Innovation of ESD Learning Module (Education for Sustainable Development) Based on Bugis Local Wisdom for Critical Thinking Skills and Environmental Literacy

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ABSTRACT Teaching modules play an important role in achieving learning goals, and their design must be adapted to student characteristics. This research aims to develop a teaching module design that integrates climate change material with Education for Sustainable Development (ESD) and the local wisdom of the Bugis community, as reflected in the Kutika text. The learning model chosen is Problem-Based Learning (PBL), which is very suitable for facilitating students' problem analysis and critical thinking skills, which are the main competencies in ESD. By incorporating local wisdom, we aim to increase students' environmental literacy and promote a deeper understanding of the values of sustainability. This research uses a qualitative descriptive analysis research method, which allows for an in-depth exploration of the design and implementation of teaching modules. The results show that the PBL local wisdom-based teaching module was successfully developed in three meetings by combining the local wisdom of the Bugis tribe and sustainability values, which align with the four pillars of ESD in Indonesia.

Keywords: Education for sustainable development, Climate change education

1. INTRODUCTION

Global challenges of the 21st century: Education must harmonize with environmental, social, and economic conditions and needs (Marouli, 2021; OECD, 2018; WEF, 2023). The Merdeka Curriculum is a curriculum with diverse extracurricular learning, where the content is optimized so that students have sufficient time to understand a concept. The Independent Learning Curriculum allows students to learn according to their potential and characteristics. One strategy that can facilitate this is through local wisdom to support sustainable development.

Independent learning and sustainable development have the same direction and goals as local wisdom (Hasibuan, 2022; Lidi et al., 2022). Sustainable Development Goals (SDGs) are agreed sustainable development agreements and goals that all countries want to achieve before 2030. These goals are based on human rights and equality with universal, integrated, and inclusive principles. The 17 SDGs goals were developed to create a more sustainable future and ensure that no one in the world is left behind (Trilling & Fadel, 2009; Martín-Sánchez et al.,

2022). One of the 17 SDGs goals is to go beyond education for sustainable development (ESD). Education for sustainable development (ESD) is a lifelong learning process that aims to inform and involve society in being creative, having problem-solving, scientific, and social literacy skills, and being committed to personal and group responsibility. These actions will ensure an economically prosperous environment (Atima, 2015).

Education for Sustainable Development (ESD), as an effort to realize the Sustainable Development Goals (SDGs) agenda, is an alternative approach in the field of education in preparing a generation to have a sustainable lifestyle. School is a place where young people learn about sustainable living. Therefore, it is vital to implement sustainable education in schools to change mindsets about utilizing energy sources for later life (Anindhita et al., 2016). ESD is essential, considering that awareness of the importance of environmentally friendly activities and empowerment can only grow slowly, even through one or

two outreach sessions or training. This explanation emphasizes that ESD's goal is to develop skills and values so that humans can contribute to preserving the environment so that it can be used for humans in the future. Humans must understand that behavioral patterns toward the environment will have an influence, so behavioral patterns must be based on ecological, social, and cultural values.

Teaching materials have a very important role in achieving learning goals; teaching materials are prepared to suit the characteristics of students. Local wisdom contains noble values that can develop knowledge to shape students' characteristics (Zulkhi et al., 2022), and ESD contains sustainability values to train students' sustainable lifestyle patterns. Therefore, teaching materials that contain local wisdom and sustainable development values related to the environment around students are needed (Wardianti & Jayati, 2018). One effort can be made to combine local wisdom and sustainable development values by designing, creating, and developing teaching materials (modules) based on local wisdom values (Ferdianto & Setiyani, 2018). Teaching materials or modules based on local wisdom and sustainable development can improve high-level thinking skills and learning outcomes, train character, and be effectively used in the learning process. This aligns with research (Putro et al., 2018), which states that developing teaching materials adapted to students' environmental needs can improve high-level thinking abilities. The need and application of teaching materials depend on the learning plan prepared. The learning plan is arranged in teaching modules. Several studies show that local wisdom-based modules can improve student learning outcomes, train student character, and be effective in biology learning (Wati et al., 2019; Wati et al., 2020; Wati et al., 2021). This is supported by the critical thinking skills of Indonesian students, which are still relatively low. Based on data from the Program for International Student Assessment (PISA) in 2012, it was stated that Indonesia's literacy score was ranked 64th out of 65 countries with a score of 382. PISA stated that students in Indonesia could only reach level 1 and level 2 from 6 countries. Levels 1 and 2 are located at the level of knowledge and understanding only, while higher-level thinking abilities are at level 4 or at the analytical level, which can then be continued at levels 5 (evaluation) and 6 (creative). The 2018 PISA results were also very low, with a score of 371 and ranked 74th out of 80 countries. PISA concludes that students' thinking abilities in Indonesia are very low.

