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# Feasibility of a Project-Based Electronic Module on Environmental Change to Promote Environmental Awareness and Support SDG 13

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**ABSTRACT**

***Objective:*** *To evaluate the feasibility of the Project-Based Learning (PjBL) Environmental Change Electronic Module, known as E-Ling, as an interactive digital teaching material designed to support environmental change learning and improve students' environmental awareness improve students' environmental awareness and support SDG 13 (Climate Action).* ***Method:*** *Using a development approach with the ADDIE model, limited to the development stage. The feasibility of the E-Ling module was assessed through expert validation involving 12 experts in material, language, learning, and media. The instrument used was a validation questionnaire, and the data were analyzed using percentage-based feasibility criteria.* ***Results:*** *The expert validation results showed that the developed PjBL-based E-Ling module obtained positive feasibility scores, namely 92.33% from material experts, 80% from language experts, 84.71% from learning experts, and 86.33% from media experts. These results indicate that the module is categorized as good and requires no major revision.* ***Novelty:*** *The development of a PjBL-based electronic module that integrates environmental change materials, learning videos, interactive access through website or application platforms, and project activities to encourage students to learn independently and develop environmental awareness.*

## INTRODUCTION

Climate change is worsening and has a significant impact on our lives. The weather has become very unstable, sometimes extremely hot, sometimes very cold, and natural disasters such as floods and storms occur frequently. In fact, according to the report by Rabecca & Lauann (2024), the year 2023 was recorded as the hottest year in history. The IPCC (2021) also reported that the global average temperature increased by 1.4 degrees Celsius, both on land and in the oceans. Fatawa et al. (2023) also stated that climate change is causing more extreme weather, with storms and floods occurring more frequently. In addition, rainfall patterns have become irregular, and the dry season is getting longer.

The urgency of climate change mitigation is closely aligned with Sustainable Development Goal (SDG) 13: Climate Action, which emphasizes the importance of strengthening awareness, education, and institutional capacity to address climate-related challenges. Education plays a strategic role in supporting SDG 13 by equipping students with environmental knowledge, awareness, and responsible behaviors. Therefore, innovative learning resources are needed to foster environmental literacy and encourage active participation in environmental protection among students.

One of the main causes of climate change is the increase in greenhouse gases in the atmosphere. One source of methane gas is produced from the decomposition of waste. The more waste that is disposed of, the more methane gas is generated. This methane gas is far more dangerous than carbon dioxide in causing global warming. In addition to waste, other human activities such as the burning of fossil fuels and deforestation also exacerbate this condition. If we do not take immediate action to reduce greenhouse gas emissions, the Earth's

temperature will continue to rise, and the impacts of climate change will become increasingly severe.

Environmental damage caused by waste, including plastic, is influenced by the low environmental awareness among people. This awareness indirectly affects the intention to act through an understanding of environmental issues (Susilowati et al., 2020). Putri et al. (2022) state that environmental awareness has a significant direct impact on the intention to act, and this intention will ultimately influence individual behavior. Everyone responds to environmental issues differently, where these behavioral differences emerge when individuals face environmental problems, which are influenced by the information they receive and then translate into action.

Reducing environmental damage caused by waste can be achieved through the enactment of waste-related laws, the development of economically viable waste management technologies, as well as through education or outreach. Education plays a vital role in shaping students' environmentally conscious character. According to Caymaz (2020), the best way to raise awareness is by educating students from kindergarten to university at all levels of education, determining their thinking, knowledge level, and alternative concepts about global warming, and preparing an appropriate learning environment.

According to Aqil's (2023) observations, the level of environmental awareness among high school students is relatively low, reaching only 23.46%. Aqil's (2022) research indicates that 51% of students at Public Senior High School 5 Depok have never used electronic modules (e-modules) in the learning process, while 88.9% of students are interested in trying to learn using application-based e-modules. These findings suggest the need for the development of teaching materials in the form of e-modules on environmental change topics.

One way to improve the quality of education is by enhancing the quality of teaching. Teaching quality can be improved by optimizing the use of learning resources, one of which is teaching materials. Teaching materials consist of knowledge, skills, and attitudes components that students must master to achieve the established learning objectives and basic competencies. One type of teaching material used is the module. Currently, the teaching materials used in schools are modules issued by the ministry of education. These modules are used in biology lessons at the high school level, but they are still in conventional module form. However, under current conditions, especially if learning is conducted online, it is recommended to use e-modules.

