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The Effect Size of Inquiry Based Learning Containing Ethno-Physics on Students 21 Century Thinking Abilities

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Abstract

The purpose of this study was to determine the effect size of inquiry based learning based on ethno-physics on students' 21st century thinking skills. The type of research is quantitative research with meta-analysis method. Data comes from the analysis of 14 national and international journals published in the last 5 years 2019-2024. Data search keywords are inquiry based learning model; Inquiry based learning based on ethno-physics and students' 21st century thinking skills. Data sources were searched through google scholar; ERIC and Mendeley. Data analysis in this study is quantitative analysis by calculating the effect size value of each study with the help of the Microsof excel 2020 application. The results of this study concluded that the ethno-physics-based inquiry-based learning model had a significant effect on students' 21st century thinking skills with an average effect size value of ES = 0.9163 (high effect size). This finding provides important information that the implementation of inquiry based learning based on ethno-physics has a positive impact on students' 21st century thinking skills.

Keywords: Inquiry Based Learning; Size Effect; Ethno-Physics; 21st Century Thinking

Introduction

21st century skills are the main foundation for the young generation in facing the complexity of global challenges characterized by technological developments, social changes, and economic dynamics. The ability to think critically, problem-solving, creativity, collaboration, and communication is no longer considered as additional skills, but as core needs in the world of education and the world of work(Prahmana & D'Ambrosio, 2020; Widyaningtyas et al., n.d.; Zulyusri et al., 2023). Critical thinking allows students to evaluate information in depth, while problem-solving trains them to formulate innovative solutions to real problems. Creativity plays a role in driving the birth of new and relevant ideas, while collaboration and communication prepare students to work effectively in cross-disciplinary teams as well as global contexts (Trilling & Fadel, 2009; Voogt & Roblin, 2012).

In addition, 21st century skills also have strategic implications for the development of competitive human resources. Education that only emphasizes mastery of content without practicing high-level thinking skills has the potential to produce graduates who are less adaptive to the changing times. On the other hand, the integration of critical thinking, problem-solving, creativity, collaboration, and communication skills in learning encourages the formation of a generation that is innovative, productive, and able to face global challenges such as the industrial revolution 4.0 and the era of society 5.0 (Ananiadou & Claro, 2009; Saavedra & Opfer, 2012). Therefore, 21st century skills-based education is a priority in shaping students who are not only academically competent, but also socially and professionally relevant (Ali et al., n.d.; Gusman et al., 2022; Syafruddin et al., 2024).

One of the main challenges of today's education world is how to prepare students to not only master content, but also be able to think at a high level. Most learning practices in schools are still oriented towards factual knowledge transfer, so students are more geared towards memorizing rather than analyzing, evaluating, and creating new solutions. In fact, higher order thinking skills (HOTS) are at the core in facing the development of science and technology that demands adaptability and innovation. This condition shows that there is a gap between the demands of 21st century skills and the reality of classroom learning which tends to be still conventional (Brookhart, 2010; Zohar & Dori, 2003). In addition, another challenge arises from the limitations of teachers in designing learning that is able to stimulate HOTS consistently. Many teachers still use memorization-based lecture and assessment methods, which hinder the development of students' analytical, critical, and creative skills(Gusman et al., 2022; Oktarina et al., 2021, 2021; Zulyusri et al., 2023). Another factor that strengthens this challenge is the limited facilities, learning resources, and education policies that have not fully integrated HOTS in curriculum and assessments. This results in students being less trained in dealing with complex real-world problems, so the world of education needs to transform learning that is more contextual, interactive, and inquiry-based (King, Goodson, & Rohani, 2019; Heong et al., 2011).

