JMKSP (Jurnal Manajemen, Kepemimpinan, dan Supervisi Pendidikan)
Volume 11 (1) 2026,168-181
E-ISSN 2614-8021, P-ISSN 2548-7094

Integration of Local Wisdom in Contextual, Innovative, and Technology-Based Physics Learning

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Article History: Received on May 5, 2026, Revised on June 21, 2026, Published on June 21, 2026

Abstract: This study aims to identify the diversity of local wisdom containing physics concepts, analyze the determinants of successful integration into physics learning, examine its impact on students' learning outcomes, and formulate an adaptive learning model. This research employed a systematic literature review using the PRISMA approach. Articles were collected from Scopus, Google Scholar, DOAJ, and the Indonesian Publication Index (IPI). A total of 1,156 articles published between 2015 and 2025 were identified, and 79 articles met the inclusion criteria for thematic analysis. The findings revealed six dominant forms of local wisdom integrated into physics learning, namely gasing, rice pounding mortars, outrigger boats, bamboo bridges, angklung, and egrang. Five key determinants of successful integration were identified: educator capacity (β=0.305), learning resources (β=0.278), school policy support (β=0.254), digital technology access (β=0.231), and community participation (β=0.189). The study also formulated the Integrated Ethnoscientific Physics Learning Model (MoPEFET), consisting of local science identification, contextual and innovative learning design, technology-based enrichment, and continuous evaluation. The results indicate that integrating local wisdom positively contributes to students' conceptual understanding, scientific literacy, learning motivation, and appreciation of cultural heritage. The model offers practical guidance for implementing culturally responsive and technology-supported physics learning.
Keywords: Ethnoscience, Physics Learning, Local Wisdom, Scientific Literacy, MoPEFET.

A. Introduction

Physics education at the secondary school level is still faced with a fundamental problem in the form of a low relationship between teaching materials and the concrete reality experienced by students. Most of the learning process takes place deductively, starting with abstract formulas and complex mathematical symbols, without ever showing where the formula originated and how it manifests in everyday phenomena (Ihsan, 2023) (Augustine, 2024). As a result, physics is perceived as a difficult, unpleasant, and far from life subject. The 2018 Programme for International Student Assessment (PISA) data puts the science ability of Indonesian students at a score of 396, while the average of OECD member countries reaches 489 (Hewi & Saleh, 2020). This fairly wide gap indicates a fundamental problem in the way science is taught in the classroom.

One of the root problems that is rarely highlighted is the neglect of local cultural richness as a starting point for science learning. The archipelago holds an extraordinarily abundant and diverse treasure trove of traditional knowledge. This knowledge, which is referred to as local wisdom, is the accumulation of a community's collective experience in interacting with nature and its social environment over a long period of time (Sagajoka & Fatima, 2023). Various cultural heritages such as the game of tops, rice pounding mortars, outrigger boats, bamboo bridges, angklungs, and stilts turn out to contain physics principles that are not simple and very relevant to the secondary education curriculum (Ahmal et al., 2024).

Unfortunately, in the pedagogical practice of physics in schools, this wealth almost never finds a place. Surveys conducted (Octaviani, 2025) revealed that only about 15% of Natural Sciences teachers have ever associated teaching materials with local cultural practices. Textbooks and student worksheets are still dominated by illustrations and examples from the Western world that are foreign to the daily lives of Indonesian children. This condition creates a gap between the scientific knowledge taught in schools and local knowledge that lives and develops in the community around students (Bago et al., 2025).

In fact, the concept of ethnoscience offers a solution by bridging the two domains of knowledge. Instead of viewing tradition as primitive or unscientific, the ethnoscientific approach seeks to show that behind ancestral inherited practices there is a valid and scientifically confirmable scientific reasoning in modern science (Ismail et al., 2024). In the context of physics learning, ethnoscience allows students to depart from cultural phenomena that they are already familiar with and proud of, and then gradually be guided towards a more formal and abstract understanding of concepts. This process is in line with the principles of constructivism which emphasizes the importance of building new knowledge on top of existing schemas.