The results of our survey, conducted by directly interviewing biology teachers and through Google Forms, indicate that the current textbooks are sufficient for classroom teaching and learning. However, teachers have not widely utilized application or website-based e-modules in their teaching. In fact, by using applications, students can learn anytime and anywhere through their devices, and reduce paper usage. Given the educational goals we aim to achieve, we need to explore more effective learning models. One interesting model is project-based learning (PjBL). According to MacDonell (2007), learning objectives are more easily achieved when students are engaged in projects. Based on the survey results and our understanding of PjBL, we plan to create a project-based e-module to enhance students' environmental awareness. This e-module will be equipped with instructional videos to support students' learning process.

## RESEARCH METHOD

This study used the ADDIE development model to create a project-based e-module (PjBL). The ADDIE model was chosen because of its clear and systematic steps. Each stage in this model allows us to refine the results before moving on to the next stage, ensuring that the resulting e-module is of high quality and reliable.

The process of creating this e-module involves five main stages: needs analysis, planning, development, implementation, and evaluation. However, in this study, we only reached the development stage. To ensure the quality of the e-module, we involved 12 experts from various fields, such as media, language, subject matter, and learning. The research was conducted on 270 class X students in October 2023 – March 2024 at Public Senior High School 5 Kota Depok.

The validation data from experts was analyzed using the following formula:

$$P = \frac{\Sigma X}{\Sigma X_i} \text{ x } 100\% \quad (1)$$

Description:
P = Percentage of eligibility
X = Validator score answer (real value) Xi = Highest answer (expected value)
The results obtained are then categorized based on table below:

**Table 1.** Eligibility level qualification

| Qualification Achievement | Level | Description |
|---|---|---|
| 80-100 % | Good | No Revision Required |
| 60-79% | Cukup Baik | No Revision Required |
| 40-59 % | Not Good | Revised |
| 0-39 % | Not Good | Revised |

## RESULTS AND DISCUSSION

The results of this study will be detailed in stages, starting from needs analysis by examining the reasons for development, defining learning objectives, and confirming potential users.

### *Needs analysis*

The analysis is conducted to identify aspects related to the need for development, beginning with examining gaps, defining learning objectives, confirming potential users, identifying resources, determining the delivery system, and compiling the project plan.

1. Examining the need for development

   This analysis is necessary to understand the gaps and the type of products that students and teachers need in learning, as well as to identify any existing gaps in the field. The learning conducted at high schools in Depok City refers to the 2013 curriculum and the Merdeka curriculum. Environmental change materials are part of the curriculum studied in Grade X, where the current learning approach still uses conventional methods and requires learning resources from other media that can be studied independently. Students enjoy learning with media, with 98.9% indicating this preference, 97.8% of students need self-paced learning, and 88.9% of students want to use modules or teaching materials with applications or websites.

The information obtained from the survey instrument related to environmental awareness at Public Senior High School 5 Depok indicates that students' environmental sensitivity is still low, at 23.46%. This is due to students only learning conventionally using the provided textbooks, and 51.1% of students have never used electronic modules that contain more engaging content for creating products related to environmental change learning. Therefore, efforts are needed to design project-based learning.

2. Defining learning objectives

The learning objectives are determined based on the core competencies and basic competencies that students in Grade X at Public Senior High School 5 Depok need to master according to the 2013 curriculum. Core competencies and competency standards are used as references in developing the material products. The learning objectives are crafted as specifically as possible using operational verbs.

The learning objectives are formulated based on the previous analysis. The learning objectives are as follows:

a. Students master the concepts of environmental change material.
b. Students produce learning outcomes in the form of a product.
c. Students develop environmental sensitivity.

These learning objectives are integrated into a single electronic module that is easily accessible both independently and through face-to-face interactions, available on a website or as an Android application. The electronic module includes environmental change material presented in video format, project-based learning steps that will result in products from the learning activities. It is hoped that this learning approach will enhance environmental sensitivity. The objectives of environmental change learning are as follows:

a. Students master the concepts of environmental change material.
b. Students produce learning outcomes in the form of a product.
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These learning objectives are integrated into a single electronic module that is easily accessible both independently and through face-to-face interactions, available on a website or as an Android application. The electronic module includes environmental change material presented in video format, project-based learning steps that will result in products from the learning activities. It is hoped that this learning approach will enhance environmental sensitivity. The objectives of environmental change learning are as follows:

a. Explain the concept of environmental change.
b. Describe the various causes of environmental damage.
c. Explain the factors causing environmental change.
d. Discuss the impacts of environmental change.
e. Analyze the factors causing environmental change.
f. Prepare a report or written proposal on solving environmental change issues.

