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SDGs in Indonesian Biology Teacher Education: A PLO-Based Curriculum Analysis

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Abstract

Teacher education plays a strategic role in preparing future educators to address global sustainability challenges articulated in the Sustainable Development Goals (SDGs). This study aims to examine how Biology Teacher Education curricula in Indonesia align with the SDGs through an analysis of Program Learning Outcomes (PLOs). A qualitative case study design was employed using document analysis of PLOs from Biology Education programs at three public universities ranked among the top 20 institutions in Indonesia according to the Scimago Institutions Rankings (SIR) 2025. A benchmarking framework was applied to assess the extent to which PLO indicators support the achievement of the 17 SDGs. The findings reveal varying degrees of alignment across institutions. Research competencies, scientific problem-solving skills, and technology integration demonstrate the strongest alignment with SDG targets, while environmental knowledge and laboratory skills particularly support goals related to quality education, innovation, and environmental sustainability. However, character- and religiosity-oriented outcomes do not explicitly correspond to specific SDG targets, and overall integration remains implicit rather than systematically embedded within the curriculum. These results indicate the need for more explicit curriculum mapping to ensure coherent and comprehensive integration of SDG dimensions in Biology Teacher Education programs.

Keyword: Biology; Curriculum; Learning Outcome; Sustainable Development Goals; Teacher Education

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INTRODUCTION

The global commitment to sustainable development was strengthened on September 25, 2015, when world leaders adopted the Sustainable Development Goals (SDGs) as a continuation of the Millennium Development Goals (MDGs), which remained partially unmet by the end of 2015. Unlike the MDGs, the SDGs were designed as a universal framework involving governments, civil society organizations, the private sector, academia, and citizen participation worldwide in achieving shared development targets (Kumar et al., 2016). This inclusive approach positions sustainable development as a collective responsibility across sectors, including education.

SDGs consist of 17 goals and 169 targets to be achieved by 2030, integrating economic growth, social inclusion, and environmental protection as interconnected dimensions of development (United Nations, 2015). A central principle of the SDGs is leaving no one behind, which emphasizes procedural equity through inclusive participation and substantive equity through development outcomes that address structural inequalities. Among these goals, quality education plays a pivotal role, as it supports the achievement of other goals by developing knowledge, values, and competencies needed for sustainable societies (UN, 2015).

Education for sustainable development extends beyond knowledge transmission and requires learning processes that foster critical thinking, ethical responsibility, and awareness of global challenges. UNESCO (2017) emphasizes that education systems should equip learners with key sustainability competencies, including systems thinking, anticipatory skills, collaboration, and normative reasoning. These competencies are essential for understanding complex sustainability issues and for supporting informed decision making in addressing SDG-related challenges.

Within this framework, biology education holds a strategic position due to its close connection with many SDG targets related to health, food security, biodiversity conservation, climate action, and ecosystem sustainability (United Nations, 2015). Biology education enables learners to understand interactions among living systems and the environment, providing a scientific basis for addressing socio-environmental challenges. Jeronen (2016) highlights that biology education contributes to sustainability by fostering ecological thinking, ethical awareness, and responsible decision making.

Therefore, biology education is not limited to conceptual understanding but also plays a role in shaping values and actions that support sustainable development.

Teacher education is critical in ensuring that these sustainability-oriented perspectives are effectively integrated into educational practice. Teachers act as key agents who translate global agendas and policy frameworks into classroom learning experiences. Tilbury (2011) emphasizes that education for sustainable development must be systematically embedded in teacher education programs to ensure coherence between curriculum goals, pedagogical approaches, and sustainability values. Consequently, teacher education curricula are expected to prepare future biology teachers who are capable of integrating SDG-related issues into teaching and learning processes.

Given this role, examining how teacher education curricula respond to the Sustainable Development Goals is essential. Curriculum analysis provides insight into the extent to which program learning outcomes reflect sustainability principles and global responsibility. Understanding this alignment is crucial to ensuring that future biology teachers are adequately prepared to contribute to sustainable development through education.

