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Learning Design for Ethnophysics-Integrated Physics: A Study on Parabolic Motion Through Gatrik Game

Winny Liliawati [1,*], Yeyet Yetia [2], Iyon Suyana [1], Ghia Syifa Maharani [1], Agus Danawan [1], dan Rizki Zakwandi [1]
[1] Program Studi Pendidikan Fisika, Universitas Pendidikan Indonesia, Bandung, Indonesia
[2] SMA Negeri 16 Bandung, Bandung, Indonesia
[*] Email: winny@upi.edu

Abstract
Ethnophysics is an innovation in physics learning that connects local culture, traditions, and community practices into learning by analyzing physics concepts that occur. One form of application is through the traditional game Gatrik, which contains the principles of motion, especially parabolic motion. This study aims to design and implement an ethnophysics-integrated physics learning design on parabolic motion material through the Gatrik game. This research uses qualitative method with participatory action research design on the implemented learning process. This research focuses on observing learning with a lesson study approach, which consists of three stages namely plan, do, and see which focus on strengthening and assisting high school physics teachers in developing ethnophysics-based teaching tools. At the plan stage, learning tools were prepared in the form of lesson plans and LKPD; at the do and see stages, open lessons were conducted to observe the implementation of learning. The data in this study were collected using a learning observation sheet, especially at the see stage of a series of lesson study activities. The results of the plan stage are in the form of lesson plans and LKPD that have been adapted to ethnophysics integrated physics learning. Furthermore, the results of observations at the do and see stages show that physics learning that integrates Gatrik games as a representation of ethnophysics can increase student learning activities. Learning combined with traditional games can significantly increase students' enthusiasm for physics material. In general, the integration of ethnophysics in learning can contribute to the preservation of local wisdom and increase students' interest and motivation to learn in Physics.

Keywords: *Ethnophysics, Gatrik, Learning Design, Projectile Motion, Traditional Game*

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INTRODUCTION

Ethnophysics, as a part of ethnoscience, is a pedagogical approach in physics education that connects physics concepts with local culture, traditions, and community practices (Ariani & Hariyadi, 2024). This approach seeks to enhance the relevance and contextuality of physics education for students by incorporating surrounding cultural elements. Ethnophysics serves both as an educational instrument for imparting physics concepts and to conserve and value local culture. The ethnophysics approach provides a novel method to enhance students' comprehension of physics concepts. Connecting physics content with local culture facilitates students' comprehension and application of physics concepts in daily life. Saputra et al., (2024) underscores the significance of ethnophysics-based educational media in connecting physics concepts with cultural contexts, thereby enhancing student engagement in the learning process. Ethnophysics represents a promising methodology in physics education, integrating scientific principles with local culture to enhance the learning experience for students. Incorporating cultural elements into physics instruction, ethnophysics enhances students' comprehension of physics while simultaneously aiding in the preservation and appreciation of their cultural heritage.

Physics learning has historically been abstracted and unrelated to students' local contexts, resulting in a disconnect between scientific knowledge and the reality of everyday life. Efforts to close this gap have resulted in a variety of novel ways to learning, including ethnopedagogy and the incorporation of ethnoscience within the science curriculum (Alditia & Nurmawanti, 2023; Damayanti et al., 2025; Sari et al., 2025). This strategy is said to be capable of offering deeper meaning and connecting scientific topics to students' local culture.

Several research have demonstrated the potential of ethnophysics, or the study of physics in local culture or technical practices, to contextualize physics ideas (Oladejo et al., 2023; Verawati & Nisrina, 2025). Traditional sports, such as stilts, kites, and jump rope, have been utilized to demonstrate the ideas of force, motion, and energy. However, the use of classic games to convey the notion of parabolic motion remains unusual in the literature. In fact, games like gatrik, which include tossing and curved routes, offer a lot of potential as a learning tool for parabolic motion content (Rohmah et al., 2024). By associating physics concepts with familiar games, educators can foster more engaging and significant learning experiences for students. This method also aids in the preservation of local culture, which is increasingly jeopardized by modernization and technological advancements. Traditional games stem from the exploration of one's culture and encompass numerous educational values, as these activities impart pleasure, joy, and happiness to the participating children (Aypay, 2016; Gultom et al., 2022; Marsh, 2008).

