Service Teachers' Integrated Science Process Skills	Journal Of Turkish Science Education	14	Q3

Table 1 above illustrates key articles related to the topic to be raised. Some studies have done a lot of research related to the topic of the dissertation to be carried out. Research conducted by (Gericke et al., 2023) with the research title A Systematic Review Of Research On Laboratory Work In Secondary School. The research results in the article show that laboratory work in science education in secondary schools has great potential to improve student learning and develop their science practice skills. Through a systematic analysis of various empirical studies conducted over the past two decades, this research identified several important findings: a) Laboratory work can assist students in understanding science concepts more deeply and acquiring skills to conduct scientific investigations, b) Implementation of student-centered teaching with a focus on guided and open-ended inquiry can be an effective approach in improving student learning, c) Integration of scientific writing in laboratory reports can assist students in effectively articulating their scientific findings.

Other research conducted by (La Braca & Kalman, 2021) which aims to compare two types of physics laboratory formats, namely labatorial and traditional laboratories, with a focus on students' learning experience and concept understanding. The main findings of his research are as follows: Labatorials using instructional scaffolding were able to improve students' collaboration, engagement, and concept understanding. On the other hand, traditional labatories focus on following step-by-step instructions to avoid mistakes, which can hinder concept understanding. In labatorials, students experience a low-pressure environment that encourages active learning and teamwork. In traditional labs, students tend to emphasize task completion and error avoidance, leading to dissatisfaction as tasks feel repetitive and procedural. Based on the article, it was found that traditional labs in physics education often focus on a rigid recipe-step-based approach, resulting in a lack of conceptual understanding and low student satisfaction.

Research (Kruse, 2022) titled *Comparing Students' Perceptions of the Thinking Required in Inquiry-Based and Traditional Laboratories*, this study aims to compare students' perceptions of inquiry-based and traditional laboratory environments, with a particular focus on critical thinking and creativity. The results showed that inquiry-based laboratories are more effective in encouraging students to think critically and creatively. The inquiry approach allows students to design their own experiments, analyze data, as well as make conclusions based on the observations, which reflects a mini-research approach. Other findings in his study suggest that even small changes to the traditional laboratory experience, such as reducing the repetition of standard procedures and making room for **inquiry** activities, can make a significant difference to students' perceptions of creativity and critical thinking. This is in line with research conducted by (Irwanto, 2019), The findings indicate that the Inquiry-Based Laboratory Instruction (IBLI) approach is effective in enhancing critical thinking and science process skills among prospective teachers. The authors recommend integrating this method into the science education curriculum. IBLI fosters active student engagement in the learning process, including planning, designing, and conducting experimental procedures. This helps students to not only learn theoretically but also apply their knowledge in practice. In addition to practical experience, IBLI also emphasizes the importance of mental engagement *(minds-on)* which helps students in analyzing and interpreting data, as well as communicating about their experimental results.

Other research findings conducted by (Andersson & Enghag, 2017) with the title *The Relation Between Students' Communicative Moves During Laboratory Work In Physics And Outcomes Of Their*

Actions. The results showed that discourse analysis can provide an in-depth understanding of how students communicate and interact during physics laboratory work. This study identified various types of communicative *moves (discursive* moves*)* used by students, including action moves, *content moves*, and *purposive moves* at the linguistic and cognitive levels. The study found that students used three main types of talk during laboratory work: *exploratory talk*, *disputational talk*, and *cumulative talk*. *Exploratory talk* was identified as the most valuable type of talk in an educational context as it allows students to challenge, accept, and extend each other's statements, thus creating agreement and promoting cognitive learning. *Disputational talk*, on the other hand, can be a barrier to learning if not directed by the teacher. *Cumulative talk* is used when students describe what they are doing or will do, which is important for understanding the process of scientific investigation. The conclusion of this study explains that different interaction structures in physics laboratory work can support or hinder the development of students' understanding, and it is important for teachers to design laboratory activities that facilitate the appropriate type of communication to achieve learning objectives.