Several studies have examined education for sustainable development and curriculum integration in general teacher education contexts (Khan, 2025; Rani, 2025; Anh et al., 2022). However, research that specifically analyzes the alignment between Program Learning Outcomes (PLOs) and the SDGs in Biology Teacher Education programs remains limited. Empirical studies that benchmark curriculum outcomes against the 17 SDGs are still scarce, particularly within the Indonesian higher education context. Biology Education has a strong conceptual connection to environmental and sustainability-related goals, which makes explicit curriculum alignment with the SDGs especially important. This gap underscores the need for a systematic curriculum analysis that focuses on outcome-level alignment. Therefore, this study aims to analyze the extent to which PLO in Biology Teacher Education programs in Indonesia align with and support the achievement of the SDGs through a benchmarking-based curriculum analysis.

RESEARCH METHOD

This study employs a qualitative case study design focusing on the curriculum of biology teacher education programs at three universities. It specifically applies a

qualitative document analysis design, as it systematically examines written curriculum documents to interpret meaning, identify patterns, and assess alignment with established sustainability frameworks. Document analysis was used as the primary data collection method. Program Learning Outcomes (PLOs) of each selected study program were examined. The analysis focused on Biology Education Programs from three universities ranked among the top 20 institutions in Indonesia according to the Scimago Institutions Rankings (SIR) 2025. This study was conducted in Indonesia between October and December 2025.

A benchmarking framework was applied as the analytical method in this study. Learning outcomes were examined to identify the added value generated through the academic processes within each institution (Amin & Amin, 2003). This process aimed to assess the extent to which PLO indicators align with and support the achievement of the Sustainable Development Goals. A coding procedure was conducted to map each PLO statement against relevant SDG goals and targets. Initially, PLOs were segmented into competency indicators. Each indicator was then compared with SDG descriptors to determine alignment. Coding categories were developed deductively based on the 17 SDGs and iteratively refined during analysis to ensure conceptual consistency. Alignment was recorded when explicit or implicit references to sustainability-related knowledge, skills, or values were identified.

Trust worthiness was established to ensure the quality and rigor of the qualitative analysis by involving two independent coders with expertise in curriculum studies and sustainability education. Inter-coder agreement was assessed to determine consistency in the interpretation of PLO–SDG alignment. Any discrepancies between coders were resolved through analytical discussion until consensus was achieved. This validation procedure enhanced the credibility and methodological rigor of the research findings.

RESULT AND DISCUSSION

The findings of this research describe how curriculum support is reflected through Program Learning Outcomes and their contribution to achieving the Sustainable Development Goals. Program Learning Outcomes serve as the primary source of information in this study because learning outcomes are a key indicator of educational success. Learning outcomes describe what learners are able to demonstrate as a result of

the learning process and function as learning objectives that guide the design of instructional activities and assessment strategies. When students achieve the intended learning outcomes, these achievements provide evidence of the value of the learning process. Conversely, when a substantial number of outcomes are not achieved, educators are expected to identify contributing factors and revise their pedagogical approaches accordingly. Learning outcomes can be formulated and assessed at the level of individual courses or across an entire curriculum (Hosier, 2017).

According to Worthen (2018), assessment of learning outcomes offers a way to explain students' limitations in mastering learning content. James and Brown (2005) describe learning outcomes as a grounded analytical framework encompassing multiple dimensions, including achievement, understanding, cognitive and creative abilities, application of knowledge, higher level learning, quality of thinking and character development, associations, inclusion, and self esteem. Alan (1996) further emphasizes that learning outcomes represent what is formally assessed and recognized by students and constitute the foundation of an effective curriculum design model in higher education.

This approach shifts attention from instructional inputs and processes toward recognizing and valuing students' learning experiences. Therefore, learning outcomes provide a meaningful basis for examining how well a curriculum supports student competencies and how these competencies align with the objectives of the Sustainable Development Goals.Benchmarking of the Program Learning Outcomes of the Biology Education program at University 1 indicates alignment with several of the 17 Sustainable Development Goals, as summarized in Table 1.