Inquiry Based Learning (IBL) is one of the learning models that emphasizes the active involvement of students in discovering and building knowledge through the investigation process. In this approach, students are encouraged to ask questions, design experiments, analyze data, and draw conclusions based on empirical evidence(Antonio & Prudente, 2023; Deniş-Çeliker & Dere, 2022). Thus, learning is no longer passive, but rather places students as subjects who play a direct role in the construction of knowledge. This model is in line with constructivist theories that assert that knowledge cannot be transferred directly, but must be built through meaningful learning experiences (Hmelo-Silver, Duncan, & Chinn, 2007; Pedaste et al., 2015). In addition, IBL has been shown to be effective in improving students' critical thinking, problem-solving, and scientific skills. Through structured investigation, students not only understand concepts in depth, but are also trained to connect theories with real phenomena(Bekteshi et al., 2023, 2023; Kwangpukieo & Sawangboon, 2024). This makes learning more relevant to the context of daily life and fosters scientific attitudes such as curiosity, openness to evidence, and the ability to reflect. Research shows that the application of IBL is able to improve learning outcomes while fostering 21st century skills, making it relevant to be applied in modern education that demands integration between knowledge, skills, and attitudes (Lazonder & Harmsen, 2016; Alfieri et al., 2011).

The integration of ethno-physics in learning is an innovative strategy that connects local wisdom with physics concepts so that learning is more meaningful and contextual. This approach was born from the idea of ethnoscience that emphasizes the importance of local knowledge as a valid and relevant source of learning(Ernawati & Sari, 2022; Hendratmoko et al., 2023). Through ethno-physics, students can study natural phenomena or cultural practices in their environment, then relate them to the principles of modern physics(Rahman et al., 2023, 2023; Santosa et al., 2023; Syafruddin et al., 2024). This not only strengthens conceptual understanding, but also builds students' awareness that science does not stand alone, but is rooted in the cultural experiences and practices of society (Aikenhead & Ogawa, 2007; Rosa & Orey, 2016). Furthermore, ethno-physical integration is able to increase students' motivation and involvement in learning because it presents a context that is close to their daily lives. For example, the application of Newton's laws in traditional activities, or the principles of mechanics in local technology, provide an opportunity for students to see the interconnectedness between the physical sciences and socio-cultural realities. Thus, ethno-physics serves as a bridge between modern science and local wisdom, while fostering students' cultural identity in the learning process. This approach not only supports the mastery of scientific knowledge, but also develops critical and reflective thinking skills that are the demands of 21st century education (Khuzaimah & Affandi, 2020; Suastra, 2017).

Research Methods

This study uses a meta-analysis method with the aim of integrating findings from various relevant studies related to the effectiveness of ethno-physics-based Inquiry Based Learning (IBL) on students' 21st century thinking skills. The research data was obtained from the results of searching 14 national and international journal articles published in the last five years (2019–2024). The search process was carried out using the keywords "inquiry based learning," "inquiry based learning based on ethno-physics," and "students' 21st century thinking skills" through several online databases, namely Google Scholar, ERIC, and Mendeley. Article selection is carried out based on the suitability of the topic, the quality of the publication, and the direct relationship with the research variables so that representative and valid data are obtained for analysis.

Data analysis in this study was carried out quantitatively by calculating the effect size value of each selected article. The effect size calculation aims to measure the magnitude of the influence of the ethno-physics-based IBL model on 21st century skills, so that more objective conclusions can be drawn about the effectiveness of its application. The calculation process is carried out with the help of Microsoft Excel 2020 applications which allow for systematic, accurate, and efficient data processing. Through this approach, the research is expected to be able to provide a comprehensive picture of the consistency of previous research results and strengthen the empirical foundation for the application of ethno-physics-based IBL models in improving students' 21st century thinking skills.

Result and Discussion

Based on the results of data search through the database, 14 studies/articles met the inclusion criteria. The effect size and error standard can be seen in Table 2.

Table 2. Effect Size and Standard Error Every Research

Code Jurnal	Years	Effect Size	Standard Error

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AR1	2020	1.02	0.42
AR2	2020	0.65	0.29
AR3	2024	1.42	0.31
AR4	2022	0.93	0.34
AR5	2024	1.52	0.22
AR6	2022	1.18	0.20
AR7	2024	0.24	0.20
AR8	2023	0.73	0.27
AR9	2022	1.90	0.37
AR10	2021	1.13	0.19
AR11	2021	0.66	0.29
AR12	2023	1.22	0.18
AR13	2024	0.81	0.39
AR14	2023	1.25	0.35

Based on Table 2, the effect size value of the 24 studies ranged from 0.22 to 1.42 . According to (Borenstein et al., 2007) Of the 24 effect sizes, 6 studies (25%) had medium criteria effect sizes and 18 studies (75%) had high criteria effect size values. Furthermore, 24 studies were analyzed to determine an estimation model to calculate the mean effect size. The analysis summary effect size can be seen in Table 2.