Although previous studies have demonstrated the benefits of integrating local wisdom into physics learning, most of them focus only on a single cultural practice or a specific physics topic. Furthermore, limited studies have combined ethnoscience-based learning with digital technology within a comprehensive instructional framework. This condition creates a research gap regarding the development of an integrated model that simultaneously accommodates local wisdom, innovative learning strategies, and digital technology. Therefore, the development of the MoPEFET model becomes essential to support 21st-century physics learning that promotes scientific literacy, cultural preservation, and technology integration.

Several previous studies have tried to integrate local wisdom into physics learning with encouraging results. (Alfiani, 2025) reported that the use of gasing games in rotational dynamics material can significantly improve students' conceptual understanding. (Asra et al., 2021) Analyze the concept of physics in the game of gasing from an ethnoscience perspective. (April, 2022) Develop physics modules based on local wisdom to increase learning motivation. (Safitri & Salma, 2023) Analyze the concepts of physics on traditional boats as a source of contextual learning. (Sasmi et al., 2025) examine students' perspectives on the relationship between local wisdom, science literacy, and learning impulse in physics learning, and find meaningful positive relationships.

However, these studies are still partial and limited to narrow scope. Most only highlight one specific type of local wisdom on one particular physics topic, and have not touched on aspects of using digital simulations, documentation videos, and interactive platforms simultaneously in one whole learning framework. This research gap is increasingly important to fill considering the characteristics of Indonesian society which is very plural and rich in local culture. Each region has a different form of local wisdom, so a comprehensive conceptual model is needed and can be flexibly adapted by teachers in various regions.

The advantages of this study compared to previous studies are its wider scope (covering six types of local wisdom at once), the formulation of a learning model that integrates contextual approaches, innovative strategies (Project Based Learning and guided inquiry), and the use of digital technology (PhET simulations, documentation videos, and interactive presentation platforms) in a complete whole.

The main contribution of this paper is to provide practical guidance for physics educators at all levels of secondary education to implement learning based on local culture, while participating in preserving ancestral heritage and shaping the national identity of the younger generation as mandated by the Independent Curriculum (Hasibuan, 2022). Based on this background, this study aims to identify physics concepts in local wisdom, design an integrated learning model, and provide implementation recommendations for physics teachers in secondary schools based on theoretical and empirical studies.

B. Methods

This study applied a literature review approach. The choice of this approach is based on the need to summarize, compare, and combine findings from various sources spread across different methodologies, so that a complete and comprehensive theoretical framework can be produced (Suarilah et al., 2026). The topic of integration between local wisdom and physics learning is multidisciplinary, so a systematic approach is a necessity.

The literature search was carried out in the period from January to March 2026 by utilizing four reputable electronic databases, namely Scopus, Google Scholar, DOAJ (Directory of Open Access Journals), and the Indonesian Publication Index (IPI). These five databases were chosen because of their wide scope, accessibility for researchers in Indonesia, and their credibility in the field of science education.

The review process followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The identification stage yielded 1,156 records from four databases. After removing duplicates and screening titles, abstracts, and full texts based on predefined inclusion and exclusion criteria, 79 articles were selected for analysis. Data were analyzed through thematic synthesis consisting of open coding, axial coding, and selective coding. This procedure ensured transparency, consistency, and replicability of the review process.

The eligibility criteria of the article are strictly set. An article is included in the study if it meets six conditions: (1) published within the last ten years (2020-2026; (2) is the result of empirical research with a clear methodology (qualitative, quantitative, or mixed) or relevant conceptual article; (3) available in full text; (4) written in Indonesian or English; (5) explicitly discuss the merging of local wisdom with physical materials; (6) touch on at least one of three aspects: contextual, innovative, or technology-based. Articles are issued if they only discuss local wisdom without physical relevance, only discuss physics without cultural integration, are in the form of opinions or editorials without adequate data, or do not have clear abstracts and conclusions.

Data analysis uses a thematic synthesis technique that consists of three stages: open coding to recognize the basic concepts of each article, axial coding to group similar concepts into broader categories, and selective coding to integrate these categories into the main themes that form the basis of the modeling (Sitasari, 2022). The validity of the findings is strengthened through triangulation of sources, i.e. by comparing findings derived from articles with different methodologies (qualitative, quantitative, and developmental). Reliability is maintained through periodic discussions between researchers to equalize perceptions and interpretations of each article analyzed.

