

An Ethnophysics Approach within the Contextual Teaching and Learning (CTL) Model to Improve Physics Learning Outcomes: A Case Study of the Traditional Lais Performance Art of West Java

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Abstract

Physics is a fundamental science that plays an essential role in understanding various natural phenomena and serves as the foundation for many other disciplines, thereby occupying a critical position in the development of knowledge. However, many first-year students in Physics Education programs continue to experience difficulties in learning fundamental physics, partly because their learning approaches are insufficiently contextual, leading to less meaningful conceptual understanding. The Contextual Teaching and Learning (CTL) model offers learning experiences based on real-world phenomena encountered in daily life. Local wisdom can be utilized as a contextual learning resource, including the traditional Lais performance art of West Java, which contains rich physics concepts. This study aims to integrate physics concepts with cultural elements through an ethnophysics approach within the CTL model to improve students' learning outcomes. The research employed a quantitative method using a quasi-experimental one-group pretest-posttest design. The N-Gain analysis yielded a score of 0.64, categorized as moderate, while the t-test produced a p-value < 0.05 , indicating a significant difference between the pretest and post-test scores. These findings demonstrate that the CTL-based ethnophysics learning approach has a positive and effective impact on improving students' physics learning outcomes..

Keywords: Ethnophysics; Contextual Teaching and Learning (CTL); physics learning outcomes; Traditional Lais Performance; West Java

INTRODUCTION

Physics is a fundamental scientific discipline that examines the basic concepts underlying various natural phenomena and serves as the foundation for many other fields of study; therefore, it plays a crucial role in advancing scientific knowledge (Frankel, 2011; Koonin, 2018). However, many first-year students in Physics Education programs still struggle to learn fundamental physics. These challenges may arise from insufficiently contextualized learning approaches, leading to less meaningful conceptual understanding and ultimately contributing to low motivation and suboptimal learning outcomes. To optimize learning outcomes, students need to engage in learning experiences that are relevant to real-life contexts through contextual learning models, enabling them to construct knowledge independently and meaningfully.

The Contextual Teaching and Learning (CTL) model is a learning approach grounded in constructivist principles (Hasnawati, 2006). This model emphasizes conceptual understanding through direct experiences with physical phenomena encountered in daily life. Contextual learning within the CTL framework encompasses five types of activities: relating, experiencing, applying, cooperating, and transferring (Yulaelawati, 2004). For this model to be implemented effectively, appropriate instructional materials and media are needed to explore physical phenomena closely related to real-life situations. An ethnophysics approach can serve as a relevant alternative, as it examines physics concepts by integrating local wisdom within an ethnic community. Local wisdom, as part of cultural heritage, includes traditional houses, dances, customs, traditional games, and various cultural practices passed down through generations, grounded in a deep understanding of the local environment (Deskarina and Atiqah, 2020).

Indonesia is a pluralistic nation rich in ethnic and cultural diversity, which forms an essential part of its national identity (Asra *et al.*, 2021; Festiyed, 2024). According to the 2010 BPS census, approximately 300 ethnic groups reside in Indonesia. This cultural richness is a national heritage that must be preserved. West Java is one of the provinces with diverse forms of local wisdom, including traditional dances, traditional games, customary houses, and performing arts. These cultural elements hold significant potential as varied and contextual learning resources. One exciting form of performing art is *Lais*, a traditional performance featuring rope-balancing acrobatics between bamboo poles several meters high. This performance has the potential to provide meaningful learning experiences and enhance student motivation throughout the learning process.

In the era of globalization and rapid technological development, local culture is increasingly marginalized, potentially diminishing societal appreciation for cultural heritage. Education plays a strategic role in cultural preservation, and integrating culture into learning processes can contribute to holistic education, including culturally grounded character education (Rahmawati *et al.*, 2019). Ethnophysics integrates cultural elements with physics concepts (Ahmad Fahrudin and Eka Maryam, 2022); however, its development in Indonesia has not progressed as rapidly as that of ethnoscience. Current ethnophysics studies have mainly focused on traditional dances (Nurhidayat *et al.*, 2020; Wulansari and Admoko, 2021; Putri, Sari Noe and M, 2022; Asbanu, 2023; Abbas and Siti Maulidiyah Zamrotin, 2024; Maksum, 2024), traditional games (Afkarina and ., 2021; Rumiati, Handayani and Mahardika, 2021), and indigenous architectural structures (Pakan, Pratiknjo and Mamosey, 2018; Shabrina and Kuswanto, 2018; Tamelan, Laos and Boimau, 2021; Jefriyanto *et al.*, 2022). In recent years, there has been growing interest in developing contextual learning grounded in ethnophysics to strengthen cultural identity in science education (Wulandari, and Suryana, 2024).