This research is crucial due to the ongoing difficulty in physics education to connect abstract scientific concepts with students' daily experiences. Despite attempts to adopt contextual learning methods, some instructional models remain culturally disconnected, leading to distracted students and a shallow grasp of concepts. Education is not merely a process of transferring knowledge, but also a vehicle for instilling values and understanding rooted in the culture of society (Zulkarnain, 2024). Simultaneously, traditional cultural assets, such as indigenous games, are increasingly endangered by the rapid progression of industrialization and globalization. These games, which intrinsically illustrate physical concepts through experiential learning, constitute a generally underutilized educational resource. Specifically, intricate subjects such as parabolic motion are seldom explored using culturally integrated educational resources. This project seeks to fulfill an urgent requirement for an educational design that contextualizes parabolic motion via the traditional Gatrik game while also aiding in the preservation of intangible cultural heritage. This research enhances culturally responsive pedagogy by incorporating local wisdom into formal scientific teaching, fostering more engagement and comprehension among students.

Traditional games are those that have persisted since antiquity, transmitted across generations. The implements in traditional games are constructed from wood, bamboo, coconut shells, and local materials. This indicates that traditional games do not necessitate substantial expenses (Yulita, 2017). Traditional games are recreational activities that evolve and flourish within a specific region (Kurniati, 2016). Traditional games offer numerous advantages, including cost-free participation, enhancement of children's creativity, development of social and emotional intelligence, connection to nature, facilitation of value learning, improvement of motor skills, health benefits, optimization of cognitive abilities, provision of joy and cheerfulness, suitability for all ages, and refinement of children's sensitivity (Hariastuti, 2016). Moreover, traditional games typically encompass educational concepts including physics, science, social studies, regional languages, physical education, and religion. Traditional games encompass learning concepts that facilitate educators in imparting knowledge (Hariastuti, 2016).

A traditional game still played in the region is gatrik. This game is commonly encountered in diverse regions of Indonesia under various appellations, including "Gatrik" in West Java, "benthink" in Central Java and Yogyakarta, "tak tek" in Bangka Belitung, "patok lele" in Madura, and "tak kadal" and "betruk" in other locales (Hariastuti, 2016). The gatrik game is a conventional activity that entails throwing and catching, as illustrated in Figure 1.

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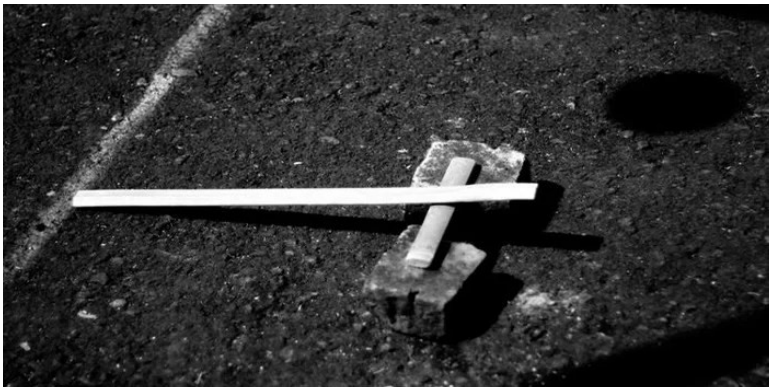

Figure 1. Gatrik Gaming Device (Sources: https://archipelagoid.com/)

This game is conducted in teams using two bamboo sticks as primary equipment and a hole in the ground or bricks as an alternative. The first bamboo measures 30 cm, while the second bamboo, being one-third of it, measures 10 cm. The regulations for playing gatrik are straightforward and uncomplicated. Two teams are assigned distinct tasks: the first team is responsible for throwing the bamboo, while the second team is responsible for catching it (refer to Figure 2).

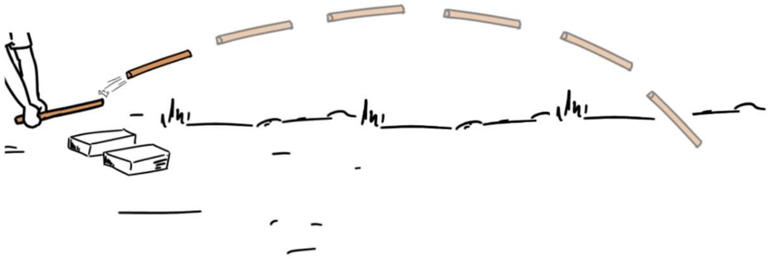

Figure 2. The short bamboo gatrik movement is a parabolic motion

If the opponent successfully captures the bamboo, the players may exchange positions. This game comprises three rounds: prying short bamboo, throwing short bamboo upward, and striking it forward, as well as hitting short bamboo resting on a hole or brick. The conventional gatrik game can enhance dexterity, agility, and speed. The gatrik hitter must exercise caution to ensure the bamboo slides more swiftly. Simultaneously, the security personnel must remain vigilant to prevent injury from bamboo strikes. The gatrik game is a traditional activity that encompasses various physics concepts suitable for educational materials.