Research with the title *The Impact Of Inquiry-Based Laboratories On Improving Pre-Service Teachers' Experimental Competency* yang dilakukan oleh (Nguyen, 2024) concluded that inquiry-based laboratories (IBL) improve the experimental competence of prospective physics teachers. The results showed that IBL was effective in developing several aspects of experimental competence, especially in determining experimental objectives and carrying out experiments. However, the least developed aspects were the ability to process data and analyze and evaluate results. The article only focused on experimental competence, but did not specifically touch on science process skills at large. Other research related to the implementation of inquiry models integrated with local wisdom was conducted by (Parmin, 2016) with the title Preparing Prospective Teachers in Integrating Science and Local Wisdom through Practicing Open Inquiry. The results showed that the application of the open inquiry model proved effective in preparing prospective science teachers to integrate science with local wisdom. This model provides authentic experience in conducting scientific investigations of local wisdom that was previously considered an unscientific tradition, so that local wisdom can be tested and transformed into scientific knowledge used in learning. The open inquiry model improves the creative and independent thinking skills of prospective science teachers, and increases their understanding of science learning materials after going through the process of scientific local investigation. The integration of local wisdom in science education also provides additional benefits in learning, as students can see the direct connection between modern science and traditional practices that exist in their culture. Research by (Fitri, S., 2019; Nasution, H., 2020) showed that when local wisdom is applied in a laboratory context, students not only understand scientific theories, but also appreciate local cultural values that are relevant to their social and environmental context.

Research by (Huang, 2022) which focused on the effectiveness of inquiry-based laboratories in improving students' cooperative skills, problem solving, and attitudes towards scientific collaboration. In traditional laboratory methods, students tend to follow limited experimental instructions, which limits their opportunities to discuss, negotiate, and justify scientific ideas in a collaborative environment. To overcome these limitations, inquiry-based laboratories were introduced with the aim of getting students to formulate experimental questions, develop procedures and solve problems in a way that is meaningful to them. This article seeks to evaluate how much influence inquiry-based learning has on the development of team and problem-solving skills among students with different backgrounds. It also explores whether inquiry-based laboratory learning can help overcome skill differences between novice and more experienced students, especially in the context of team-based problem solving. The conclusion of this research article is that inquiry-based science laboratories are proven to be effective in improving team-based problem solving skills and attitudes towards teamwork. This research is also in line with research (Baharom, 2020) who found that the integration of inquiry-based learning applications significantly improved student achievement in both basic and integrated science process skills. The significant increase in *pre-test* and *post-test* scores indicates that the inquiry-based approach integrated with mobile technology can have a positive impact on science learning. The results of data analysis showed that students who learned with the app-based inquiry approach were able to show significant improvement in basic and integrated science process skills. This illustrates that this approach not only facilitates a more interactive learning process, but also helps students develop critical and analytical thinking skills needed in solving science problems. The significant improvement in integrated science process skills also indicates that the use of mobile apps gives students the freedom to explore and investigate science problems, thus strengthening their understanding.

Research conducted by (Adlim et al., 2018) with the title *The Effect of Conventional Laboratory Practical Manuals on Pre- Service Teachers' Integrated Science Process Skills.* The results showed that although prospective teachers did a lot of laboratory practicum, their skills in several aspects of ISPS, such as identifying and controlling variables, stating operational definitions, and designing experiments, were still at a low level. This is due to the format of the practicum manuals, which are generally confirmative and do not provide opportunities for students to actively practice these skills. Most of the existing lab manuals do not cover the essential elements of ISPS, so prospective teachers do not gain adequate experience in the required skills. This study also found that although there was an increase in ISPS scores as the frequency of practicum increased, there was no significant difference between the ISPS scores of teacher candidates from science majors (biology, physics, and chemistry) and teacher candidates from math majors who did not have laboratory practicum. This suggests that the experience of laboratory practicum is not always directly proportional to the improvement of science process skills, especially if the manuals used are not designed to support the development of these skills.

Laboratories play a key role in the development of students' science process skills (Zhang, 2019) reported in his research that the use of laboratories in the context of IBL improves students' science process skills, including the skills of planning experiments, collecting data, and analyzing results. In a study involving 150 secondary school students, the group that followed the IBL-based experiment showed a 40% improvement in science process skills, based on the Science Process Skills Test (SPST).

For example, in an experiment testing the skills of planning experiments and analyzing data, students involved in laboratory-based learning using the IBL approach scored on average 15% higher than students using traditional learning methods. These results suggest that laboratories not only provide practical skills in science, but also strengthen students' theoretical understanding through hands-on experience.

CONCLUSION

The article concludes that implementing a laboratory based Inquiry Learning (IBL) approach integrated with local wisdom has been proven effective in enhancing students' critical thinking and science process skills. The integration of local wisdom in laboratory learning provides a more relevant and meaningful context for students, which in turn enriches their learning experience. Learning that connects physics or science theories with students' cultural values and daily practices allows them to more easily understand scientific concepts and apply them in real life. This approach not only strengthens scientific understanding, but also fosters the ability to think critically through local culture-based observation, experimentation and reflection. This approach also shows that laboratory based learning integrated with local wisdom can increase students' involvement in the learning process and make them more interested in exploring and testing science concepts. In this context, the laboratory is not only a place for experimentation, but also a space to connect science with the local cultural, social and environmental context.

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