Integrating local wisdom and sustainability values into learning is necessary because it has many biological concepts. Integrating local wisdom in the learning process, especially biology, is rarely done (Safitri et al., 2018; Widiya et al., 2021). Biology learning is linked to the local wisdom of the environment and will add to the learning atmosphere and make learning meaningful. Local wisdom is related to

environmental conditions and developing community understanding practices. Integrating local wisdom in learning means prioritizing community involvement by preserving traditions that develop with active collaboration from students (Lestari et al., 2024). Teaching modules based on local wisdom will allow students to explore their knowledge further (Hafizah et al., 2021). Learning that integrates cultural elements has a significant impact on student learning processes. First, harmony between teaching materials at school and students' daily cultural knowledge can produce positive effects through learning enculturation mechanisms. Second, student-centered learning shows higher effectiveness because assimilation and accommodation of knowledge occur more optimally. This allows students to overcome learning problems more effectively through integrating academic knowledge with everyday experiences (Suprapto et al., 2021). This approach supports the development of critical and creative thinking skills and the application of knowledge in various life contexts.

Based on existing problem findings, researchers aim to develop ESD-based teaching modules integrated with local wisdom to improve critical thinking skills and environmental literacy. This research aims to develop a teaching module or learning plan (RPP) on environmental change material. The teaching module developed is ESD-based (*Education for Sustainable Development*) and integrated with the local wisdom of the Kutika script of the Bugis community. The research questions asked are as follows.

1. How are SDG points integrated into the design of ESD-Local Wisdom-based teaching modules on environmental change material?
2. What skills does the ESD-Local Wisdom-based teaching module design provide on environmental change material?
3. How do we design ESD-Local Wisdom-based teaching modules based on environmental change material?

2. METHOD

This research is qualitative research with descriptive analysis methods. This descriptive qualitative research is based on the approach described by Creswell (2007; 2015) which emphasizes the importance of exploring contextual and in-depth understanding of the phenomenon being studied. Additionally, ESD (Education for Sustainable Development) The approach to developing teaching modules is based on the framework proposed by UNESCO (2014), which emphasizes the importance of integrating sustainability values and local wisdom in education for sustainable development. This research also refers to the approach proposed by Saldana (2016) in qualitative data analysis, which emphasizes the importance of exploring meaning and interpretation in an in-depth context.

3. RESULT AND DISCUSSION

Based on the presentation of the research question formulation presented, this section will explain several things as follows: 1) Integration of ESD with local wisdom in the teaching module, 2) Skills provided in the designed module, 3) ESD-Local Design of the wisdom teaching module in environmental change material. The following is an explanation of these points:

3.1 Integration of ESD with local wisdom in the teaching module

SDG 13, "Action on climate change," aims to take action to reduce and mitigate climate change (OWD, 2023). Climate change is an environmental problem that can affect aspects of human life. An increase in greenhouse gases, human activities, and natural disasters causes the climate change phenomenon. The significant impacts of climate change are increasing global temperatures, extreme weather, rising sea levels, and ecosystem damage. SDG point 13 highlights the need for collaborative action and active participation both locally and globally. This can be innovated starting from the education level.

The integration of SDG 13 in sustainable development education is important because education has a key role in preparing future generations to face and respond to the challenges of climate change. Sustainable development involves in-depth environmental awareness education, including information about natural resources, environmental degradation, and sustainable practices. This can help students understand the relationship between human behavior and climate change and adopt an environmentally friendly lifestyle. In its implementation, sustainable development education carries out four main pillars, which serve as a reference in developing educational activities. These pillars are important indicators of achieving sustainable development education. The four

pillars are social, environmental, economic, and legal (Table 1).

This research focuses on applying sustainable development education activities in independent curriculum-based extracurricular activities, especially on environmental change material. The following are the pillars of the ESD aspect of environmental change material.