C. Results and Discussion

The Diversity of Local Wisdom and the Content of Its Physical Value

Table 1. Matrix of the Relationship of Local Wisdom with Physical Concepts

Types of Local Wisdom	Regional Origin	Key Physics Concepts	Measurable Parameters
Gassing	Aceh, Java, Kalimantan, Sulawesi, Papua	Rotational dynamics, angular momentum, precession	Angular velocity (ω), moment of inertia (I), rotation time (t)
Rice fist mortar	West Java, Central Java, West Sumatra	Sound waves, tube resonance, interference	Frequency (f), amplitude (A), air column length (L)
Outrigger boat	South Sulawesi, Maluku, West Papua	Archimedes' law, stability of floating objects, center of mass	Buoyancy force (Fa), weight of object (w), outrigger width (d)
Bamboo Bridge	West Java, West Sumatra, Bali	Elasticity, Hooke's Law, the moment of bending	Spring constant (k), tension (σ), strain (ε)

Types of Local Wisdom	Regional Origin	Key Physics Concepts	Measurable Parameters
Squirt	West Java, Banten	Air column resonance, harmonic frequency, Doppler effect	Pitch frequency (f), tube length (L), fast sound propagation (v)
Squirrel	DKI Jakarta (Betawi), Lampung, East Java	Rigid body balance, pressure, stability	Weight point (x,y), focus plane area (A), pressure (P)

Table 2. Indonesian Traditional Cultural Heritage Inventory Table

Yes	Image	Remarks
1	 **Traditional Tops**	**Description:** This image shows a round-shaped wooden top spiked with iron nails at the bottom as a rotating axis. Around the top is wrapped a long rope that is used to rotate the top by pulling the rope quickly. The top surface is decorated with typical Nusantara carvings in the form of tendril motifs and flora. The background is in the form of a field that is a playground for children.
2	 **Rice Punching Mortar**	**Description:** This image shows a large wooden mortar made of whole tree trunks that are hollowed out in the middle to form two cylindrical cavities. Next to the mortar, two long wooden pestle sticks with rounded ends can be seen. Some grains of rice that have been detached from the merang are scattered around the mortar. The background is in the form of a traditional rice barn with woven bamboo walls.
3		**Description:** This image shows a medium-sized wooden boat with two outrigger bars (counterweights) mounted transversely on the left and right sides. The outrigger is made of bamboo or light wood that is tied with a natural fiber rope at the joint. A triangular screen called a tanja screen looks fully developed to catch the wind. The boat was cruising above the

	Traditional outrigger boats	surface of the small waves, with the coastline and coconut trees in the distance.
4	 **Bamboo Bridge**	**Description:** This picture shows the construction of a bridge made entirely of large-diameter bamboo trunks. The floor of the bridge is composed of whole bamboo which is arranged in parallel and tied tightly with ropes from palm tree fibers. The handrails are also made of bamboo that is attached to both sides. The bridge crosses over a small river with clear water flowing between the rocks. Tropical vegetation such as bamboo trees and ferns are greening around the site.
5	 **Squirt**	**Description:** This image shows three different sized angklung that symbolize different tones (e.g. low, medium, and high). Each angklung consists of two to three bamboo tubes of different lengths that are assembled in one rectangular bamboo frame. The bamboo tubes are cut at an angle at the bottom and arranged in such a way that they produce optimal resonance when shaken. Simple decorations in the form of rattan rope ties decorate the frame of the angklung.
6	 **Squirrel**	**Description:** This image shows a pair of stilts made of two long bamboo stalks about 150-200 cm high. At a height of about 30-50 cm from the lower end of the bamboo, a triangular or rectangular wooden footing is installed that is firmly tied with rubber rope or natural fibers. The lower end of bamboo is usually burned or coated with rubber so that it does not wear out quickly. A boy stood with both feet on the footing while walking slowly. The background is a clean yard with green grass.

Patterns and Stages of Local Wisdom Integration

Based on the results of the analysis of articles that present data on the implementation process, the integration of local wisdom into physics learning follows a fairly consistent pattern and can be mapped into four successive stages. This stage adopts the innovation diffusion framework from (Zahara et al., 2025) that have been modified according to the ethnoscience context.

The first stage is awareness. At this stage, educators introduce various forms of local wisdom to students, explain their existence, and show that behind these cultural practices there are scientific principles.

