Mapping the Sustainable Development Goals in AI-Assisted Senior High School Workbooks: A Content Analysis From the Philippines

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Abstract

This study examines the integration of the Sustainable Development Goals (SDGs) in AI-assisted senior high school workbooks developed by teachers at the Cebu Institute of Technology - University (CIT-U), Philippines. Through quantitative and qualitative content analysis of 321 learning exercises, the research identifies patterns, gaps, and opportunities in SDG representation, with a focus on the role of artificial intelligence (AI) in shaping sustainability-related content. Key findings reveal that SDG 4 (Quality Education) dominates the workbooks (35.83%), followed by SDG 3 (Good Health and Well-being) (15.89%), while critical goals such as SDG 1 (No Poverty), SDG 13 (Climate Action), and SDG 14 (Life Below Water) are severely underrepresented (< 2%). AI-assisted content demonstrates strengths in generating interdisciplinary scenarios but lacks depth in localizing themes and addressing environmental and socioeconomic challenges. The study recommends strategic rebalancing of SDG coverage, leveraging AI for contextualized and action-oriented activities, and enhancing teacher training for cross-curricular SDG integration. These insights contribute to the broader discourse on technology-enhanced Education for Sustainable Development (ESD), offering practical pathways to align workbook design with global sustainability agendas in the Philippine educational context.

Keywords: SDG, workbooks, AI-assisted

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Introduction

The Sustainable Development Goals (SDGs), adopted by the United Nations in 2015, provide a universal framework for addressing pressing global challenges, from poverty and inequality to climate change and environmental degradation. Education is widely recognized as a key driver in achieving the Sustainable Development Goals by equipping learners with sustainability-related competencies (United Nations, 2015; Yuan & Yu, 2022). It plays a pivotal role in advancing these goals, as it equips learners with the knowledge, skills, and values needed to contribute to a sustainable future**.** Despite global policy support, several studies report limited awareness and uneven integration of the SDGs in secondary and higher education curricula (Frank & Ricci, 2023; Rubio et al., 2022).

Recent literature underscores the transformative potential of Education for Sustainable Development (ESD) materials, which foster critical thinking, problem-solving, and ethical reasoning among students (Jurnal Pembelajaran dan Sains, 2024; Zwolińska et al., 2022). Research suggests that Education for Sustainable Development (ESD) materials enhance students' critical thinking, ethical reasoning, and problem-solving skills when sustainability concepts are intentionally embedded (Zwolińska et al., 2022). Workbooks, as key pedagogical tools, offer a strategic avenue for embedding SDGs into curricula, yet their effectiveness depends on deliberate and systematic integration. Research highlights that while some institutions, particularly in Europe and Latin America, have made strides in SDG-aligned education, others face challenges such as uneven coverage, limited teacher training, and a lack of localized examples (Frank & Ricci, 2023; Rubio et al., 2022). For instance, technical fields often treat sustainability as peripheral, despite student demand for interdisciplinary connections (Zwolińska et al., 2022).

Active learning strategies such as problem-based learning have been shown to deepen students' engagement with the SDGs by linking classroom activities to real-world sustainability challenges (Van Nguyen et al., 2024). However, studies also reveal disparities in the depth of SDG treatment, with some goals receiving minimal attention (Van Nguyen et al., 2024). This observation is supported by Rubio et.al. (2022) that certain SDGs are underrepresented in learning materials, highlighting the need for systematic review and alignment of instructional resources. Mapping SDGs in educational materials can help educators identify these gaps and refine their approaches to ensure comprehensive and meaningful integration.

In response to this educational imperative, this study investigates the presence and integration of the Sustainable Development Goals in the learning exercises of senior high school workbooks—created with the assistance of artificial intelligence (AI)—by teachers of the Cebu Institute of Technology - University. By examining 321 learning exercises across these AI-assisted instructional materials, the study aims to identify which SDGs are represented, which are missing or underrepresented, and what enhancements may be proposed to align workbook content with sustainability education goals more effectively. Through this analysis, the study contributes to the growing body of research advocating for meaningful and systematic integration of the SDGs in teaching and learning practices, especially within the secondary education level in the Philippine context.

SDG Integration in Teaching Materials

The integration of the Sustainable Development Goals (SDGs) into educational materials, such as workbooks, is a crucial step toward fostering sustainability awareness and competencies among students. This review synthesizes findings from recent studies on the effectiveness of SDG integration in educational contexts, highlighting the roles of teaching materials, curriculum design, and student outcomes.

The incorporation of the Sustainable Development Goals (SDGs) into curricula and educational workbooks plays a critical role in fostering student awareness and aligning educational systems with global sustainability objectives. Embedding SDG concepts within learning materials enables learners to understand the interconnectedness of global challenges and the importance of contributing to solutions through informed actions. As education serves as a fundamental platform for shaping future leaders, integrating the SDGs—especially within early and higher education—ensures that learners are not only knowledgeable but also responsible and responsive to sustainability demands.