This stage determines what students need in learning to achieve the learning objectives. The definition of learning objectives refers to the current curriculum or practical experience with students' learning difficulties in the classroom. The objectives are identified through the analysis of the syllabus and lesson plans for environmental change material in Biology at Public Senior High School 5 Depok City.

3. Confirming potential users

In this stage, potential users of the media are evaluated based on their learning experiences, learning abilities, and learning motivation. The identified data includes group identification, general characteristics, number of students, and student locations.

Identifying student characteristics aims to analyze the attributes of students, focusing on their actual capabilities. These characteristics are influenced by two factors: internal and external factors derived from the students' current conditions. This identification helps the author design a learning program to determine the ideal design to be used.

***Design***

The next stage after analysis is to design the media product, which involves several steps: aligning core competencies, basic competencies, and learning objectives with the previous analysis stage, creating a flowchart, drafting the product, developing the product, and determining the testing strategy.

1. Determining core competencies, basic competencies, and learning objectives
   After identifying the learning objectives, the required teaching materials for students will be determined. This analysis covers students' abilities in knowledge (cognitive), attitudes (attitudes), and skills (psychomotor) that they should acquire after undergoing the learning process.

   In this section, several instructional objectives related to knowledge, attitudes, and skills needed by students to achieve the desired competencies in environmental change learning will be obtained. Environmental change learning, integrated into a project-based electronic module in the form of a website and application accessible to students, is designed to achieve the expected output according to the learning objectives. Assessment is conducted with three aspects: knowledge of environmental change, attitudes (environmental sensitivity), and skills (product of environmental change learning). The learning indicators used to develop the media should refer to the 2013 Curriculum, syllabus, and lesson plans, in accordance with the materials determined in the previous needs analysis stage.
2. Creating a flowchart
   The development of this electronic module is based on the material from the BSE book published by the Ministry of Education and Culture of the Republic of Indonesia, aligned with the 2018 revised KI and KD. This includes the addition of instructional videos, themes, assignments, and evaluations.
3. Drafting the product
   The initial draft of the project-based e-module (PjBL) will be created in Word format, developed from the previously created flowchart. This draft will serve as a reference for designing the subsequent e-module draft.
4. Designing the PjBL e-module draft
   The initial draft will be developed into an interactive multimedia draft using a website/application. This is the preliminary step in designing the environmental change e-module based on PjBL.
5. Developing a testing strategy
   The assessment strategy for the e-module will include cognitive aspects evaluated through evaluation questions and affective questions using instruments both before and after the project work. The psychomotor domain will be assessed based on the project, project report sheets, and presentations conducted.

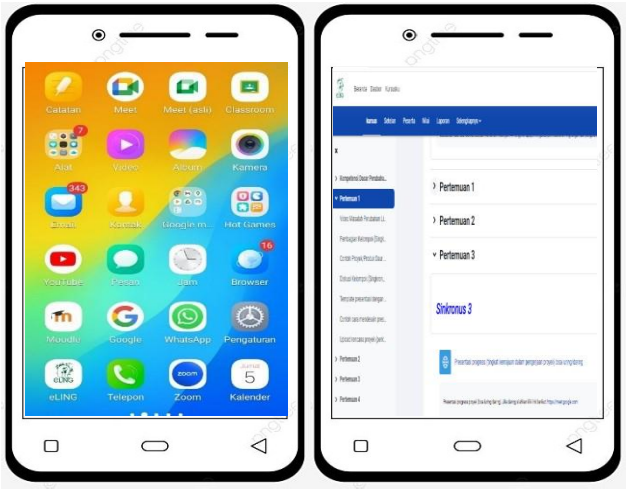


**Figure 1.** Video and desain project E-Ling

***Development***

The content is designed following the principles of the electronic environmental change module (E-Ling) based on Project-Based Learning (PjBL) to promote environmental awareness. It integrates a mix of text, images, and videos presented in a storyboard format to effectively facilitate PjBL and achieve the intended objectives. The PjBL-based E-Ling concept is structured according to the PjBL framework, which encompasses the stages of planning, implementation, reporting, and evaluation at both individual and group levels. The product development process includes the planning and design of the website/application and the e-module design phase.