Based on these four aspects, it is hoped that it can equip students with knowledge and understanding of environmental change, especially sustainable climate change. SDG points are integrated into local wisdom to maximize this. The local wisdom chosen is the local wisdom of the Bugis community, which is written in Kutika script. In the social pillar, students are not only involved in various campaigns and outreach to increase awareness about climate change in society, but they are also active in building sustainable social networks to strengthen support for environmental protection efforts. Through various humanitarian activities, such as assistance for victims of disasters related to climate change, students learn about empathy and social responsibility towards affected communities. They become agents of change in their environment and role models for others.

In the environmental field, students carry out practical activities such as tree planting, environmental cleaning, and waste management to deepen their understanding of the complex interactions between humans and the environment. By monitoring air and water quality around schools and communities, students practice scientific methods to understand their communities' environmental challenges. They also study important concepts such as material cycles, biodiversity, and ecology, which affect the balance of nature.

Table 1 ESD pillar regarding environmental change materials

ESD Pillar	Student Action	Results
Social	Students engage in climate change awareness campaigns, community outreach regarding environmentally friendly practices, and participation in humanitarian activities to help victims of climate change-related disasters.	Students understand environmentally friendly practices and campaign for them to the general public.
Environment	Students are involved in tree planting, environmental cleanup, and waste management activities. They also monitor the air and water quality around their schools and communities.	Students know about waste management, making recycled products, efforts to reduce carbon footprints, and good management of natural resources. Students contribute to waste management activities as an environmental mitigation effort.
Economy	Students are involved in projects based on the green economy, such as developing environmentally friendly technologies or promoting recycled products. They can also support economically sustainable local businesses.	Students know the impact of environmental changes on the production of important commodities in the agricultural sector. Students provide ideas for solutions to overcome the impact of climate change on the agricultural sector and the economy. Students Develop Recycled Product Entrepreneurship.
Law	Students are involved in legal education regarding environmental issues and climate change and support efforts to monitor violations of environmental laws.	Students have an awareness of the role of law in protecting the environment

In the economic pillar, students are involved in green economy-based projects and develop entrepreneurial skills that enable them to become agents of change in the business world. Through developing environmentally friendly technologies or promoting recycled products, students learn about sustainable economics principles and the importance of innovation and creativity in facing increasingly complex environmental challenges.

In the legal pillar, students are not only involved in legal education regarding environmental issues and climate change, but they are also active in advocating for environmental protection through participation in advocacy movements and monitoring violations of laws related to the environment. In this way, they not only become citizens who are aware of the law but also become active agents of change in pushing for changes in policies that are more environmentally friendly. Through this involvement, students understand the important role of law in protecting the environment and learn to use the legal system to achieve broader environmental goals.

The Bugis people have a unique agricultural system that is still preserved today. The Bugis people run their agricultural system based on guidance from the *Beating* script. *Beating* is a manuscript that contains the tradition of counting days in the Bugis community. In general, Kutika is defined as a collection of records of the good and bad times that must be carried out. *Beating* Manuscripts is a modern invention of the Bugis people, who can recognize the phenomenology of plants and animals. This manuscript collects various calculation methods and has many characters written using four characters in four languages: Bugis, Malay, Arabic, and Banjar (Thahir, 2021).

Cuticle is preserved today because it was passed down monarchically to each traditional head. The Bugis believe that their agricultural success depends on the techniques taught by their ancestors through this text. It was through this manuscript that the Bugis people started their agricultural system. Before starting the agricultural stage, the Bugis community will hold a deliberation. The deliberation is intended to consider the right time to start farming. The agriculture in question focuses on rice farming as the primary food ingredient for the Bugis people. In the Kutika manuscript, there is some knowledge about indicators of environmental change based on animal and plant phenomenology as shown in Table 2.

The environmental change indicators in Table 2 are climate change studies in Table 2, *Ticking* script. Students can understand the causes and impacts of real environmental change through these indicators. Students will be given a more concrete and measurable picture of how environmental changes influence everyday life through the indicators listed in the table. The indicators can cover various aspects, such as changes in air temperature, sea level rise, extreme weather intensity, rainfall patterns, and ecosystem degradation. By understanding these indicators, students can recognize and interpret signs of change in their environment. They will learn how climate change is not just an abstract issue but has a real and tangible impact on their daily lives. Apart from that, through understanding the indicators of environmental change, students will also be able to identify the causes, including human activities that contribute to global climate change. Table 3 shows the forms of integration of local wisdom in learning activities.