While several research have investigated the incorporation of local culture into science education, the majority have concentrated on broad or qualitative applications of ethnoscience, lacking the development of specialized instructional strategies associated with well defined physics topics. Moreover, conventional games have frequently been employed to illustrate fundamental concepts such as motion, force, or energy, but never to investigate more intricate subjects like parabolic motion. Consequently, a substantial vacuum persists in the literature about the systematic incorporation of culturally relevant games into organized physics education. The Gatrik game, a traditional Indonesian activity characterized by projectile velocity, has not been employed as a contextual framework for studying parabolic trajectories. Due to its intrinsic physical attributes and cultural familiarity, Gatrik possesses significant promise as an educational tool to enhance conceptual comprehension. Consequently, developing a physics educational strategy that incorporates the Gatrik game is both pedagogically pertinent and culturally meaningful. This study aims to address that deficiency by developing and examining a contextualized learning design that integrates physics principles with cultural experiences, so offering students a more significant and engaging educational experience.

This study seeks to design and implement physics education by incorporating the traditional Gatrik game into the curriculum on parabolic motion. The design and implementation process employs a lesson study framework that commences with problem analysis, followed by the formulation of a learning implementation plan, execution of the learning, observation of the implementation, and concludes with reflection. The designed learning is anticipated to engage students' interest and attention, promote active participation in learning, and enhance their comprehension of parabolic motion concepts.

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METHOD

This study employed qualitative research with the participatory action research design. In this study, we focused on to elucidate the process of designing and implementing ethnophysics-based physics education, in accordance with the previously stated objectives. As a context in qualitative analysis, the model teacher involved in the lesson study stage was a teacher who was very active in traditional games as a child. While the students involved were just learning about this game. Thus, there was a visible gap between the knowledge of students and teachers about this game, not only in the context of physics material.

This activity adheres to the lesson study phases (Plan, Do, See) (Hendayana, 2006). During the planning phase, a cohort of educators from Bandung city engaged in a dialogue concerning the selection of ethnophysics subjects. The traditional *Gatrik* game was selected due to its familiarity among high school students in Bandung, its relative simplicity, and the numerous physics concepts that can be explored through it. A Lesson plan and Student Worksheet was subsequently developed (See APPENDIK 1 and APPENDIX 2). During the Do and See phases, the lesson plan that was developed was executed at one of Public Senior High School in Bandung, by model teachers from the institution, with additional educators serving as observers. After the implementation process, a reflection on the execution of learning ensued (see APPENDIX 3).

This study delineates the procedures for the preparation and execution of educational activities. The utilized instruments comprise lesson plans, observation sheets for learning implementation, and student questionnaires which is adjusted to the research focus. The study comprised 20 grade XI students, consisting of 8 males and 12 females, selected using a convenience sampling technique, as the participants were chosen based on their accessibility and availability to the researcher. The selection of students was contingent upon the availability of those who could attend on Saturdays, during which no teaching or learning activities occurred. The data analysis method employed was descriptive qualitative, focusing on the design and execution of learning activities derived from lesson plan instruments, learning observation sheets, and student response questionnaires.

RESULTS AND DISCUSSION

The learning outcomes for Physics subjects in Senior High School Phase F within the Independent Curriculum (*Kurikulum Merdeka*), pertaining to the integration of ethnophysics in the traditional gatrik game, indicate that students will be able to comprehend the concept of motion, the correlation between force and motion, and apply this understanding to elucidate natural phenomena, as well as to design or engineer structures. This study highlights the gatrik movement, specifically parabolic motion. In accordance with this description, a Lesson plan was formulated during the planning phase in collaboration with a cohort of 11 Physics teachers from Bandung City High School through online discussions, which are integral to the Community Service initiatives of the Physics Education study program at Indonesian Education University. Subsequently, engaged in discussions with instructors or facilitators. The established learning objectives are: (1) comprehending the kinematics of object motion via the gatrik game, and (2) examining the concept of parabolic motion within the gatrik game.