Ethnophysics studies in West Java have thus far been limited to analyses of the *Mojang Priangan* dance and the traditional game *Egrang*. In fact, many forms of local wisdom remain unexplored, including the *Lais* traditional performance. Despite its strong potential as a source of contextual learning, no ethnophysics research has yet integrated *Lais* into the CTL learning model. This integration is noteworthy because CTL is highly relevant to learning activities grounded in real-life experiences, including those rooted in local cultural practices. This condition indicates a significant research gap that warrants further investigation. Therefore, this study integrates an ethnophysical approach based on the *Lais* traditional performance (**FIGURE 1**) into the CTL learning model for teaching motion dynamics in an introductory physics course, following the instructional syntax presented in **TABLE 1**.



(a)



(b)



(c)

FIGURE 1 illustrates the various movements performed by the Lais performer at different positions and rope inclination angles (a, b and d).

TABLE 1. Syntax and learning activities

No	Syntax of CTL model (Sa'ud, 2014)	learning activities
1.	Invitation	Students experienced the <i>Lais</i> performance directly during a live demonstration and indirectly through video recordings.
2.	Exploration	Students identified the various types of motion performed by the <i>Lais</i> performer and constructed the corresponding force diagrams.
3.	Explanation and solution	Students received conceptual reinforcement through explanations and solutions to the issues encountered.
4.	Decision-making	Students were capable of transferring their conceptual understanding to both the <i>Lais</i> context and other cases.

METHOD

This study employs a quantitative approach using a quasi-experimental method, with a one-group pretest–posttest design (Sugiyono, 2017), as presented in TABLE 2.

TABLE 2. One Group Pre-test – Post-test Design

Experimental Group	Pre-test	Treatment	Post-test
	O ₁	X	O ₂
O ₁	= Pre-test		
O ₂	= Post-test		
X	= Treatment in the form of learning using an ethnophysical approach in the CTL learning model.		

The study population consisted of all first-year physics education students enrolled in a basic physics course at the university. The sample comprised one class of 20 students, based on the assumption that all first-year classes in the physics education program possess relatively similar cognitive abilities. Therefore, cluster random sampling was employed. The data collected in this study were quantitative, obtained through both test and non-test instruments. Observation and testing were used as data collection techniques. The observation technique, using a non-test instrument, was applied to measure the implementation of learning. In contrast, a multiple-choice test instrument was used to measure students' physics learning outcomes. The test instrument assessed cognitive domains limited to memorization (C1), understanding (C2), application (C3), and analysis (C4) based on Bloom's taxonomy.

The data obtained from the test instrument were analyzed to determine the improvement in students' cognitive learning outcomes using the normalized gain (N-gain) score, which was calculated using the following equation (29):

$$\langle g \rangle = \frac{\langle S_{post} \rangle - \langle S_{pre} \rangle}{\langle S_{mideal} \rangle - \langle S_{pre} \rangle} \quad (1)$$

where $\langle g \rangle$ is the normalized average gain score, $\langle S_{post} \rangle$ is the average post-test score, $\langle S_{pre} \rangle$ is the average pre-test score, and $\langle S_{mideal} \rangle$ is the ideal maximum score. The normalized average gain score was then interpreted using the criteria presented in TABLE 3.

