Indigenous Science-Based Science Learning Model to Develop Science-Culture Literacy and High-Order Thinking Skills of Elementary School Students

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Abstract. The main problem in education today is that students' scientific-cultural literacy and high-level thinking abilities are still weak. The inability of many students to apply scientific knowledge to real-world issues and critically analyze information underscores the pressing need to enhance both scientific literacy and high-level thinking skills. The general aim of this research is to develop and produce an elementary school science learning model containing indigenous science that is effective for developing students' scientific-cultural literacy and thinking skills. Data to test its effectiveness was analyzed using Manova at a significance level of 5 percent. Based on the results of data analysis, several things were found as follows. 1) The science learning model with indigenous science content is effective in developing students' scientific literacy and higher-order thinking, 2) the science learning model with indigenous science content is effective in developing students' cultural scientific literacy, and 3) the science learning model with indigenous science content is effective in developing high level thinking student. In this way, the science learning model containing indigenous science can be used by teachers in an effort to develop students' cultural science literacy and higher-order thinking.
Keywords: indigenous science-infused learning, science cultural literacy, higher order thinking

1 Introduction

The current education system faces a significant challenge in nurturing students' science-culture literacy and high-order thinking skills. This issue stems from a pedagogical overemphasis on knowledge content, neglecting the development of essential skills such as communication, critical thinking, creativity, collaboration, and science-culture literacy. This overemphasis on content has led to a disconnect between classroom learning and real-world applications of science.

According to Indra Charismiadji, the low scores in the National Exams (UN) for junior high school students in science (average 47.43) and mathematics (average

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43.32) are indicative of ineffective teaching methods that fail to incorporate higher-order thinking skills (HOTS). Charismiadji emphasizes the need for education to nurture creativity, character, and critical thinking, skills that are essential for the present and future. He stresses the importance of training teachers to effectively implement HOTS-oriented teaching methods. Indonesia's consistent low rankings in the Program for International Student Assessment (PISA) further highlight the shortcomings of the current education system. Since the first PISA assessment in 2000, Indonesia has consistently ranked among the lowest-performing countries. In 2018, Indonesia placed 71st out of 79 participating countries in science, reading, and mathematics. Based on the qualitative analysis identifying trends and patterns of Indonesia's students' performance in math and sciences from PISA assessment, it can be seen that among ASEAN countries, Indonesia still has a moderate performance in mathematics and science. While showing some improvement over the years, Indonesia's scores in these areas were still below the OECD average. [1].

Indigenous science (or ethnoscience) is a knowledge system possessed by a nation, or more precisely, an ethnic group. It is passed down from one generation to the next and used to solve daily life problems. However, in reality, ethnoscience receives little attention in the context of school learning. This supports findings, which state that the low quality of science education in Indonesia is due to the lack of attention to local culture (indigenous science). [2] assert that if science education in schools does not consider the local culture of the children, the consequence is that students will 'reject' some of the scientific concepts they learn. [3] found that there are 8 aspects of character based on Balinese local wisdom, which include: religious, honesty, tolerance/tat twam asi, responsibility (sesana/swadharma), curiosity, diligence, hardworking and generosity, and care for the socio-cultural and natural environment. Additionally, a conceptual model of learning containing indigenous science was found. This model is capable of developing character based on local wisdom and higher-order thinking skills in junior high school science learning with the following steps: (1) initial orientation, (2) exploration of students' prior knowledge, (3) investigation from various perspectives (scientific, socio-cultural, historical), (4) elaboration, and (5) confirmation and reinforcement. found that (1) there are 4 steps of indigenous science-based learning that can be developed in elementary school learning, namely: exploration of students' prior knowledge, investigation from various perspectives, elaboration, confirmation and reinforcement; (2) there are 5 aspects of science-culture literacy that can be developed in elementary school learning, namely: knowledge about science, investigation of the nature of science, science as a way to understand phenomena, interaction between science, technology, and society, and literacy; (3) there are 4 aspects of higher-order thinking that can be developed in elementary school learning, namely: problem-solving, critical thinking, creative thinking, and scientific argumentation.