The instructional design was developed for two lesson hours (2x45 minutes) utilizing the Problem-Based Learning (PBL) model, which encompasses stages of problem orientation, student organization for learning, facilitation of group investigations, development and presentation of work outcomes, and analysis and evaluation of the problem-solving process. The instructor directs students to develop problems by presenting video clips of students' gatrik game recordings from the initial round and posing the stimulus question, "How does the short wood move when thrown by the player in round 1 of the game?" How does the placement of the long wood influence the trajectory of the falling short wood? Subsequently, the instructor organizes the students into four groups and allocates students worksheet for discussion. Students collaborate in groups utilizing a projectile motion simulation to address the problem formulation. Upon discovering the solution, students articulate their conclusions during the discussion. The final phase involves the teacher reinforcing problem-solving skills.

Due to the duration of class instruction and student mobility, a video recording was initially made while students participated in the gatrik game. A cohort of students engaged in the gatrik game in teams, and the activity was documented via video recording. To facilitate the gatrik game, the instructor assembled two bamboo or wooden pieces measuring 30-40 cm and 10-13 cm, along with two bricks. For convenience, the short piece of wood utilized during the game measured 13 cm, while the long piece measured 40 cm. Prior to the commencement of the game, the teacher instructed the students (refer to Figure 3) and organized them into four teams, each comprising two males and three females, resulting in a total of five students per team. The

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team that would compete first was the one that triumphed in hompimpa and rock-paper-scissors. Prior to the game, each team received instructions in the student's worksheet.

(a)

(b)

Figure 3. (a). Briefing before playing *gatrik*, and (b). Students playing *gatrik*

During the Do and See phase, the execution of learning in the classroom occurs, while observers monitor the implementation of the educational process. The distribution of instructional time is 2 x 45 minutes. Learning commences with the activities outlined in Table 1.

Table 1. Learning Design Plan

Phase	Activity	Description
Introduction		
	Opening & Greeting	Teacher opens with a greeting and leads a class prayer to start the session.
	Attendance Check	Teacher checks student attendance.
	Conveying Objectives	Teacher presents the objectives of the lesson via PowerPoint slides, explaining the integration of physics concepts with cultural context.
Apperception & Motivation	Cultural Contextualization	Teacher shows a video clip of *gatrik* game and asks reflective questions to activate students' prior experiences.
	Linking Prior Knowledge	Teacher recalls previous topic on motion kinematics and connects it to the observed game.
Core Activities *(Guided Inquiry-Based Learning)*		
Phase 1: Orientation to the Problem	Problem orientation	Students observe a video of the *gatrik* game and answer teacher's guiding questions about the motion of the short stick and impact factors.
Phase 2: Organizing Students	Group Formation	Students are divided into groups and given worksheets and digital learning materials (simulation access).
Phase 3: Group Investigation	Hypothesis Testing & Discussion	Students work in groups to discuss, simulate, and analyze the projectile motion related to *gatrik*. Teacher provides scaffolding as needed.
Phase 4: Developing and Presenting Work	Group Presentations	Selected group presents findings; peer groups provide feedback and ask questions.
Phase 5: Analysis and Evaluation	Simulation-Based Validation	Using PHET, teacher confirms and elaborates on students' findings; misconceptions addressed through guided inquiry.
Closing	Conclusion & Reinforcement	Teacher guides students to reflect and summarize the lesson. Final reinforcement of key physics concepts.

Following the implementation of learning, observers conducted a reflection. The subsequent outcomes of the observers' reflections are presented in Table 2.

Table 2. Reflections from Observer Teachers

No.	Reflection
1.	Ethnophysics education offers a profound learning experience for students, enabling them to investigate physics concepts through the perspective of their own culture. Prior to formal instruction, students are encouraged to observe and investigate natural phenomena and technology, thereby establishing a robust foundational understanding before engaging with more abstract concepts.
2.	Throughout the educational process, students will identify correlations between the physics concepts they acquire and their daily experiences. This facilitates students in developing a more profound comprehension and enhances material retention.
3.	When designing classroom instruction, educators must consider the varied intelligence of their students. Moreover, educators must offer ample opportunities for students to engage in experiments, both independently and collaboratively. These experiments can enhance students' motivation for learning and facilitate a deeper comprehension of physics concepts.
4.	The objective of physics education extends beyond imparting knowledge; it also seeks to cultivate students' character. In ethnophysics-based education, educators can impart values such as curiosity, creativity, collaboration, and accountability. This education can also enhance students' appreciation for culture and their surrounding environment.
5.	To address spatial limitations, learning activities necessitating extensive areas can be substituted with simulations or virtual laboratories. Consequently, students can still perform experiments and directly observe phenomena, albeit in a digital format.
6.	The allocation of tasks in group work must be equitable and explicit, ensuring that each student bears equal responsibility and can contribute effectively. Educators must oversee and facilitate the collaborative work process to guarantee that all students are actively engaged.
7.	The teacher's role is crucial in facilitating group work. Educators must deliver explicit instructions, offer constructive feedback, and facilitate student discussions.