By using the Moodle-based website, developers will find it easier to create. In this stage, the designer prepares a layout to be filled with various menus and information by selecting activity templates provided by Moodle, tailored to the learning needs. Moodle, which stands for Modular Object-Oriented Dynamic Learning Environment, is an online platform designed to facilitate an interactive and user-friendly learning experience. It allows for the creation and management of online courses, offering various features to support effective learning. At this stage, data, information, and images (including the E-Ling logo) are entered to be displayed according to the application's requirements in the layout developed during the previous stage.

**Table 2.** Suggestion and correction

| Validator | Suggestions | Corrections |
|---|---|---|
| **Subject Matter Expert** | 1. Align the video material with the learning content.<br>2. Explore the material based on current issues to improve its relevance.<br>3. Design the module to motivate and inspire students.<br>4. Add empirical studies by conducting field research, presenting the results through PPT or video, and providing recommendations based on the | 1. The video was developed based on environmental change learning material.<br>2. The instructional video addresses current issues, especially waste problems.<br>3. The e-module was designed to be engaging and attractive for students.<br>4. The video was adjusted to reflect current issues related to environmental change. |

| Validator | Suggestions | Corrections |
|---|---|---|
| **Linguist** | findings.<br>1. Correct the spelling of "Singkronus" and "Asingkronus" to "Sinkronus" and "Asinkronus."<br>2. Replace "yang mana" with "di mana" to improve sentence clarity.<br>3. Use "bagian" instead of "part" for consistency in Indonesian terms.<br>4. Simplify the chemical substance terminology so it is easier for students to understand.<br>5. Adjust several terms to standard Indonesian diction, such as "link" to "tautan," "upload" to "unggah," and "dibawah" to "di bawah." | 1. The spelling has been corrected to "sinkronus" and "asinkronus."<br>2. The phrase "yang mana" has been changed to "di mana."<br>3. The word "part" has been replaced with "bagian."<br>4. The chemical substance terms have been adjusted according to the learning material.<br>5. The terms have been revised into standard Indonesian diction, including "tautan," "unggah," and "di bawah." |
| **Learning Expert** | 1. Improve the video quality so it can be heard and followed more effectively.<br>2. Present real-world problems in an engaging way to stimulate students' curiosity.<br>3. Strengthen independent, collaborative, communicative, and cooperative learning activities.<br>4. Add more varied instructional videos to support meaningful and contextual learning. | 1. The instructional video has been improved in terms of content and sound quality.<br>2. The video has been adjusted to real-life contexts, particularly waste accumulation issues.<br>3. The learning process has been aligned with the steps of project-based learning.<br>4. The video content has been varied to support independent learning. |
| **Media Expert** | 1. Add animation to the images or logos on the dashboard or initial screen.<br>2. Add a welcome screen to introduce the module.<br>3. Smooth the transitions between video segments.<br>4. Make the thought process in the first video more coherent and aligned with the questions.<br>5. Improve the fourth video so that it better represents the completeness of the ideas. | 1. The module logo was renamed "E-Ling," which stands for Electronic Module on Environmental Change.<br>2. A welcome message has been added to the front page of the module.<br>3. The transitions between video segments have been improved.<br>4. The video sequence has been revised to make it more coherent with the questions.<br>5. The fourth video has been updated with clearer and more complete ideas. |

Table 2 shows the viability of the electronic module product is determined through expert evaluations. The feasibility analysis process involves assessing the accuracy, effectiveness, and appeal of the project-based electronics, which include environmental change videos. The analysis results from the experts are as follows: material experts gave a score of 92.33%, language experts 80%, learning experts 84.71%, and media experts 86.33%, as illustrated in the table below.

**Table 3.** Results of the module feasibility test from experts

| No. | Expert | Eligibility Percentage % | Qualification | Explanation |
|---|---|---|---|---|
| 1 | Language | 92.33 | Positive | No need for revision |
| 2 | Learning | 80.00 | Positive | No need for revision |
| 3 | Material | 84.71 | Positive | No need for revision |
| 4 | Media | 86.33 | Positive | No need for revision |

Based on the analysis of the characteristics of students at Public Senior High School 5 Depok, considering both internal and external factors, it was found that students' interest in learning is one factor that makes them more environmentally conscious. However, there are still students who do not fully understand environmental issues, which is attributed to the lack of discussion and integration of environmental education in the school curriculum. The assignments given by teachers tend to be theoretical and not yet applicable, particularly concerning environmental issues.