Based on the data in Table 3, we can learn from local knowledge that links natural phenomena with science. This knowledge helps us understand environmental changes, such as decreased crop yields, which can indicate environmental damage. Science helps us understand the causes and impacts of environmental change, including climate change caused by natural factors and human activities, which can result in environmental pollution and ecosystem changes. Species migration can also be a clue to environmental change. In the context of learning, we can learn about environmental changes, pollution, ecosystems, and animal behavior and realize the importance of our role in preserving them. This can encourage our awareness of the environment and inspire steps to preserve it.

3.2 Skills provided in the designed module

Teaching modules are designed with the main aim of maximizing student learning outcomes. We can maximize these learning outcomes by providing specific skills. The skills provided in the designed teaching module are critical thinking skills and environmental literacy. These skills were selected with consideration of aligning key competencies

Table 2 Climate change indicators based on the Kutika Manuscript

Phenomenology	Environmental Change Indicators
Banana heart petals fall and face upwards, bamboo shoots grow more prominent than their parents, and mango plants bear fruit twice a year.	many rainy days in 1 year
Guava fruit grows in forests and not in forests.	rice will be harvested safely without
Pest infestation	pest risk
Rat holes are often found in the middle to the top of the embankment	heavy rain and potential flooding due to the large number of rainy days
Rat holes were found in the middle of the rice fields	there will be a long dry season
Red ants leave their nest and move to higher ground. Fish are often found in lakes, rivers, or seashores.	There will be heavy rain and flooding

(Limpo et al, 2022)

Table 3 Integration of local wisdom in learning activities

Local wisdom (Source: Kutika Manuscript)	Scientific Science	Learning Topic (Source: Independent Curriculum, 2022)
Natural phenomena can be used as indicators of climate change	Environmental changes can influence climate change. Environmental changes can occur due to natural or artificial factors such as human activities (NASA, 2024).	Environmental Change (Phase E, Ecosystem Chapter)
The phenomenon of reduced crop yields occurs due to environmental damage	Environmental pollution can cause environmental changes and affect the ecological cycles (Chia Bai et al., 2018).	Pollution (Phase E, Ecosystem Chapter; Phase D, Environmental Pollution chapter)
The behavior of animals moving around indicates a change in the environment. Changes can take the form of a decrease in environmental quality or an increase in natural factors, such as the availability of water and food	The migration of certain species is an indicator of environmental change (Rohr & Cohen, 2020).	Interactions between ecosystem components (Phase E, Ecosystem Chapter)

with SDG goals. The following is a further explanation regarding the main competencies provided.

Main Competency 1: Critical Thinking Skills

Critical thinking skills are one of the supporting factors for successful learning. John Dewey defines critical thinking as an active, continuous, and comprehensive consideration of a belief or form of knowledge that is taken for granted by including supporting reasons and rational conclusions (Wayudi et al., 2020). (Fitriyah & Ramadani, 2021) explains that critical thinking skills are a thinking process that allows someone to evaluate or investigate the evidence, assumptions, and logic underlying other people's ideas. Critical thinking skills are important in the learning process because these skills provide students with the opportunity to learn through discovery.

Based on the definition above, critical thinking identifies several assumptions that combine previous knowledge to obtain relevant knowledge to generalize mathematical situations reflectively. It includes problem-solving, formulating conclusions, calculating possibilities, and making decisions. decision (Kusumawati et al., 2022). According to Norris and Ennis, this research used indicators of critical thinking skills (Norris & Ennis, 1989). According to the Norris-Ennis *Framework* (Norris & Ennis, 1989), there are 12 indicators of critical skills, which are grouped into five aspects of critical thinking skills as shown in Table 4.