TABLE 3. Interpretation of Normalized Average Gain Scores (Hake, 1999)

Nilai $\langle g \rangle$	Kriteria
$\langle g \rangle \geq 0.7$	Tinggi
$0.7 > \langle g \rangle \geq 0.3$	Sedang
$\langle g \rangle < 0.3$	Rendah

To determine whether there was a significant difference between the pre-test and post-test scores, a paired sample t-test was employed. This test was chosen because the measurements were taken from the same group of students before and after the learning intervention, yielding two related (dependent) data sets—the paired-samples t-test tests whether the mean difference between the two sets of scores is statistically significant. Before conducting the test, the data were examined for normality to ensure the t-test assumptions were met. The analysis was performed at a significance level of $\alpha = 0.05$, where a p-value less than 0.05 indicates a significant improvement in students' learning outcomes following the treatment.

Data analysis of the observation results regarding the implementation of learning using the ethnophysical approach within the CTL learning model was conducted by calculating the percentage of learning implementation. The percentage score was obtained using the following formula.

$\text{Model Implementation Percentage} = \frac{\text{Total Score Obtained}}{\text{Maximum Possible Score}} \times 100\%$	(2)
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The categories of learning model implementation were interpreted based on the criteria shown in **TABLE 4.**

TABLE 4. Percentage and criteria of implementation of learning model

Percentage of Model Implementation	Criteria
KM = 0	None of the activities were implemented
$0 < KM < 25$	Only a small number of activities were implemented
$25 \leq KM < 50$	Almost half of the activities were implemented
KM = 50	Half of the activities were implemented
$50 < KM < 75$	Most of the activities were implemented
$75 \leq KM < 100$	Almost all of the activities were implemented
KM = 100	All of the the activities were implemented

RESULT AND DISCUSSION

The Results and Discussion section is divided into two parts. The first part explores physics concepts in Lais' traditional performing arts, and the second part analyzes test instruments to evaluate improvements in students' physics learning outcomes.

3.1 Exploration Results of Physical Concepts in the Lais Performance

During the exploration phase, students directly observed the structure and movements involved in the Lais performance, particularly the bamboo poles used as supports and the rope that suspends the performer. Measurements were also taken of the length of each bamboo internode that forms the Lais pole (**FIGURE 2**). The data obtained from these measurements are presented in **TABLE 5**.



FIGURE 2. Measuring the length of bamboo segments

TABLE 5. Length of Bamboo segment

No	Length Bamboo Segment $i^{th} (L_i)$ (cm)
1	36
2	23
3	36
4	40
5	42
6	43
7	46
8	46
9	48
10	48
11	48
12	47
13	49
14	49
15	48
16	49
17	47
18	47
19	45
20	44
21	40

In addition to measuring the length of each bamboo segment, the field data indicated that the portion of the bamboo embedded in the ground was 64 cm. So, the bamboo not only serves as a vertical support but also acts as a lever that must withstand the moment due to the player's weight. The total length of the bamboo structure was 985 cm, indicating that the section above ground acts as a free lever that receives the load from the rope tension and the player's weight.

Measurements also revealed that the average body weight of the Lais performer was approximately 55 kg. This value is essential for determining the magnitude of the gravitational force acting on the system, calculated as $W = mg$. Thus, the player exerts a downward force of approximately 539 N with gravitational acceleration 9.8 m/s^2 . This gravitational force becomes the primary torque source acting on the bamboo and directly determines the required rope tension to maintain equilibrium. The heavier the performer, the greater the torque generated at a given distance from the pivot, resulting in a proportionally larger tension force in the rope.

FIGURE 3 illustrates the analysis of forces acting on the Lais performance system. The bamboo acts as a flexible beam functioning as a lever, while the rope provides a tension force (T) that supports the player at height. The tension force T acts upward along the rope, while the weight force W acts downward due to gravity. The horizontal or inclined distance of the player from the pivot point

(denoted as J) determines the magnitude of the torque generated by the weight. Meanwhile, the distance of the rope from the end of the bamboo (denoted as M) influences the tension required to balance the system. The number of bamboo segment supporting the load (LB) represents the contribution of bamboo's natural structural segments to its bending resistance. The size of the angle between the rope and the bamboo was calculated using the triangle cosine formula, based on the measured lengths of sides J , M , and LB .