This proposed R&D study aligns perfectly with the vision, mission, and target indicators outlined in the Undiksha LPPM Strategic Plan for 2017-2021. LPPM Undiksha aspires to become a leading center for the development and application of excellent and characterized science and technology. The research directly supports several key missions of the plan: developing research that bridges global scientific advancements with local cultural knowledge, enhancing educational quality through improved research, increasing research relevance to address the needs of businesses and society, producing superior research to elevate Undiksha's community engagement and international publications, and finally, fostering the acquisition of intellectual property rights. Therefore, this research aims to create a valid, practical, and effective science learning model that incorporates indigenous science. This model has the potential to significantly enhance students' science-culture literacy and higher-order thinking skills.

2 Methods

This research was an experimental study. Considering that not all variables or phenomena that emerge and experimental conditions can be strictly controlled and regulated, this research can be categorized as quasi-experimental research. In relation to this type of research, the research design used in this study was the posttest only control group design as presented in Table 1.

Table 1. Research Design

Group	Treatment	Posttest
Experiment	X_1	O
Control	X_2	O

(Modified from Gall & Borg, 2003)

Explanation:
X_1: Treatment with the local wisdom-based learning model.
X_2: Treatment with the conventional learning model.
O: Final observation of both the experimental and control groups.

Based on Table 1, O was the final observation (post-test) for the experimental and control groups, X_1 was the treatment with the science learning model for elementary schools containing indigenous science, and X_2 was the treatment with the conventional learning model. Data on students' science-culture literacy and higher-order thinking in this study were collected solely from post-test scores conducted at the end of the model's implementation.

The population in this study consists of all sixth-grade students in Singaraja City who were not in ranking classes, thus they could be categorized as academically homogeneous classes within the population. Based on the results of the equivalence test of the class subjects used in this study, all classes were found to be equivalent based on the results of a one-way analysis of variance test. Based on the lottery results, one experimental class group and one control class group were obtained. The number of students involved in this study was 228, as presented in Table 2.

Table 2. Sample Composition of the Research

Group	School	Class	Number
Experiment	SD 1 Banyuasri	VI	30
	SD 1 Bhaktiseraga	VI	30

	SD 2 Banjar Tegal	VI	29
	SD 1 Liligundi	VI	25
Control	SD 4 Banjar Jawa	VI	30
	SD 1 Paket Agung	VI	30
	SD 1 Banyumala	VI	27
	SD 4 Kampung Baru	VI	27
		Number of Samples	228

3 Results and Discussion

The general description of the research results includes the science-culture literacy and higher-order thinking skills of students who learned using the elementary school science learning model containing indigenous science (ISL) and those who learned using the conventional learning model (CL). The details can be seen in Tables 3 and 4 below.

Table 3. Average Scores for Each Aspect of Science-Culture Literacy

No	Indicators of Science-Culture Literacy	ISL	Category	CL	Category
1	Knowledge about Science	86,50	Very Good	75,40	Good
2	Investigation of the Nature of Science	75,10	Good	65,50	Sufficient
3	Science as a Way to Know Phenomena	76,20	Good	67,50	Sufficient
4	Interaction between Science, Technology, and Society	84,50	Good	82,20	Good
5	Science-Culture Literacy	82,25	Good	75,20	Good
	Average	80,91	Good	73,16	Good

Based on Table 3, it can be seen that in the ISL group, only one indicator, knowledge about science, is rated as very good, while the other four aspects—investigation of the nature of science, science as a way to know phenomena, interaction between science, technology, and society, and science-culture literacy—are rated as good. In the CL group, three indicators—knowledge about science, interaction between science, technology, and society, and science-culture literacy—are rated as good, while two indicators—investigation of the nature of science and science as a way to know phenomena—are rated as sufficient. This indicates that the ISL group is better at developing science-culture literacy compared to the CL group. The average science-culture literacy score for students learning with ISL is 80.91 (good qualification), compared to 73.16 (good qualification) for those learning with CL.