Tabel 2. Summary/ Mean Effect Size

Coeficient						
	Effect Size	Standard Error	z	p	Coeficient Interval	
					Lower	Upper
Intercept	0.9164	0.189	9.56	< 0.01	0.875	1.27

The results of the meta-analysis showed that the intercept value of the model was 0.9164 with a standard error of 0.189. The z-value obtained was 9.56 with a significance level of $p < 0.01$, which indicates that this result is statistically significant. This indicates that in general, the ethno-physics-based Inquiry Based Learning model has a real influence on improving students' 21st century thinking skills. The effect size value of 0.9164 can be categorized as a major influence according to Cohen's interpretation, so the effectiveness of the application of this model is quite strong and consistent. In addition, the confidence interval showed a range of 0.875 to 1.27, which further strengthened the finding that the influence of this learning model was not only significant but also stable in the various studies analyzed. The relatively narrow range of intervals indicates that the estimated effect size value has a good level of precision. Thus, it can be concluded that the integration of ethno-physics-based IBL has great potential in supporting the development of critical thinking skills, problem-solving, collaboration, and creativity as part of 21st century competencies. These results are in line with various previous studies that confirm that IBL is able to stimulate high-level thinking skills through the process of investigation, data collection, and conclusion drawing based on evidence (Hmelo-Silver et al., 2007; Lazonder & Harmsen, 2016). With the integration of ethno-physical elements, learning becomes more contextual so that students not only understand scientific concepts, but are also able to relate them to the surrounding cultural reality.

The huge influence resulting from ethno-physical integration demonstrates the importance of contextual approaches in science learning. Students tend to be more motivated and actively involved when the subject matter is associated with local cultural practices and phenomena that they are familiar with. These findings support the view that ethnoscience, including ethno-physics, plays an important role in bridging modern science with local wisdom, thereby providing deeper meaning for students (Aikenhead & Ogawa, 2007; Suastra, 2017). Thus, learning is not only oriented towards mastering the content, but also strengthens students' cultural identities and increases the relevance of education to real life. Furthermore, the results of this study show that the application of ethno-physics-based IBL is able to train students in developing critical thinking, problem-solving, creativity, collaboration, and communication skills. This is in line with the demands of 21st century skills that are becoming a global focus in education. Through an inquiry process that is integrated with local culture, students learn to evaluate information, propose innovative solutions, and work together in groups to solve contextual problems. Thus, this learning model supports the goal of modern education that emphasizes mastery of 21st century competencies, not just knowledge transfer.

Although the results show a high effect size, there are important implications that need to be considered in its application. Teachers need to have a deep understanding of the IBL approach as well as the skills to integrate local wisdom into physics learning materials. In addition, support for facilities, training, and responsive education policies is needed so that this learning model can be implemented in a sustainable manner. With this support, ethno-physics-based IBL can be an effective learning strategy to produce graduates who are adaptive, innovative, and have 21st century thinking skills that are relevant to the demands of the global era (Albu et al., 2020; Ichsan et al., 2023; Ningsih et al., 2023; Zulyusri et al., 2023).

Conclusion

This study concludes that the application of ethno-physics-based *Inquiry Based Learning* (IBL) has a significant and strong influence on improving students' 21st century thinking skills. The results of the meta-analysis of 14 national and international articles showed an *effect size* value of 0.9164 which was included in the large category, with a high level of significance ($p < 0.01$). These findings confirm that IBL combined with the context of local culture is not only effective in deepening the understanding of physics concepts, but is also able to develop critical skills, problem-solving, creativity, collaboration, and communication that are at the core of 21st century skills. In addition, this study shows that the integration of ethno-physics in IBL can increase the relevance of learning, strengthen student motivation, and bridge modern science with local wisdom. Thus, this learning model has great potential to be widely applied in science education, especially physics, in Indonesia. The results of this study also make a theoretical contribution in enriching the study of the effectiveness of context-based learning models, while offering practical implications for teachers and policymakers in designing learning strategies that are able to prepare students to face the global challenges of the 21st century.

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