In static equilibrium, the system satisfies $\Sigma\tau=0$ and $\Sigma F=0$. Therefore, the torque produced by the player's gravitational force must be balanced by the torque generated by the rope tension. The larger the value of J , the greater the torque, and consequently, the greater the rope tension required for equilibrium. It explains why the performer's position is crucial to maintaining stability and safety in the Lais performance. The results of this exploration confirm that the Lais performance incorporates relevant concepts of classical mechanics, including rigid-body equilibrium, torque ($\tau = F \cdot r$), rope tension, bamboo elasticity, and the structural strength of natural materials. Thus, Lais can serve as a practical context for learning in physics education, allowing students to link theoretical concepts of force, moment, and equilibrium with real-world phenomena rooted in local cultural practices.

Moreover, Lais offers students the opportunity to calculate rope tension using concrete data, such as rope length, rope inclination angle, bamboo length, and the performer's position. By applying trigonometric cosine relationships to irregular angles and conducting image-based measurements, students can analyze how variations in rope inclination affect the magnitude of tension. This activity enables them to explore the relationship between rope tension and angle using authentic data obtained from different positions captured in Lais performance images.

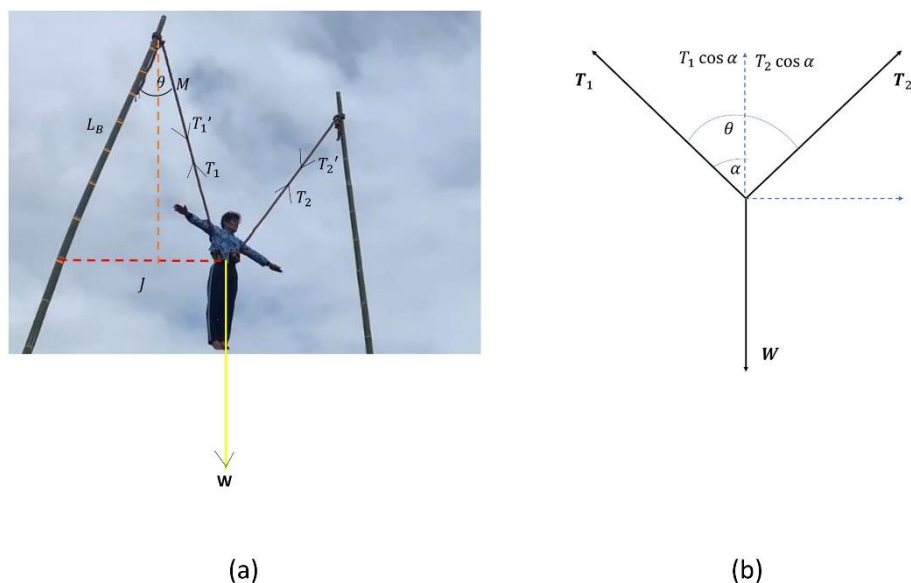


FIGURE 3. Force Analysis on Lais Players (a) and force diagram (b). Where T is the tension of the rope, W is the weight force, J is the distance from the player to the bamboo, M is the distance from the rope to the end of the bamboo, and LB is the length of 7 bamboo segments.

This exploration focuses on calculating the rope tension force and examining its relationship with the angle formed between the rope and the supporting bamboo, which plays a crucial role in influencing the performer's stability and movement dynamics during the Lais performance (TABLE 6). The analysis for equilibrium force is:

$$\Sigma F = 0 \quad (3)$$

$$T_1 \cos \alpha + T_2 \cos \alpha = W \quad (4)$$

with $T_1 = T_2$

$$2T \cos \alpha = W \quad (5)$$

$$T = \frac{W}{2 \cos \alpha} \quad (6)$$

TABLE 6. relation angle on different positions to rope tension force

Position	LB (m)	θ (°)	α (°)	T (N)
1 (Figure 1.a)	2.30	37.16	18.58	284.342
2 (Figure 1.d)	2.53	38.19	19.09	285.336

From the two positions above, it can be observed that there is a proportional relationship between the player's position and the angle formed between the rope and the supporting bamboo, in which a larger angle results in a greater rope tension. Therefore, Lais performers typically execute rotational movements at smaller angles to maintain stability and minimize the required tension force.