Critical thinking is one of the abilities that can be developed through the problem-solving learning process. Critical thinking skills can be improved through PBL because the learning approach is on authentic problems, and students are not only asked to understand a problem but must also be able to work together to solve the problem and stimulate students' abilities and skills, especially critical ones—thinking skills (Masrinah et al., 2019). According to

Table 4 Thinking skills according to Norris Ennis

Critical thinking skills	Critical Thinking Sub-Skills
Basic Clarification	Focusing Questions
	Analyze the Argument
	Ask And Answer Clarifying Questions
	Challenging Questions
Basic Support	Considering Credibility (Source Criteria)
	Observe and Consider Observation Results
Conclusion	Make Subtractions and Consider the Results
	Induction
	Making Inductions and Considering Inductions
	Making And Considering Value Decisions
Further clarification	Define Terms
	Considering Definitions Identifying Assumptions
Strategy And Tactics	Deciding on a Course of Action Interacting with Others

(Norris & Ennis, 1989)

Costillas (Wayudi et al., 2020), educating students to have critical thinking skills is challenging for teachers. This is due to the many students who are weak in critical thinking. In line with the statement (Kusumawati et al., 2022), sometimes students have difficulty developing critical thinking skills because when students solve mathematical problems without being linked to critical thinking, students are less creative in choosing the right strategy and less thorough in solving problems (Kusumawati et al., 2022). In addition, critical thinking skills are developed in learning

and must be supported by assessment instruments that reflect critical thinking skills (Susilawati et al., 2020).

Main Competency 2: Environmental Literacy

Environmental literacy equips students to understand key concepts of natural phenomena and apply their knowledge. The existence of environmental literacy makes learning more manageable, significantly when solving environmental problems with unlimited resources through technology. Environmental literacy is a goal and indicator of environmental education. The essence of environmental literacy is the ability to handle, minimize, and solve environmental problems. Individuals who demonstrate a good level of environmental literacy will be willing to act to improve the welfare of other individuals, communities, and the global environment and can participate as part of life. Environment-based learning effectively improves students' attitudes and knowledge (Sırakaya et al., 2020).

Measuring environmental literacy can be used as an input for starting an environmental education program and an output from environmental education (Szczytko et al., 2019). EL-PBL integrated learning also trains students to work together to solve problems and involves students in problem-based learning to help increase knowledge and strengthen important concepts in ecological knowledge and environmental thinking skills. Environmental literacy can be studied through four aspects: environmental knowledge, cognitive skills, environmental attitudes, and habits.

Environmental literacy assessment indicators can be mapped. Ecological knowledge involves students' understanding of the relationships between living organisms and their physical environments, including energy flows and material cycles. Understanding the environment includes knowledge and awareness of environmental problems like pollution, climate change, and biodiversity loss. Furthermore, cognitive skills are the mental processes involved in acquiring and applying knowledge, such as problem-solving, critical thinking, and decision-making. This skill involves identifying environmental problems and developing solutions to address them. Environmental impact refers to people's emotions, values, and attitudes toward the environment. Meanwhile, behavior involves people's actions and choices that impact the environment, where this attitude is expected to be a sustainable attitude towards the environment, including a positive attitude towards the environment and taking action to encourage environmental preservation.

3.3 Design of ESD-Local Wisdom-based teaching modules on environmental change material.

The design of teaching modules is carried out by analyzing local wisdom learning material and then integrating it into the learning scheme. The material chosen is environmental change material, which contains the concept of understanding climate change. The learning
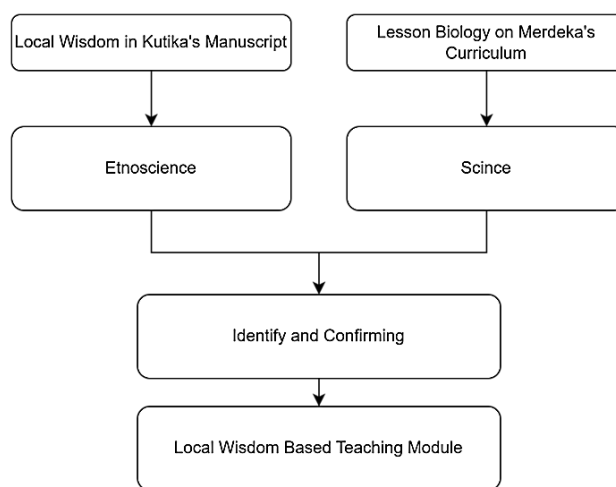

Figure 1 Integration of local wisdom

model chosen is the problem-based learning model (PBL). Figure 1 shows a more detailed explanation of the teaching module design.