According to Table 2, feedback from observers indicates that the implemented learning process is functioning effectively. Students exhibited considerable enthusiasm and active participation in learning activities that incorporated the traditional Gatrik game to comprehend the concept of parabolic motion. The utilization of learning media that is relevant to daily life and local culture has been demonstrated to enhance
8 students' motivation for learning (Gaol & Sitepu, 2020). This aligns with sociocultural learning theory, which
8 underscores the significance of social and cultural context in the learning process. A learning environment pertinent to students' experiences enables them to connect scientific concepts with their known reality (John-Steiner & Mahn, 1996; Nasir & Hand, 2006; Polly et al., 2017).

The Gatrik game, featuring a small stick that is thrown and follows a parabolic trajectory, exemplifies the principle of two-dimensional motion as seen in Figure 4.

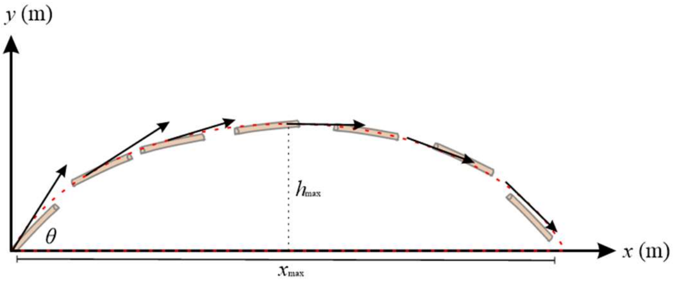

Figure 4. Physical Analysis of *Gatrik* Bamboo Motion

Parabolic motion is a well-known phenomenon that results from the combination of two distinct linear motions, uniform linear motion (GLB) in the horizontal axis and uniformly accelerated linear motion (GLBB) in the vertical axis (Prastyo & Hartono, 2020). The gatrik game encompasses not only parabolic motion but also the principles of force, momentum, impulse, and rotational motion. By observing this activity, students can concretely understand how the parabolic trajectory is created, how initial velocity influences height and
5 distance, and the role of gravity. Crogman et al. (2025) experiential learning theory posits that learning is enhanced when students engage directly with the process or phenomenon under examination. In this context, Gatrik serves as a medium for amalgamating tangible experiences with physics concepts, thereby prompting students to develop understanding reflectively.

The word frequency analysis of comments and observations pertaining to ethnophysics education revealed three primary themes: education, students, and physics. The terms "education" and "students" were the most frequently mentioned, signifying that the primary emphasis of this study was on physics learning and students' active participation in the educational process. Moreover, terms like experiments, collaboration, and curiosity underscore the significance of direct experimentation, teamwork, and inquisitiveness in enhancing students' comprehension of physics ideas. This educational approach emphasizes not only the acquisition of physics information but also the cultivation of students' character via collaborative efforts and creative experimentation.

This comment highlights the significance of technology by noting the utilization of simulations or virtual laboratories to mitigate spatial constraints. This enables students to persist in experimenting and seeing physical events firsthand, albeit being in a digital format. Moreover, the study indicates that within this learning environment, each student possesses distinct duties inside the work group, with equitable distribution of tasks to guarantee the active participation of every individual in the collaborative process (Hussein, 2021; Lakkala et al., 2021).

This ethnophysics-oriented physics education offers a more inclusive and culturally relevant methodology, wherein physics topics are elucidated via students' quotidian experiences (Jardim et al., 2021). This education seeks to impart information while simultaneously cultivating students' character, including qualities such as creativity, teamwork, curiosity, and responsibility. This emphasizes the significance of holistic education, which combines academic knowledge with social and cultural values.

The observation results indicated that the majority of students were content with this educational model. They believed that engaging in traditional games was not only enjoyable but also facilitated a deeper comprehension of the material.