Improving Learning Outcomes

In this study, improvements in learning outcomes were analyzed based on students' pre-test and post-test scores. From a sample of 20 students, the distribution of individual N-gain scores ranged from 0.5 to 0.9. The analysis showed that the average pre-test score was 57.75, while the average post-test score increased to 84.75, resulting in an average gain of 27.05 points (**FIGURE 4**). This increase in scores demonstrates the positive effect of the treatment applied to the measured parameter, namely, students' physics learning outcomes.

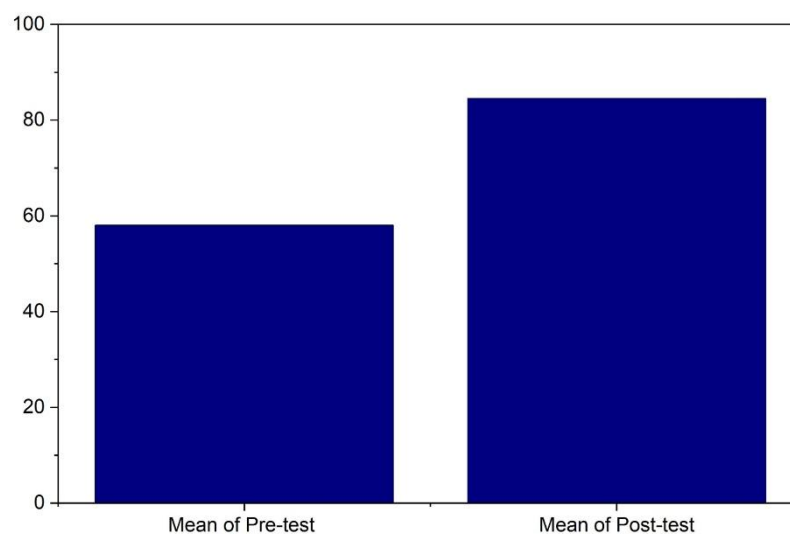


FIGURE 4. Mean of pre-test post-test score.

The relatively low pre-test scores indicate that, prior to the implementation of the learning model, most students had not yet mastered the material. This may be attributed to limited prior understanding or previous learning approaches that did not provide sufficient conceptual reinforcement or meaningful learning experiences. After the treatment or the implementation of the learning model, the average post-test scores showed a substantial increase. This improvement demonstrates that the applied learning intervention had a positive impact on enhancing students' understanding. In other words, students were able to internalize the concepts more effectively after participating in the learning activities.

The distribution of Gain scores obtained by each student varied, ranging from 0.17 to 0.90 (**FIGURE 5**). The overall normalized gain (N-Gain) value was 0.64, which falls within the moderate category. A moderate N-Gain score indicates that the learning process implemented was reasonably effective in enhancing students' understanding. This shows that the improvement is not only statistically observable but also pedagogically meaningful, as the applied learning model enabled students to better construct and internalize physics concepts.

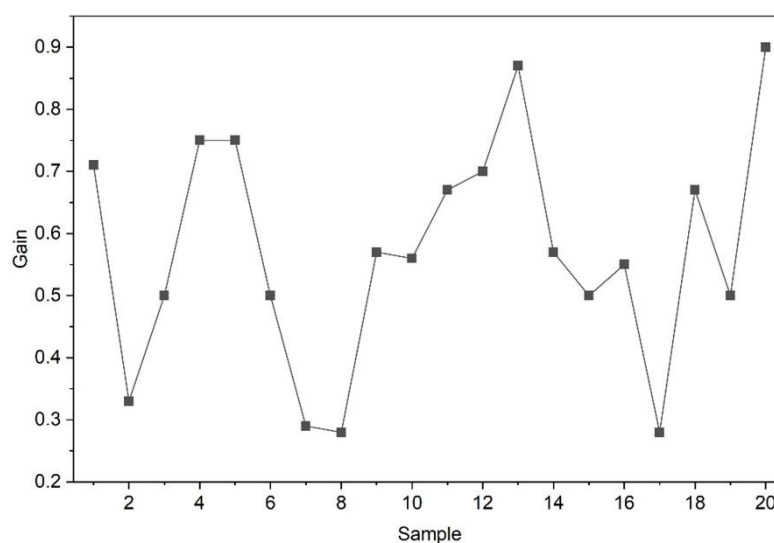


FIGURE 5. illustrates the Gain score obtained from every sample.