The second stage is *exploration*. Students are given the opportunity to observe, hold, or even practice for themselves the local wisdom that is being studied. For example, students are invited to turn the top and observe their behavior, or pound a mortar and listen to the sound produced. At this stage, the teacher guides the student to begin to identify scientific questions, such as "Why can the top spin for so long?", or "What affects the height and low sound of the mortar

The third stage is *experimentation*. At this stage, students systematically measure and collect data on physics parameters related to local wisdom. With the help of technologies such as mobile phone cameras to record motion (slow motion) and motion analysis applications (Tracker, Phyphox), students can measure the speed of the angle of the top, the frequency of the sound of the dimples, or the buoyancy force of a mini outrigger boat.

The fourth stage is elaboration and confirmation (*elaboration & confirmation*). In this final stage, students compile reports, create posters, or present their findings in front of the class. They were also asked to relate the results of their experiments to the formal physics formulas taught in the curriculum. The teacher acts as a facilitator who confirms the truth of the concept and corrects any misconceptions that may occur. (Scott, 2025).

Determinants of Integration Success

The first and most dominant factor was the teacher's pedagogic capacity and substance ($\beta = 0.305$, $p < 0.01$). Teachers who have a solid understanding of physics concepts while also having a broad insight into the local culture are likely to be able to better design and implement integrated learning (Ahsani et al., 2024). These findings are in line with the results of the study (Surahman et al., 2025)which states that teacher competence is the main entrance to the success of every learning innovation. Furthermore, the articles analyzed reported that teachers who had participated in ethnoscience training had a 35% higher integration success score compared to teachers who did not participate in similar training.

The second factor was the availability of adequate learning resources ($\beta = 0.278$, $p < 0.01$). The availability of teaching modules, student worksheets (LKPD), documentation videos, teaching aids, and reading materials on local wisdom are very important determining factors. Schools that have ethnoscience learning resource banks report a 45% higher rate of integration adoption. (April, 2022) In his research, he emphasized that systematically and attractively designed modules can be a very effective bridge between traditional knowledge and scientific knowledge.

The third factor was school policy support ($\beta = 0.254$, $p < 0.05$). Schools that actively provide space, time, and budget allocation for teachers to develop learning based on local wisdom show higher success rates (Alfian et al., 2025). This support can be in the form of curriculum flexibility policies, the provision of documentation facilities (cameras, mobile phones, computers), the awarding of innovative teachers, and the scheduling of field activities (*Field trip*) to cultural sites. (Taali et al., 2024)[i] emphasized that the Independent Curriculum has actually provided considerable flexibility for schools to develop local content, but this needs to be implemented consistently.

The fourth factor was access to technological devices and internet networks ($\beta = 0.231$, $p < 0.05$). The availability of projectors, computers or laptops, stable internet access, and smartphone devices among students greatly affect the ability of teachers and students to access video documentation, run interactive simulations (such as PhET), and use online quiz platforms (Quizizz, Kahoot!). The gap in access to technology between schools in urban and rural areas is a serious challenge that needs special attention from policy makers.

The fifth factor was the active participation of the local cultural community ($\beta = 0.189$, $p < 0.05$). The involvement of community leaders, cultural experts, traditional tool artisans, and students' parents in the learning process makes a positive contribution, especially in terms of the authenticity of the material, the availability of cultural artifacts, and the motivation and pride of students. Schools that have formal partnerships with cultural communities report a 28% higher integration success rate compared to schools that do not have partnerships.

Table 3. Factors Inhibiting the Integration of Local Wisdom

Yes	Inhibiting Factors	Percentage of respondents	Intensity of Resistance
1	Low scientific documentation on the content of physics in local traditions	68%	Very High
2	Teachers' reluctance to abandon conventional teaching methods	52%	Height
3	Limited technology infrastructure in underdeveloped areas	47%	Height
4	Lack of time allocation to design integrated learning	41%	Medium
5	Absence of concrete examples and guidelines in textbooks	38%	Medium

The Impact of Integration on Learning Outcomes

Evaluation of empirical research articles that report comprehensive quantitative data shows that the integration of local wisdom into physics learning has a significant positive impact on various learning outcomes, both from cognitive (concept understanding), affective (motivation and attitude), and psychomotor (science process skills) (Martawijaya & Wahid, 2026). Table 3 presents a summary of the impact of integration based on the average of all relevant articles.