The analysis also reveals that environmental awareness among students is still low. For instance, only 33% of students refuse to burn trash due to understanding its impact on air pollution, while 86.7% agree to do so, indicating a low level of awareness about the dangers of burning waste. Only 20% of students take the initiative to reduce waste by creating creative projects, showing a lack of creativity in finding waste management solutions. Additionally, only 33.3% of students separate organic and inorganic waste at home, indicating poor waste management habits. Furthermore, 48.9% of students still purchase food wrapped in plastic, reflecting a low awareness of plastic pollution hazards, and 55.5% of students litter, demonstrating a lack of discipline and concern for environmental cleanliness.

Research by Salino (2014) shows that sensitivity is a unique construct influenced by genetic and environmental factors, as well as individual personality, which affects behavior, including decisions to purchase eco-friendly goods and services. Yoke (2015) found that personality traits and emotional intelligence are significantly correlated, as emotional intelligence relates to awareness, understanding, and regulation of emotions, which are crucial for personality development. Di Paola (2022) states that an individual's level of environmental sensitivity can affect the impact of emotional neglect in childhood on the quality of their relationships in adulthood. Adults who are highly sensitive and experienced emotional neglect in childhood are more easily influenced by positive environmental benefits, leading to better quality relationships compared to less sensitive adults.

The educational programs implemented by the government, such as the biology curriculum in high schools outlined in Permendikbud No. 64 of 2013, aim to guide teachers in helping students achieve comprehensive competencies across spiritual, affective, cognitive, and psychomotor domains. Therefore, project-based learning is needed to address environmental issues through products that may harm the environment.

Project-based learning can be an appropriate alternative among other teaching models in implementing the 2013 Curriculum and the Merdeka Curriculum. This model aims to develop students' thinking skills through collaborative problem-solving. In this context, the teacher plays a role as a guide or leader and also as a learning facilitator. As Sagala (2010:196) mentions, students engage more in self-directed or group activities to solve problems with teacher guidance, making the learning process student-centered. Additionally, Bas (2011:2) states that project-based learning is an authentic teaching model where students plan, implement, and evaluate projects that are not only confined to the classroom but also

oriented toward real-world applications, such as designing products from waste materials that are no longer used and have the potential to pollute the environment.

Project-based learning involves steps that begin with preparing questions or project assignments. This initial step helps students focus on questions arising from existing phenomena. The phenomenon provided during the learning process is the increasing amount of waste, and the focus is on how this waste can be utilized to create products that are useful and even economically valuable. The second step is to design the project plan. To address the questions raised in the first step, the project is structured by linking the previous questions with the project's design, which is aligned with the content and learning objectives to be achieved.

In the third step, students create a schedule as a guideline to complete the project. Developing a project schedule is an important aspect of the project; besides setting completion targets, the project schedule and guidelines help students build discipline, honesty, and adherence to rules. The fourth step involves the teacher monitoring the project work. Monitoring is done throughout the project, where the teacher facilitates and guides students in carrying out the assigned project. This also aids in fostering interaction and collaboration among students and the fifth step is testing the results with presentations by each group, followed by a process of testing or conclusions drawn by students with teacher guidance.

The sixth step involves evaluating the activities. This evaluation serves as a reflection on the activities and results of the project completed by students, carried out individually. At this stage, students are asked to express their feelings and experiences during the project completion process through the electronic module. Holubova (2008:29) describes that students use project stages in the form of tangible evidence and products to demonstrate what they have learned. Students create videos, artworks, reports, photos, music, construction models, digital stories, and websites as examples of project-based learning. Bilgin et al. (2015) in their research found that the experimental group showed satisfaction with the use of the Project-Based Learning method. This study found that the PjBL method can achieve academic goals in environmental change education.

Ballantyne & Packer (2010) conducted research on 580 students aged 8-17 years, showing that outdoor learning is engaging for students and positively impacts their attitudes towards the environment, as evidenced by an increased desire to protect the environment, changes in their behavior in natural areas, and better environmental practices. This research indicates that learning that interacts directly with real conditions can enhance students' awareness and sensitivity towards the environment. Sterm (2013) found that students are involved in selecting, planning, implementing, and evaluating real-world environmental projects and making appropriate action choices. Project-based learning is highly suitable for environmental change material because it allows students to actively engage with the subject matter through real and relevant projects in their lives. PBL supports constructivist, collaborative learning and aligns with contexts that develop problem-solving skills and motivate student learning outcomes. The following is an example of a project-based learning product from Public Senior High School 5 Depok.