In addition to examining individual gains and the overall average gain, an analysis of students' learning outcomes was also conducted across the cognitive levels of Bloom's Taxonomy: C1 (remembering), C2 (understanding), C3 (applying), and C4 (analyzing). This analysis aimed to determine which levels of cognitive ability were most influenced by the treatment. The highest gain was found at C2, approximately 0.73, followed by C3 at 0.68, C1 at 0.60, and the lowest at C4 at 0.55 (**FIGURE 6**)

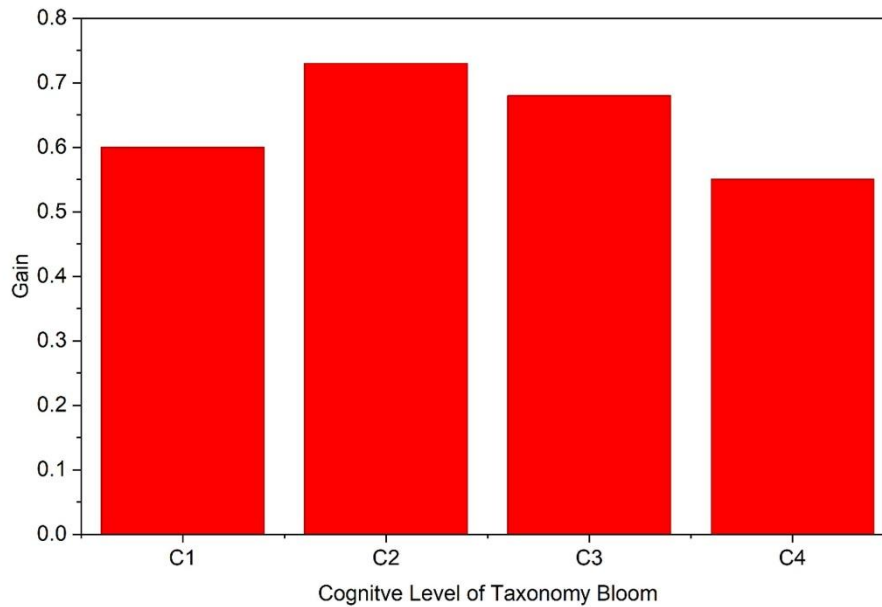


FIGURE 6. illustrates the Gain score from Cognitive Level.

The highest gain at the C2 level indicates that the implementation of the learning model was most effective in improving students' conceptual understanding. This finding aligns with the principles of Contextual Teaching and Learning (CTL), which emphasizes connecting learning materials to real-world contexts to strengthen conceptual comprehension (Johnson, 2002). When physics concepts are integrated with local wisdom through an ethnophysical approach, students experience learning that is more contextual, meaningful, and culturally relevant, thereby reinforcing conceptual internalization (Suryawati and Osman, 2018).

A high gain at the C3 level suggests that students were not only able to understand the concepts but also effectively apply them in real situations. The CTL approach provides opportunities for students to explore, observe, and solve real-world problems, thereby improving their ability to transfer theoretical knowledge into practical applications (Rusman, 2020). The use of the traditional *Lais* performance as a contextual learning medium allowed students to concretely apply the concepts of force, tension, torque, and equilibrium, bridging the gap between theory and practice. Meanwhile, the gain score at C1, although moderate, was lower than other levels, which is consistent with CTL's emphasis on meaningful learning rather than rote memorization.

The lowest gain at the C4 level indicates that students' analytical skills remain an area requiring further development. Analytical skills fall into the category of Higher-Order Thinking Skills (HOTS), which require habits of deep reasoning, evaluating evidence, and organizing information in a structured manner (Zohar and Dori, 2003). Improving achievement at this level requires strengthened learning strategies such as reflective discussions, scientific inquiry, argument-based reasoning, and interpretation of real data (Yuliyanti et. al, , 2024)

Overall, these findings suggest that ethnophysics-based CTL learning is effective in enhancing lower- and middle-order thinking skills (C1–C3), while the improvement of higher-order thinking skills (C4) requires more intensive analytical activities. This is consistent with the notion that integrating local cultural practices into science learning increases relevance and provides authentic experiences that support deeper conceptual understanding.