Education for Sustainable Development (ESD) teaching materials have been recognized for their significant impact on enhancing students' critical thinking, sustainability awareness, and problem-solving abilities. Research by Zwolińska et al. (2022) confirms that integrating ESD resources in educational settings—whether in primary, secondary, or tertiary levels—enables learners to develop cognitive skills that are essential for understanding and addressing sustainability issues. These materials encourage learners to analyze environmental, social, and economic problems from multiple perspectives, fostering deeper reflection and critical evaluation of real-life situations.

The effectiveness and practicality of ESD materials are further supported by both experts and students who have used them. According to Zwolińska et al. (2022), these resources are considered not only theoretically sound but also pedagogically useful, as they bridge abstract scientific concepts with tangible, real-world applications. By linking classroom knowledge to local and global challenges, ESD materials empower students to make informed decisions and take responsible action toward sustainable futures. This alignment with experiential and problem-based learning makes ESD a valuable component of modern curricula.

Moreover, systematic reviews underscore the heightened relevance of ESD materials in disaster-prone regions. In these contexts, ESD contributes significantly to raising community resilience and awareness, making education a key driver in mitigating the effects of environmental and humanitarian crises. As noted in a review published in the Jurnal Pembelajaran dan Sains (2024), the integration of sustainability themes in education not only promotes knowledge acquisition but also enhances the overall quality of education by embedding values of preparedness, adaptability, and responsible citizenship. Therefore, the adoption of ESD resources holds promise for both educational improvement and sustainable development, particularly in vulnerable areas.

Higher Education Institutions (HEIs), in particular, bear the responsibility of embedding SDGs not only within syllabi but also into their broader institutional processes. This includes revising learning objectives, aligning assessment methods, and ensuring that sustainability values are embedded in administrative and pedagogical decisions (Pacheco et al., 2022). When SDGs are systematically integrated, they foster the development of competencies such as critical thinking, ethical reasoning, and collaborative problem-solving—skills vital for

addressing complex sustainability issues. Thus, HEIs must go beyond superficial mentions of SDGs and embed them meaningfully into all aspects of academic life.

One effective approach to SDG integration is the use of Problem-Based Learning (PBL), which immerses students in real-world challenges that require interdisciplinary and practical solutions. Van Nguyen et al. (2024) examined seven PBL programs and found that all 17 SDGs were touched upon; however, the depth of treatment varied, with some goals receiving limited focus. This underscores the importance of ensuring balanced and comprehensive SDG integration, especially through hands-on applications such as case studies and community-based projects. Likewise, mapping SDGs within textbooks, workbooks, and classroom exercises provides educators with a strategic tool for identifying gaps and enhancing the relevance and effectiveness of sustainability education (Van Nguyen et al., 2024). Through deliberate and thoughtful integration of SDGs, educators can significantly enhance students' readiness to contribute to a more sustainable future.

Despite the growing global emphasis on the Sustainable Development Goals (SDGs), student knowledge and awareness of these goals remain surprisingly limited. A study conducted among Chinese high school students revealed low levels of SDG awareness across the population, with no significant differences observed between male and female respondents (Yuan & Yu, 2021). This suggests that gender is not a key factor in SDG awareness and that the gap is likely due to the absence of a strong emphasis on sustainability education in both formal curricula and informal learning environments. The study reinforces the urgent need to enhance SDG education more comprehensively and inclusively across educational systems.

In response to this challenge, active learning methodologies have shown promise in enhancing student understanding and engagement with the SDGs. Design challenges, in particular, have proven effective in expanding students' perspectives by encouraging them to address real-world problems through creative and ethical solutions. According to research (Skene & Malcolm, 2019), these approaches often promote nature-based solutions, environmental consciousness, and social responsibility, all of which align with the core values of the SDGs. Active learning also fosters a participatory and student-centered environment, which increases motivation and deepens conceptual understanding compared to traditional lecture-based instruction.

Experiential learning, including capstone projects and community-based initiatives, has likewise emerged as a powerful strategy for advancing SDG awareness. These experiences allow students to apply theoretical knowledge in practical contexts, addressing sustainability issues through interdisciplinary collaboration and reflective practice. O'Toole and Fang (2023) emphasize that such approaches not only raise awareness about global challenges but also develop crucial employability skills such as problem-solving, communication, teamwork, and leadership. By engaging directly with SDG-related themes, students cultivate a global perspective and a sense of personal agency in contributing to sustainable development.

Moreover, the long-term impact of SDG-integrated education extends beyond the classroom and into the workforce. Graduates from academic programs that align their curricula with the SDGs—especially those focused on economic development—tend to experience more favorable employment outcomes. According to Alimehmeti et al. (2024), these graduates report higher salaries, greater job satisfaction, and stronger alignment between their skills and

job requirements. This suggests that employers value sustainability-related competencies and that SDG education can serve as a strategic tool for improving graduates' career prospects.

Despite the increasing recognition of the importance of integrating the Sustainable Development Goals (SDGs) into education, several persistent barriers hinder their full and effective incorporation into curricula. One of the most pressing issues is the uneven coverage of SDG-related topics across different educational levels and disciplines. Frank and Ricci (2023) highlight that many institutions still struggle with limited teacher training on sustainability concepts, resulting in educators feeling ill-equipped to teach these complex, interdisciplinary topics. Furthermore, in many emerging contexts, there is a noticeable lack of practical applications and localized examples that would make SDGs more relevant and relatable to students. This gap reduces the effectiveness of SDG integration and prevents learners from fully grasping the real-world implications of sustainable development.