The indicators used to measure higher-order thinking skills include problem-solving, creative thinking, critical thinking, and scientific argumentation. Each indicator has a scoring range of 1-5, with a minimum score of 1 and a maximum score of 5. The maximum average score for each indicator is 5. Based on the questionnaire, the average scores for students on each indicator are shown in Table 4.

Table 4. Average Scores for Each Indicator of Higher-Order Thinking Skills

No	Indicators of Higher-Order Thinking Skills	ISL	Category	CL	Category
1	Problem-Solving	73,50	Good	70,20	Good
2	Creative Thinking	71,25	Good	63,50	Sufficient
3	Critical Thinking	70,20	Good	65, 10	Sufficient
4	Scientific Argumentation	72,30	Good	71,20	Good
	Average	71,81	Good	67,50	Sufficient

Based on Table 4, it can be observed that in the ISL group, all indicators—problem-solving, creative thinking, critical thinking, and scientific argumentation—are rated as good. However, in the CL group, problem-solving, creative thinking, and critical thinking are rated as sufficient, with only scientific argumentation rated as good. This indicates that higher-order thinking skills among students who learned with the indigenous science-based learning model (ISL) are better compared to those who learned with the conventional learning model (CL) in developing higher-order thinking skills through science education in elementary schools. The average score for higher-order thinking skills for students learning with ISL is 71.81 (good qualification), which is higher compared to 67.5 (sufficient qualification) for those learning with CL.

This study also aims to examine and determine the significance of the differences in science-culture literacy and higher-order thinking skills between students learning with the indigenous science-based learning model and those learning with the conventional model. The MANOVA test results show an F value of 12.32 with a significance level of 0.001. This significance value is less than 0.05, indicating that science-culture literacy and higher-order thinking skills are significantly ($p < 0.05$) affected by the type of learning model applied.

Statistically, the results show that ISL and CL groups differ significantly in achieving higher-order thinking skills at a 0.05 significance level. The post hoc LSD test reveals a significant difference in the average scores for science-culture literacy and higher-order thinking skills between students learning with ISL and CL, with a $\Delta\mu = [\mu(ISL) - \mu(CL)]$ of 5.06, a standard deviation of 1.12, and a significance level of 0.001 ($p < 0.05$). The $\Delta\mu$ value is greater than the LSD rejection threshold. Thus, the average higher-order thinking scores for students in the group learning with the indigenous science-based model (ISL) are significantly different from those in the conventional model (CL) at a 0.05 significance level. Descriptive analysis further shows that the indigenous science-based learning model (ISL) is more effective than the conventional learning model in developing both science-culture literacy and higher-order thinking skills in students.

Examining the aspects of science-culture literacy in the ISL group, two aspects—knowledge about science (average score of 86.50, very good) and interaction between science, technology, and society (average score of 84.50, good)—are rated very good or good. The remaining three aspects are: investigation of the nature of science (average score of 75.10, good), science as a way to know phenomena (average score of 76.20, good), science-culture literacy (average score of 80.91, good). In the CL group, two aspects of science-culture literacy are still categorized as sufficient: investigation of the Nature of Science (average score of 65.50, sufficient), science as a way to know phenomena (average score of 67.50, sufficient). The other three aspects are rated as good: knowledge about science (average score of 75.40, good), interaction between science, technology, and society (average score of 82.20, good), science-culture literacy (average score of 75.20, good)

For higher-order thinking skills in the ISL group, all four aspects are rated as good: problem-solving (average score of 71.50, good), creative thinking (average score of 71.25, good), critical thinking (average score of 70.20, good), scientific argumentation (average score of 72.30, good). In the CL group, two aspects are rated as good: problem-solving (average score of 70.20, good), scientific argumentation (average score of 71.20, good). The other two aspects are rated as sufficient: creative thinking (average score of 63.50, sufficient), critical thinking (average score of 65.10, sufficient)