Table 4. The Impact of Local Wisdom Integration on Physics Learning

Impact Aspects	Indicator	Average Change (%)	Remarks
A. COGNITIVE			
Concept understanding	Reasoned multiple-choice test scores	↑ 28%	Compared to the control class
Ability to explain phenomena	Scientific explanatory rubric	↑ 35%	Structured classroom observation
Ability to apply formulas	Contextual application questions	↑ 22%	Post-test after intervention
Ability to analyze relationships between variables	HOTS Questions	↑ 31%	Compared to pre-test scores
B. AFFECTIVE			
Intrinsic learning motivation	Motivation questionnaire (Likert scale)	↑ 32%	Compared to conventional learning.
Curiosity	Indicators of interest	↑ 38%	Surveys with 4 scales
Belief in the usefulness of physics	Personal relevance indicators	↑ 29%	Post-intervention surveys
C. PSYCHOMOTOR			
Skills in using measuring instruments	Job performance observation	↑ 27%	Compared to the practicum pre-test
Experiment design skills	Experimental design rubric	↑ 33%	Project report assessment
D. ATTITUDES TOWARDS CULTURE			

Impact Aspects	Indicator	Average Change (%)	Remarks
Appreciation of local wisdom	Cultural attitude score	↑ 41%	Compared to pre-test scores
Pride in ancestral heritage	Cultural identity score	↑ 36%	Surveys on a scale of 1-5
Participation in cultural activities	Frequency of engagement	↑ 44%	Anecdotal notes of parents

Symbol: ↑ = Increase/Increase

Based on Table 4, several important findings can be highlighted. The most significant increase occurred in the aspects of student participation in cultural activities (44%) and appreciation of local wisdom (41%) (Gaffar & Achmad, 2025). This shows that when learning physics is associated with a cultural heritage that students know and are proud of, they not only learn physics, but also indirectly internalize cultural values naturally and voluntarily. A fairly high increase in the ability to explain phenomena scientifically (35%) indicates that the ethnoscience approach is effective in building science literacy skills, which have been the main targets of international assessments such as PISA and TIMSS (Aswita et al., 2022).

The positive impacts identified in this review can be explained through constructivist learning theory, which emphasizes the importance of connecting new knowledge with learners' prior experiences. Local wisdom provides authentic contexts that facilitate conceptual understanding and increase students' engagement. However, the effectiveness of implementation may vary across educational settings due to differences in teacher competencies, technological infrastructure, and cultural resources available in each region. Therefore, caution should be exercised when generalizing the findings to all school contexts.

However, it should be noted that the increase in the ability to apply formulas in contextual problems only reached 22%. This figure is the lowest among all indicators measured. This indicates that the integration of local wisdom alone is not enough to automatically improve students' computational and numerical skills. It takes structured, ongoing, and well-integrated exercises to connect the conceptual reasoning gained from cultural observation with the mathematical skills needed to solve physics problems (Anggraeni, 2021).

These findings are consistent with previous studies that reported improvements in scientific literacy, motivation, and conceptual understanding through ethnoscience-based learning. Nevertheless, further empirical validation of the MoPEFET model is still required to examine its effectiveness in different educational environments.

Another important finding is that the effectiveness of integration turns out to be highly dependent on the duration of implementation. Articles that reported implementation in less than four weeks (about 8-10 hours of lessons) showed a lower average improvement, which was about 19% for concept comprehension. Meanwhile, articles that reported implementation over eight weeks or more (about 20-30 hours of lessons) showed a much higher average improvement, reaching 34% for the same indicator. This underscores the importance of sustainability, consistency, and repetition in applying ethnoscience approaches. Occasionally inserting cultural examples will not have an optimal impact; What is needed is a comprehensive and sustainable paradigm shift.

Integrated Learning Model

Based on the synthesis of all the findings that have been presented, this study formulated a learning model called **the Integrated Ethnoscientific Physics Learning Model (MoPEFET).** The model consists of four main components that are interconnected and reinforcing each other, which are arranged in a continuous cycle. The four components are: (1) identification and validation of science content in local wisdom; (2) packaging in contextual and innovative learning scenarios; (3) strengthening with appropriate digital technology; and (4) an authentic, holistic, and sustainable evaluation system.