To determine the significance of the improvement in learning outcomes, a hypothesis test was conducted. Prior to the hypothesis test, a normality test was performed to assess whether the learning outcome data were normally distributed. Based on the Shapiro-Wilk normality test, both the pre-test and post-test data yielded p -values < 0.05 , indicating that the data were not normally distributed. However, since the sample size was ≥ 20 , the analysis could still be conducted using a paired-sample t -test. The paired t -test results showed a t -value of -8.75 with a p -value of 0.000 ($p < 0.05$), indicating a statistically significant difference between the pre-test and post-test scores. Therefore, it can be concluded that the implemented learning model had a positive and effective effect on improving students' learning outcomes.

Implementation of Learning Models

The implementation of learning using an ethnophysical approach based on the Lais performance was observed through four stages: Invitation, Exploration, Explanation and Solution, and Decision-Making. The Invitation and Explanation–Solution stages were fully implemented (100%), the Exploration stage was highly implemented (90%), and the Decision-Making stage was well implemented (80%) (**FIGURE 7**).

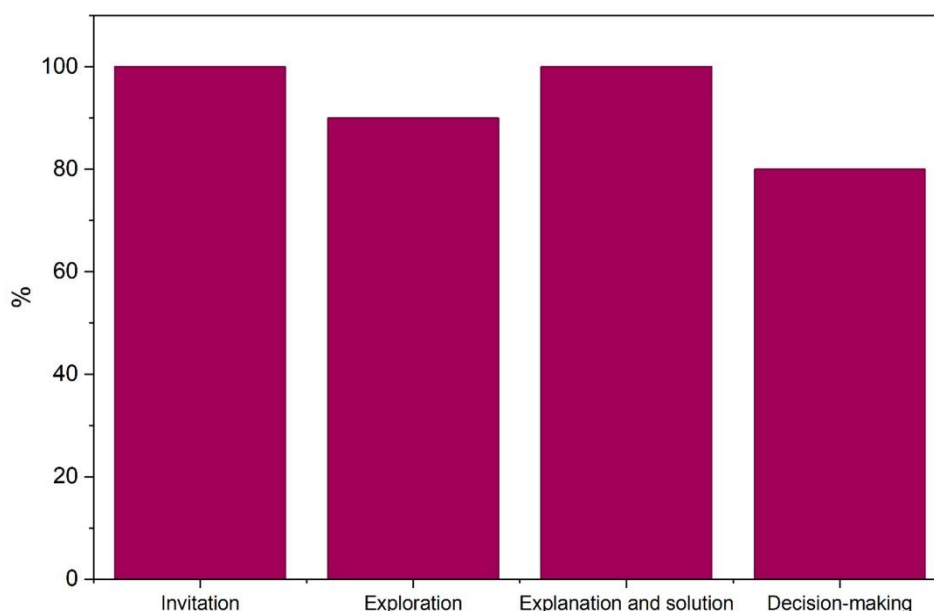


FIGURE 7 illustrates the Gain score from Cognitive Level.

In the Invitation stage, students were introduced to the learning context through live or video observation of the Lais performance, which effectively stimulated curiosity and connected real-life experiences with physics concepts. During the Exploration stage, students identified various motions of the Lais performer and constructed force diagrams, engaging actively in analyzing physical phenomena. The Explanation and Solution stage provided conceptual reinforcement, ensuring students gained a clear understanding of forces, equilibrium, and motion dynamics. In the Decision-Making stage, students applied their conceptual understanding to the Lais context and other relevant situations, demonstrating knowledge transfer.

Overall, the observation results indicate that the ethnophysical CTL-based learning model effectively engaged students, stimulated curiosity, developed analytical skills, and promoted meaningful conceptual understanding.

SUMMARY

Physics learning that integrates physics concepts with local wisdom through an ethnophysics approach in the Contextual Teaching and Learning (CTL) model has been proven effective in improving student learning outcomes. The N-Gain analysis showed a moderate learning increase (0.64), and the t-test showed a significant difference between pretest and post-test scores ($p < 0.05$). This analysis confirms that the ethnophysics-based CTL approach in the case study of Lais' traditional art performances provides a more contextual and meaningful learning experience, thereby improving students' conceptual understanding of basic physics.

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