"…. *after following this learning, I feel challenged to find more information about the gatrik game culture, making me understand the lesson material better and making me feel more appreciative of cultural diversity after studying culture-based physics learning.*" – student interview and questionaire interpretation

This discovery reinforces a prior study by Abrantes & Bargamento (2024) that demonstrated local culture-based physics education enhances conceptual comprehension and mitigates learning monotony. This approach positively influences students' affective dimensions, such as motivation, curiosity, and cultural pride (Jardim
12 et al., 2021; Oriol et al., 2016; Zhang et al., 2023). Numerous students indicated that this methodology is anticipated to be implemented with additional materials, as it renders the learning experience more contextual and significant. This concept of culturally responsive teaching, asserting that education tailored to students' cultural backgrounds can enhance their engagement and academic performance (Kondo, 2022). In this instance, Gatrik serves both as an educational tool and as a mechanism for safeguarding local culture and reinforcing student identity.

Consequently, it can be inferred that the incorporation of the traditional Gatrik game into physics education is not only effective in enhancing comprehension of parabolic motion but also aligns with the theoretically acknowledged culturally-based pedagogical approach. This ethnophysical approach serves as a strategic alternative to connect scientific education with students' socio-cultural contexts, thereby enhancing a more humanistic and pertinent model of physics learning.

CONCLUSION

Integrating the culture of the surrounding community into physics education (ethnophysics) can serve as a method to enhance comprehension of fundamental natural phenomena while safeguarding the traditions of the local community, which are increasingly endangered by generational changes and technological advancement. The ethnophysics education derived from this gatrik game can provide an engaging learning experience for students, particularly for the current generation unfamiliar with traditional games. The game is not only exhilarating and demanding, necessitating skill in striking the bamboo towards the opponent, but it also provide a new perspective to deliver physics concepts through direct experience and observation. This facilitates teachers' ability to elucidate abstract concepts. The gatrik game can serve as a tool for comprehending parabolic motion and other physics concepts, including force, impulse, momentum, object rotation, and equilibrium, among others. This study possesses many drawbacks. The learning design was first evaluated under a restricted scope and context, potentially failing to encompass the range of student backgrounds or educational settings. Secondly, although Gatrik has significant potential for intellectual

2

engagement, its physical characteristics may provide practical obstacles in some classrooms, including spatial limitations or safety issues. This study focuses more on presenting qualitative insights, so it does not provide a comprehensive assessment of students' learning outcomes in measurable terms, both in terms of cognitive ability improvement and the achievement of objective learning indicators. Subsequent study should investigate wider applications, evaluate students' conceptual advancements statistically, and analyze the adaptation of many conventional games across diverse physics subjects. To facilitate further development, a study may be conducted on the cultural practices of the surrounding community, focusing on traditional games or other activities pertinent to the principles of physics or alternative educational concepts. It is anticipated that this study will enable teachers to implement the learning concept more effectively.

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AUTHOR CONTRIBUTION
Winny Liliawati: Conceptualization, Methodology, Data Curation, Supervision, and Writing - Review & Editing; **Yeyet Yetia**: Data Collection and Resources; **Iyon Suyana**: Conceptualization, Validation, and Supervision; **Ghia Syifa Maharani**: Data Curation, Formal Analysis, and Writing - Original Draft; **Agus Danawan**: Validation and Supervision; and **Rizki Zakwandi**: Software, Visualization, and Writing - Review & Editing. All authors have read and agreed to the published version of the manuscript. 5

1 **DECLARATION OF COMPETING INTEREST**
The authors declare no known financial conflicts of interest or personal relationships that could have influenced the work reported in this manuscript.

DECLARATION OF ETHICS
The authors declare that the research and writing of this manuscript adhere to ethical standards of research and publication, in accordance with scientific principles, and are free from plagiarism.

DECLARATION OF ASSISTIVE TECHNOLOGIES IN THE WRITING PROCESS
The authors declare that generative artificial intelligence (GenAI) and other AI-assisted tools were used prudently, not excessively, during the research and preparation of this manuscript. Specifically, DeepL and Google Translate were employed to assist in the translation process, while QuillBot and Grammarly were used
1 for grammar and style correction. All AI-generated material was thoroughly reviewed and edited to ensure accuracy, completeness, and compliance with ethical and scholarly standards. The authors accept full responsibility for the final content of the manuscript.

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