According to Lumbantoruan (2024), there is a significant difference of 21.69% between using a module and not using a module. This study indicates that the developed module significantly improves student learning outcomes. Learning through e-modules also increases learning effectiveness and allows students to learn anywhere according to their conditions. Villanueva (2022) found that students have very high engagement in learning

activities at home or with e-modules, with generally satisfactory learning achievements. Based on these findings, the project-based learning model using e-modules in Indonesia should be recommended to train students in critical thinking and positive environmental behavior. Abude (2021) concluded that module-based distance learning has a positive impact on student learning outcomes and offers a flexible and effective educational approach, especially in remote areas. These findings indicate that the use of e-modules can help students learn outside school hours, which in turn will enhance their understanding of environmental changes.

Learning materials, in this study, refer to teaching resources that are easily accessible through students' smartphone applications, namely project-based electronic modules equipped with environmental change material videos that can be accessed via a website or on the Play Store. The feasibility of the project-based electronic module equipped with environmental change material videos was assessed by experts. Feasibility analysis is used to determine the accuracy, effectiveness, and appeal of the project-based electronic module equipped with environmental change material videos. Based on the results from the development stage, the project-based E-Ling product equipped with learning videos, as assessed by experts, is considered positive or good, thus it is recommended for use in high school biology education. The project-based E-Ling equipped with environmental change learning videos has several advantages. This module is easily accessible, its content is highly relevant to everyday life, and it is presented interactively. The discussion column feature allows students to interact and exchange ideas on environmental issues, especially waste problems. It findings indicate that the E-Ling module can contribute to SDG 13 (Climate Action) by strengthening environmental awareness, promoting responsible environmental behavior, and facilitating climate change education among secondary school students.

## CONCLUSION

**Fundamental Finding:** This study found that the Project-Based Learning (PjBL)-based Environmental Change Electronic Module (E-Ling) achieved a high level of feasibility based on expert evaluations, with scores of 92.33% from material experts, 80.00% from language experts, 84.71% from learning experts, and 86.33% from media experts. These findings indicate that the developed E-Ling is suitable for supporting environmental change learning and has the potential to enhance students' environmental awareness through interactive and project-based learning activities. **Implication:** The findings suggest that integrating project-based learning with digital learning materials can provide a more engaging and meaningful learning experience. The E-Ling module can serve as an alternative teaching resource for biology learning, particularly in environmental change topics, by promoting independent learning, critical thinking, and environmental responsibility among students. The developed module contributes to SDG 13 by providing an innovative educational tool that supports climate change awareness and sustainable environmental behavior among students. **Limitation:** This study was limited to the development and expert validation stages of the ADDIE model. The effectiveness of the E-Ling module in improving students' environmental awareness and learning outcomes has not yet been tested through large-scale implementation involving students. **Future Research:** Future studies should proceed to the implementation and evaluation stages of the ADDIE model to examine the effectiveness of the E-Ling module in real classroom settings. Further research may also involve larger and more diverse student populations and investigate its impact on environmental awareness, academic achievement, and sustainable environmental behavior.

## AUTHOR CONTRIBUTIONS

**Deden Ibnu Aqil** contributed to the conceptualization of the study, research design, development of the project-based electronic module (E-Ling), data collection, validation process, data analysis, and manuscript drafting. **Hafid Abbas** contributed to the supervision of the research, conceptual refinement, validation of the study design, and critical review of the manuscript. **I Made Astra** contributed to the methodology development, data interpretation, validation process, and manuscript review and editing. **Sisean Baga** contributed to project administration, resource provision, validation activities, and manuscript review. All authors have read, reviewed, and approved the final version of the manuscript.

## CONFLICT OF INTEREST STATEMENT

The authors state that no financial or personal conflicts of interest exist that may have affected the content or findings of this research.

## STATEMENT ON THE USE OF AI OR DIGITAL TOOLS IN WRITING

The authors acknowledge the use of digital tools, including artificial intelligence (AI)-based technologies, during the preparation of this manuscript. Specifically, ChatGPT (OpenAI) was used to assist with language refinement, grammar checking, sentence restructuring, and improving the clarity of academic writing. All AI-generated outputs were carefully reviewed, verified, and revised by the authors to ensure accuracy, originality, and compliance with academic and ethical standards. The authors take full responsibility for the content of this manuscript.

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