Table 1. Benchmarking Between PLO of Biology Education Program in University 1 and SDGs

Program Learning Outcomes (PLO)	Goal No.
Religiousness and humanity to fulfill the tasks	-
Having the attitude of living in society, nation and state based on Pancasila.	1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 16, 17
Demonstrate responsible attitude, independency, entrepreneurship, leadership, and adaptation to fulfill the tasks.	1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 14, 16, 17
Mastering basic biology and other knowledge relevant to science.	2, 6, 7, 9, 12, 13, 15
Understand the principles of TPACK (Technological Pedagogical and Content Knowledge) in instruction of biology.	4, 8
Mastering information and communication technology for biology instruction.	4, 8
Capable of carrying out laboratory work and field studies independently.	2, 6, 7, 9, 12, 13, 15
Able to plan, implement, evaluate and make continuous efforts in teaching biology.	4, 8

Program Learning Outcomes (PLO)	Goal No.
Mastering research methodologies in biology and education of biology both in theory and practice.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17
Proficient in communicating and collaborating, both orally and in writing.	17
Expert in managerial according to the profession under their responsibility.	16
Improve professional skills through training, work experience, or intensive and continuous education.	4

Based on the benchmarking process, first PLO"religiousness and humanity to fulfill the tasks" is not directly related to any points in the SDGs. However, this PLO has the aim of forming the character of prospective biology teacher that can support them to become good educators, and possibly support the achievement of all SDGs points. This is supported by Margerison and Ravenscroft (2020), stating that understanding character and its use is the basis of learning, therefore, character education allows personal and social development that can be used to form relationships with the SDGs by enabling students to learn how to shape their own lives.

Meanwhile, research skills developed based on PLO 9 are considered the most capable of providing support for the SDGs. A similar view was also initiated by the Monash University teaching staff union from various fields, specifically science, social science, and business. Together, they designed an integrated sustainability course to prepare students to solve SDG-related problems through a research skills development framework (Stubbs et al., 2021). The 2015 Annual Report: Strengthening Research Capacity and Knowledge Management released by UNICEF (2016) also states that research is part of efforts directed at sustainable development. Research is recognized as having supported substantial progress towards the MDGs and will support progress towards the SDGs.

Furthermore, if we look at the PLO from Biology Education Program at University 2 and benchmarking it with 17 goals of SDGs, there are also correlation between them. The relationship between PLO for the education of prospective biology teachers and the points of SDGs can be seen in Table 2.

Table 2. Benchmarking Between PLO of Biology Education Program in University 2 and SDGs

Program Learning Outcomes (PLO)	Goal No.
Demonstrate professional skills to make precise decisions based on information and adata analysis, as well as skills to select the best available strategies to solve problems encountered in the classroom to facilitate optimum instruction for students.	4

Program Learning Outcomes (PLO)	Goal No.
Understand biological concepts, principles, theories and laws to solve problems encountered in instructional environtment.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16
Understand the curriculum, instructional, and assessment supporting problem solving skills.	4
Understanding mathematics and basic science principles to support problem solving capacity related to learning problems.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16
Apply subject-specific pedagogy to teach biology concepts as the implementation of their pedagogical content knowledge.	4
Mastering managerial and technological skills to manage school laboratories.	2, 4, 6, 7, 13, 14, 15, 17
Applying the principles of biology and biology education as a basis for entrepreneurship.	1, 3, 5, 8, 9, 10, 12
Make research-based evidence and decisions and communicate them effectively.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17
Religiosity, national pride, outstanding personality, moral, and ethical behavior.	-
Mastering knowledge and learning skills to manage and utilize technology to support the capacity for lifelong learning.	4

Point 8 in their PLO can be considered to support the achievement of all SDGs because research is an important basis for various things that are trying to be achieved. Universities can play an important role in the SDGs by dint of advantages they have in responding to social challenges through the functions and operations of these institutions. The advantages in question, especially in the support that universities have in conducting research and innovation (Mawonde & Togo, 2019).Another PLO, which is related to religion and personality or character, cannot directly support the SDGs. However, religious education and personality or character will form people who have personal and social developments so that they are able to learn how to shape their own lives which in the end are expected to support the achievement of the SDGs (Margerison & Ravenscroft, 2020).

The next discussion will be on PLO at University 3, which also has a Biology Education Program. By understanding the PLO from the program, some of them are also compatible with the 17 goals of SDGs that is trying to achieve globally. The relationship between PLO from the Biology Education Program of University 3 can be seen in Table 3.