Wisdom The local community has a crucial role as a valuable learning source in the educational context. According to (Parhan et al., 2023), integration of local wisdom in education can be done in four forms. First, using local wisdom as learning material; second, applying local wisdom as a learning medium for character education; third, making local wisdom the basis for implementing character education through guidelines, curriculum, or curricular activities; fourth, integrating local wisdom values as the final goal in learning, which is reflected in students' activities or habits. The implication requires teachers to have strong abilities to strengthen students' understanding of the concepts being studied (Jumriani et al., 2021). However, to achieve this, innovation is needed that is integrated into all stages of learning, from planning and implementation to evaluation or assessment. Teaching modules based on local knowledge are a relevant solution to overcoming this challenge. These modules enrich students' learning experience by combining traditional aspects with modern concepts utilizing local wisdom as a foundation. This approach not only increases the connection between the academic curriculum and local realities but also increases the relevance and interest of students in the learning process. In developing local wisdom-based modules, innovation is the key to ensuring that students understand the material in depth, develop critical thinking, and respect the values of their culture and environment.

Environmental Change Topic

Environmental change is one of the topics of Biology study. The independent curriculum gives this material at stage E, specifically class X high school. The coverage of environmental change material consists of three important sub-chapters: 1) factors that influence climate change, 2) review of the text on indicators of environmental change,

and 3) problems of environmental change ranging from pollution to global warming. Table 5 shows a further review of the learning outcomes of environmental change material in the independent curriculum.

Based on Table 5, the coverage of environmental change material consists of 1) descriptions of environmental changes, 2) factors causing environmental changes, and 3) environmental pollution and changes. The coverage material is integrated with local wisdom*, and the* manuscript is used as a *prototype* to analyze the impact of environmental change.

Learning plan using a problem-based learning model combined with local wisdom.

The learning model was implemented during three meetings: two in class and one outside class. Syntax in *PB Wisdom Local* According to Lubis et al. (2022), the learning model consists of nine stages: orientation, collaboration, exploration, definition, investigation, presentation of findings, and evaluation.

The problem-based learning syntax becomes broader in the eight foremost syntaxes. This differs from the PBL syntax offered (Widodo, 2021), comprising six learning syntaxes. One of the things that characterizes the difference between the PBL model and the PBL-Local Wisdom model is the syntax of its meaning. At this stage, students will make the meaning of local wisdom studied into scientific understanding in studying an environmental problem. The problems solved through PBL are authentic problems found in everyday life (Tan, 2003; Tan, 2007). Problem-based learning is a learning approach that places students at the center of the learning process by giving them real-world challenges or problems to solve. PBL emphasizes active, collaborative learning and the application of knowledge in the context of real-life situations. Problem-based learning can increase motivation, which impacts improving problem-solving skills (Argaw et al., 2016; Fitriyah & Ramadani, 2021). In this research, the learning experience identifies problems in the surrounding environment through a scientific approach. Apart from increasing environmental knowledge and literacy, this activity also trains sensitivity and will ultimately trigger students' actions to save the environment (Suryawati et al., 2020). Apart from that, PBL can improve student learning achievement. This aligns with research (Uluçinar, 2023), which reveals that PBL applied to science learning can improve student learning outcomes. The design of the teaching module can be seen in Table 6.

Table 5 Learning results on environmental change material

Learning outcomes	Learning objectives	Flow of Learning Objectives
In the final phase of phase E, Students can create solutions to problems based on local, national, international, or global issues related to understanding environmental change.	Planning investigates the causes and impacts of environmental changes and campaigns to find solutions.	Analyzing local wisdom through beating script on climate change indicators and their mitigation.

Table 6 Teaching module design

PBL Syntax	Learning Activities			Place
	Meeting 1	Meeting 2	Meeting 3	
Orientation	The teacher introduces the concept of environmental changes and their causes	Introducing local wisdom Beating script as a prototype for climate change analysis	Conduct a study of climate change problems based on actual daily actions such as: Use of motorized vehicles Use management of waste products that are not environmentally friendly	In the classroom
Collaboration	Students form groups to discuss the factors that cause climate change	Student formed an exploration group to study climate change indicators based on Beating's manuscript	Students form groups to learn active solutions related to the problems offered	In the classroom
Exploration	Students conduct a literature review regarding the factors that cause climate change	Students explore Beating manuscripts based on literature	Students deepen the study of literature related to the problem being offered	In the classroom
Make meaning	Students make meaning of these factors that cause climate change	Students create meaning based on Beating's manuscript and examine its relationship with climate change indicators scientifically	Students give meaning to the problem of climate change: Increased carbon footprint Accumulation from trash Use of products that are not environmentally friendly	In the classroom