Therefore, it can be said that the indigenous science-based learning model (ISL) is more effective in developing both science-culture literacy and higher-order thinking skills compared to the conventional learning model (CL). This is due to the indigenous science-based learning model's four crucial steps: exploration of students' prior knowledge, investigation from various perspectives (scientific, socio-cultural, and historical), elaboration, and confirmation and reinforcement. During the exploration of students' prior knowledge, teachers can understand what students know, both regarding the content of science lessons and their ideas about culture (indigenous science). Students' prior knowledge may sometimes align with scientific understanding, be incomplete, or even be incorrect. Based on this initial knowledge, teachers can more easily guide students toward scientific understanding. Similarly, early knowledge of students' cultural understanding allows teachers to more easily address and correct misconceptions or conceptual errors.

Learning with an indigenous science-based model that starts with exploring students' initial ideas and beliefs about the material to be studied is grounded in the constructivist philosophy, which emphasizes that students' prior knowledge should be explored and used as a reference in the learning process. This is in line with Ausubel's [4] view that "the most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly." Subsequently, the teacher focuses students' attention on preparing for an investigation of their initial ideas and beliefs. This focus aims to guide students in understanding the tools and steps needed to test their initial ideas, so the investigation is more directed and does not take a long time. The next stage of ISL is inquiry from various perspectives. At this stage, students conduct investigations from both scientific and historical/socio-cultural perspectives. If the concept relates to scientific concepts, the activity is scientific inquiry. However, if the study relates to socio-cultural aspects, it can be investigated from socio-cultural perspectives, including historical perspectives. This activity provides students with the opportunity to develop higher-order thinking skills such as critical thinking, creative thinking, and problem-solving abilities. This finding aligns with [5], who found that science education can enhance students' critical thinking skills and awareness of local culture among junior high school students in Lombok. Furthermore, Meador (1997) states that creative thinking is not only needed for arts, music, or drama but also for real life, particularly in solving work-related problems such as fluent, flexible, original, and elaborative thinking. Therefore, the results of this study are very positive and should be further developed. This is supported by Minner's (2009) opinion that inquiry-based science education not only improves students' conceptual understanding but also develops higher-order thinking (creative thinking, problem-solving, and critical thinking) and fosters a sense of responsibility for their own learning. The elaboration activity provides a great opportunity for students to relate what they previously knew to what they are currently learning. If prior knowledge aligns with the concepts being studied, it will reinforce each other; however, if it does not align, it will create a state of disequilibrium. In this condition, the teacher needs to be wise in mediating students to ensure their understanding is directed towards the correct scientific concepts. Patience and wisdom are essential for teachers in guiding students, especially regarding indigenous science (their local culture). The teacher acts as a cultural broker in the learning process [6]. Learning with an indigenous science content (ethnoscience) is quite effective in developing science-culture literacy and higher-order thinking skills in students [7][8]

Integrating indigenous science into elementary school science education provides a different flavor to the learning experience. Integrating local values into science education makes the subject more engaging and connects students with their natural and socio-cultural environments. This is in accordance with [9] opinion that science should not be understood by a select group of people (exclusively) but should be science for daily living, science for the future, and science for all. Thus, local wisdom-based learning models integrate cultural values that are deeply rooted in students, making the learning experience more meaningful.

4 Conclusion and suggestions

Based on the research results and problem formulation, several conclusions can be drawn as follows: First, indigenous science-based elementary school science teaching is effective in simultaneously developing both science-culture literacy and higher-order thinking skills in students. Science-culture literacy and higher-order thinking skills are better taught using the indigenous science-based model compared to conventional models.

Second, indigenous science-based elementary school science teaching is effective in developing students' science-culture literacy. Students learning with the indigenous science-based model achieve better science-culture literacy compared to those using the conventional model. In the MPBSA group, science-culture literacy aspects include: knowledge about science (average of 86.50, classified as very good), and three aspects: investigation of the nature of science (average of 75.10, classified as good), science as a way to understand phenomena (average of 76.20, classified as good), interaction between science, technology, and society (average of 84.50, classified as good), and overall science-culture literacy (average of 80.91, classified as good).