Table 3. Benchmarking Between PLO of Biology Education Program in University 2 and SDGs

	Program Learning Outcomes (PLO)	Goal No.
1.	Mastering basic knowledge of science and mathematics related to biology and learning problems.	2, 3, 4, 6, 7,12, 13, 14, 15
2.	Mastering basic biology and its branches to solve biological problems.	2, 3, 6, 7,12, 13, 14, 15

	Program Learning Outcomes (PLO)	Goal No.
3.	Mastering pedagogical knowledge and being able to apply it in planning, organizing, evaluating biology instructional, also aiding students with problems in education.	4
4.	Have knowledge related to biological research methodologies and their learning, be able to apply and publish the results.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17
5.	Experts in skills related to technology, data and information, and are able to apply them in solving problems in their field of expertise.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17
6.	Have the ability to work in the laboratory and in the field by paying attention to aspects of work safety, environmental issues, social and ethical issues.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17
7.	Memilikikemampuanmemecahkanmasalahdalamlingkupkerjanya, dan mempresentasikanhasilnyasecaraargumentatif.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17
8.	Have the ability to solve problems within the scope of work, and present the results in an argumentative manner.	17
9.	Able to apply managerial and leadership concepts, able to work in multi-disciplinary and cultural teams, make decisions, and build networks within the scope of work.	16
10.	Demonstrating creativity, thoroughness, discipline, responsibility, adaptability, initiative independence, independent and lifelong learning ability.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17

PLO from the University 3 specifically targets its graduates to become biology educators, researchers, and entrepreneurs. This goal is generally in accordance with the UN 2030 agenda of SDGs. Kioupi and Voulvoulis (2019) state that education plays an important role in the future of inclusive equality, fairness, and prosperity within environmental boundaries as stated in Goal 4 of the SDGs. Education is recognized as a medium to achieve these goals. Using the SDGs as an endpoint, education stakeholders and learners work together to build a shared vision of sustainability, identify required competencies, and develop appropriate pedagogy and learning strategies. This framework can support educational institutions to monitor and manage their progress in transforming society towards sustainability.

Across the three universities, the level of SDG integration within PLOs can be categorized into explicit, implicit, and absent alignment. Explicit integration refers to learning outcomes that directly address sustainability-related knowledge, research competencies, environmental responsibility, or innovation aligned with specific SDGs. Implicit integration appears in outcomes related to character development, religiosity, leadership, and general problem-solving skills, which may indirectly support sustainability goals but do not explicitly reference SDG-related dimensions. Absent integration is observed in PLO statements that focus solely on internal academic or

institutional values without identifiable connections to sustainability principles. Overall, integration remains predominantly implicit rather than systematically articulated in SDG-oriented terms.

A cross-university comparison reveals both similarities and distinctions in SDG alignment patterns. All three institutions demonstrate strong alignment in research competencies and scientific problem-solving, which map broadly across multiple SDGs. However, University 3 shows more comprehensive alignment across environmental and technological dimensions, while Universities 1 and 2 emphasize character formation and professional responsibility. Despite these variations, none of the programs demonstrate a fully structured SDG-based curriculum framework at the outcome level. The alignment appears distributed across competencies rather than strategically embedded.

CONCLUSION

This research demonstrates that Biology Teacher Education programs across the three universities exhibit varying degrees of alignment with the Sustainable Development Goals (SDGs). Research competencies, scientific problem-solving skills, environmental knowledge, and technology-related outcomes show the strongest connections to multiple SDG targets, whereas integration remains largely implicit and key sustainability competencies such as systems thinking and socio-scientific issue analysis are not explicitly articulated within Program Learning Outcomes (PLOs). Theoretically, this research contributes to the Education for Sustainable Development discourse by offering an outcome-level benchmarking approach that systematically maps PLOs to the SDGs, thereby providing a structured model for curriculum alignment analysis. From a curriculum perspective, the findings underscore the need for explicit SDG-based curriculum mapping and clearer articulation of sustainability competencies to ensure coherent integration at the program level. Future research may extend this analysis to a wider range of institutions, examine course-level implementation, or investigate how SDG-aligned outcomes are translated into pedagogical practices and assessment strategies.

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