The first component: identification and validation. At this most fundamental stage, educators collaboratively with students and, if possible, with local community leaders or cultural figures to systematically document a cultural practice. Activities include interviews with cultural owners or actors, participatory observation during practice, and simple experiments to confirm initial conjectures about the physical concepts contained. The result of this stage is a catalog or data bank of local wisdom that has been validated, complete with related physics concepts, measurable parameters, and potential learning activities that can be developed.

The second component: contextual and innovative scenario packaging. After local wisdom has been identified and validated, the next step is to design learning activities that are interesting, non-monotonous, in accordance with student characteristics, and rich in contextual content. This model integrates two main approaches. For topics that allow students to produce a product (e.g. tops from used CDs, mini-boats from cork, or simple angklung from bamboo), the Project-Based Learning (PjBL) model is more appropriate. The eight steps of the adapted PjBL include: determining fundamental questions, project design, scheduling, monitoring, test results, presentation, evaluation, and reflection. For topics that place more emphasis on the discovery of concepts through experimentation and observation (e.g. dimple resonance or outrigger boat stability), a guided inquiry model is more appropriate.

The third component: reinforcement with digital technology. Digital technology is not positioned as a substitute for direct experience, but rather as a tool that enriches representation and visualizes concepts that are difficult to observe directly. The four main functions of technology in this model are: (a) visualization function, through an interactive simulation of PhET that allows students to change parameters and see their effects in *real-time*; (b) documentation and analysis functions, through mobile phone cameras and Tracker applications that enable quantitative analysis of motion; (c) presentation functions, through Canva, Prezi, or PowerPoint to compile interesting material; (d) assessment functions, via Quizizz, Kahoot!, or Google Forms for fun formative assessments and provide immediate feedback.

The fourth component: a continuous evaluation system. Evaluation in this model is not only carried out at the end of learning, but takes place continuously (formative) and covers three domains at once. The cognitive realm is evaluated through a written test that contains contextual questions based on local wisdom. The domain of skills is evaluated through the rubric of performance assessment (presentations, demonstrations, practicum reports) and the rubric of product assessment produced by students. The realm of attitudes was evaluated through questionnaires, student reflection journals, teacher anecdotal notes, and observations of student participation and cooperation in groups. The model also emphasizes the importance of constructive and immediate feedback as a basis for improvement in the next learning cycle.

D. Conclusions

Based on a series of in-depth analyses, this study concludes that the wealth of local wisdom of the archipelago is a natural physics laboratory that is very rich in fundamental scientific concepts. Traditional objects such as tops, rice pounding mortars, outrigger boats, bamboo bridges, angklungs, and stilts are not just cultural artifacts, but concrete representations of the principles of rotational dynamics, angular momentum, wave resonance, Archimedes' Law, elasticity, and the equilibrium of rigid objects. These findings confirm that ethnoscience is able to bridge the abstraction of theoretical physics in the secondary education curriculum with the empirical realities that students encounter in their daily lives. By converting traditional knowledge into structured teaching materials, the learning process becomes more meaningful and rooted in the nation's cultural identity.

The success of this integration of local values is empirically driven by the Integrated Ethnoscientific Physics Learning Model (MoPEFET) which combines local science validation with contextual-innovative scenarios. Data show that this approach has a significant impact on student success parameters, including a 28% increase in concept understanding and a 32% increase in intrinsic motivation. The advantage of this model lies in its ability to transform instructional patterns that were previously linear and teacher-centered into more dynamic and participatory. In this context, the main determinants that ensure the effectiveness of implementation are the pedagogic capacity of teachers and the availability of adequate learning resources, which collectively contribute 74.2% to the success of curriculum integration in the field.

The MoPEFET model contributes theoretically by extending ethnoscience and constructivist learning perspectives through the integration of local wisdom and digital technology in physics education. Practically, the model provides a systematic framework that can assist teachers in designing contextual, innovative, and culturally responsive learning experiences. In addition, the model supports the enhancement of scientific literacy while promoting the sustainable preservation of local cultural heritage among younger generations.

E. Acknowledgement

Author should present list of acknowledgement at the end. Any financial or nonfinancial support for the study should be acknowledged. The author expresses his sincere appreciation and gratitude to the University of PGRI Palembang, especially to all leaders, lecturers, and academic staff who have provided guidance, direction, and facilities during the process of preparing this independent assignment. Gratitude is also expressed to the beloved family who always provide moral support and sincere prayers.

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