Third, indigenous science-based elementary school science teaching is effective in developing students' higher-order thinking skills. Students learning with the indigenous science-based model show better higher-order thinking skills compared to those using the conventional model. The indigenous science-based model effectively develops all five aspects of science-culture literacy to a good qualification, while the conventional model only achieves a good qualification in two aspects. In the MPBSA group, all four aspects of higher-order thinking are classified as good, including: problem-solving (average of 71.50, classified as good), creative thinking (average of 71.25), critical thinking (average of 70.20, classified as good), and scientific argumentation (average of 72.30, classified as good).

Recommendations for teachers who teach science at elementary schools are to implement the indigenous science-based model to develop students' science-culture literacy and higher-order thinking skills in the following ways: (1) Teachers should explore students' prior knowledge and beliefs related to the subject before starting the lesson. (2) Teachers should actively and wisely facilitate students in investigating from various perspectives, such as scientific, historical, and local indigenous. (3) Teachers should wisely facilitate discussions to bridge students from local cultural knowledge to Western (scientific) science. For education authorities and teacher training institutions, it is essential to conduct outreach through scientific activities such as workshops, training, and seminars to enhance teachers' knowledge about integrating indigenous science into school learning. Other researchers are encouraged to continue exploring the additional impacts of this indigenous science-based model for elementary school science education.

References

[1] Wuryanto, H., & Abduh, M. (2022). Mengkaji kembali hasil PISA sebagai pendekatan inovasi pembelajaran untuk meningkatkan kompetensi literasi dan numerasi. Retrieved Abu, L., et al. (2015). How to develop character education of madrassa students in Indonesia. *Journal of Education and Learning, 9*(1), 79-86.

[2] Baker, et al. (1995). The effect of culture on the learning of science in non-western countries: The results of an integrated research review. *International Journal of Science Education, 17*. Aisah, A. R. (2014). The implementation of character education through contextual teaching and learning at personality development unit in the Sriwijaya University Palembang. *International Journal of Education and Research, 2*(10).

[3] Suastra, I. W., et al. (2020a). Elaborating indigenous science into science learning process: A new science instructional model to develop students' local wisdom-based character and higher order thinking skills. Article presented at the 2nd International Conference of Education and Science, Jakarta, Indonesia, 9-10 December 2020.

[4] Suastra, I. W. (2017). *Pembelajaran sains terkini*. Singaraja: Undiksha Press.Aktamis, H. (2012). Developing scientific creativity tests. *Journal of Educational Research, 6*(2), 89-97.

[5] Hikmawati, Suastra, I. W., & Pujani, N. M. (2021). Ethnoscience-based science learning model to develop critical thinking ability and local cultural concern for junior high school students in Lombok. *Jurnal Penelitian Pendidikan IPA (JPPIPA), 7*(1).

[6] Suastra, I. W. (2012). Model pembelajaran fisika untuk mengembangkan kreativitas berpikir dan karakter bangsa berbasis kearifan lokal. Makalah disajikan pada Konvensi Nasional Pendidikan (Konaspi) 7, Yogyakarta, 31 Oktober - 3 November 2012.

[7] Sanjayanti, A. H. N. P., Suastra, I. W., Suma, K., & Budiadnyana, P. (2022). Effectiveness of science learning model containing Balinese local wisdom in improving character and science literacy of junior high school students. *International Journal of Innovative Research and Scientific Studies, 5*(4), 332-342.

[8] Suastra, I. W., Rapi, N. K., Yasa, P., & Arjana, I. G. (2021). Elaborating indigenous science contents into science learning process: A new science instructional model to develop students' local wisdom-based character and higher order thinking skills. *Jurnal Pendidikan Indonesia (JPI), 10*(3)

[9] Suastra, I. W., Ristiati, B., Jatmiko, L. P. B., & Yasmini, Y. (2017). Developing characters based on local wisdom of Bali in teaching physics in senior high school. *Jurnal Pendidikan IPA Indonesia (JPII), 6*(2), 306-312. https://doi.org/10.15294/jpii.v6i2.10681