Table 6 Teaching module design (*Continued*)

PBL Syntax	Learning Activities			Place
	Meeting 1	Meeting 2	Meeting 3	
Research	Students carry out investigations to find practical solutions to combat climate change in actual actions related to everyday life	Students investigate Beating manuscript based on observational studies and interviews	Students investigate looking for practical solutions to combat climate change in real action	Inside and outside of the classroom
Present findings	Students present the solutions found	Students present relationships between Beating scientific manuscripts and indicators of climate change	Students present the solutions found	Inside the class
Evaluation	The teacher provides an evaluation regarding the effectiveness of the solutions submitted by students	The teacher provides an evaluation regarding the ethno-science discovered in the Beating script	The teacher provides an evaluation regarding the effectiveness of the solutions submitted by students	Inside the class

Based on Table 6, in this series of PBL (Problem-Based Learning) activities, the learning process begins with an orientation to environmental change and its causal factors. The teacher introduces this concept at the first meeting. In contrast, at the second meeting, the learning focuses on introducing the local wisdom *from* the manuscript as a prototype for analyzing climate change. Through these discussions, students are introduced to diverse traditional knowledge that can provide valuable insight into global issues such as climate change. At the third meeting, students were invited to conduct a field study on climate change by examining daily actions that directly contribute to climate change, such as using motorized vehicles, environmentally unfriendly products, and waste management. This activity aims to bring a theoretical understanding of climate change into the practical context of students' daily lives.

Collaboration between students is the focus of the next stage in this learning process. In discussion groups, students share their understanding of the factors that cause climate change and explore the climate change indicators. Through this collaboration, students can view climate change from multiple perspectives and develop a deeper understanding of the complexity of the problem. Knowledge exploration is carried out through literature review activities and further studies *from* manuscripts and issues related to climate change offered in the local context. Students are invited to explore the relationship between traditional knowledge *from* manuscripts and scientific knowledge about climate change, thereby expanding the scope of their understanding of this issue.

The meaning-making stage requires students to reflect and interpret the information they have learned. They were asked to understand the implications of the factors causing climate change, analyze their relationships *with* scientific texts and indicators of climate change, and consider solutions that can be applied to overcome climate change problems at the individual and community levels. This investigation was carried out as a step towards real action in overcoming climate change. Students conduct further investigations to find practical solutions they can apply daily, whether reducing their carbon footprint, managing waste, or choosing environmentally friendly products. This process combines theoretical knowledge with real action, enabling students to become agents of change when facing the challenges of climate change. Presentation of results is an important part of this learning process, where students share their findings and solutions with the class. Through this presentation, students strengthen their understanding and inspire and motivate their friends to get involved in efforts to overcome climate change. Finally, evaluations are carried out by teachers to evaluate students' understanding of the material, the effectiveness of their proposed solutions, and their ability to apply the knowledge gained in authentic contexts. This evaluation provides valuable input for students to continue to improve their understanding and contribution in responding to the challenges of climate change.

Thus, using the PBL-local wisdom model provides an in-depth understanding of climate change and the factors that influence it and encourages students to become change agents in overcoming these problems. Through a combination of theoretical knowledge, practical research, and collaboration between students, students develop a broader understanding of the complexities of climate change. They have the skills and knowledge necessary for this global challenge. This is in line with the opinion of (Irhasyuarna et al., 2022), which states that learning that

integrates teaching modules based on local wisdom can significantly improve critical thinking skills. Likewise, the opinion of (Lubis et al., 2022) reveals that learning based on local wisdom can increase students' environmental literacy. This learning can inspire students to continue to contribute to environmental protection efforts and strengthen awareness of the importance of sustainability for the future of our planet.

4. CONCLUSION

The design of teaching modules based on ESD and integrated local wisdom from The Bugis community is motivated by the problem of a lack of teaching materials that integrate local wisdom and add sustainability value to support the SDGs. Integrated teaching modules based on ESD and the local wisdom of the Bugis community about the material changes in the environment are formed. The teaching module is oriented towards the PBL learning model for three meetings to improve students' critical thinking skills and environmental literacy and add sustainability value to the four pillars of ESD in Indonesia.

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