Additionally, the need for curricular innovation is particularly evident in technical and science-oriented fields, where sustainability education is often viewed as peripheral rather than integral. Students at AGH University, for example, have expressed a strong demand for more interdisciplinary content that connects their technical expertise with the broader economic, social, and environmental goals outlined in the SDGs (Zwolińska et al., 2022). This feedback points to a critical opportunity for curriculum designers to revisit and revise academic programs to better reflect the interconnected nature of today's global challenges. By embedding sustainability themes across disciplines—not just in the humanities or social sciences—educational institutions can produce well-rounded graduates capable of contributing to holistic and sustainable solutions in various sectors.

In summary, while there is a clear need to address the limited awareness of SDGs among students, especially at the secondary level, the literature points to a variety of effective pedagogical strategies. Active and experiential learning methods—including design challenges and capstone projects—have demonstrated strong potential to enhance SDG knowledge and skill development. Furthermore, evidence suggests that embedding SDGs into the curriculum yields not only educational benefits but also professional advantages for students post-graduation. These findings underscore the importance of integrating sustainability education holistically across all levels of learning to ensure that future generations are equipped to tackle complex global issues.

In conclusion, the integration of Sustainable Development Goals (SDGs) into education—particularly through workbooks, curricula, and experiential learning—plays a vital role in promoting sustainability awareness, skill development, and real-world application among students. The literature consistently emphasizes that teaching materials grounded in Education for Sustainable Development (ESD) not only enhance cognitive skills such as critical thinking and problem-solving but also foster ethical responsibility and global citizenship (Jurnal Pembelajaran dan Sains, 2024; Zwolińska et al., 2022). However, uneven implementation across institutions and disciplines highlights the need for more inclusive, systematic, and interdisciplinary approaches, particularly in technical and emerging educational contexts (Frank & Ricci, 2023; Zwolińska et al., 2022). Addressing these gaps requires teacher training, curriculum innovation, and the meaningful use of local examples to make sustainability education more impactful.

Moreover, active and experiential learning strategies such as problem-based learning, design challenges, and capstone projects have proven effective in embedding SDGs into academic

programs (O'Toole & Fang, 2023; Skene & Malcolm, 2019; Van Nguyen et al., 2024). These methods not only raise SDG awareness but also prepare students for the workforce by developing competencies aligned with employer needs, particularly in the context of economy-related SDGs (Alimehmeti et al., 2024). With increasing student demand for relevant, interdisciplinary sustainability content, especially in technical fields, educational institutions are called to revisit and revise their curricular frameworks. A comprehensive and intentional approach to SDG integration will not only improve learning outcomes but also contribute meaningfully to shaping a more sustainable, equitable future.

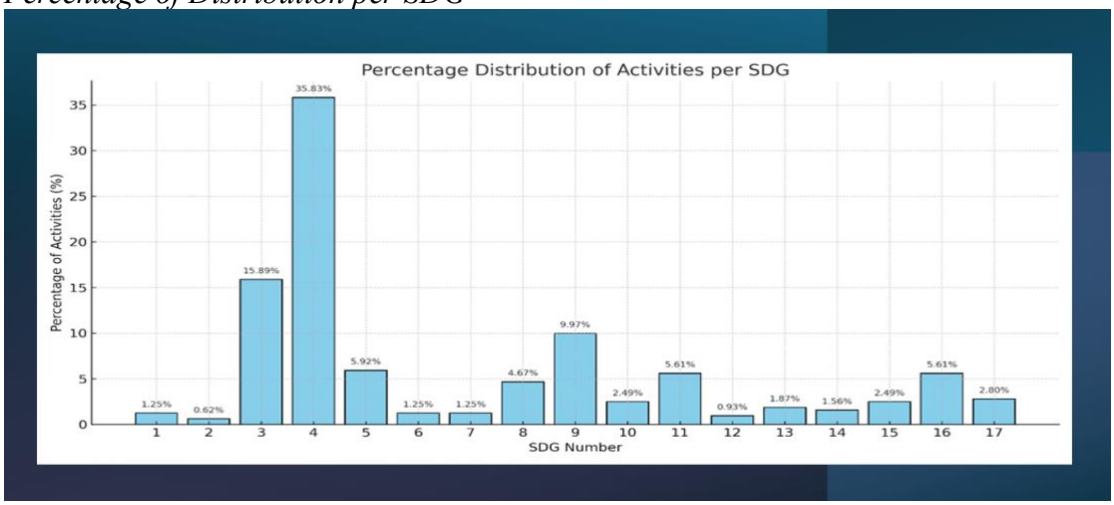
Methodology

This study utilized a quantitative and qualitative content analysis approach to investigate the integration of the Sustainable Development Goals (SDGs) within AI-assisted senior high school workbooks crafted by teachers at the Cebu Institute of Technology - University (CIT-U). The methodology unfolded across four structured phases. In the data collection phase, researchers analyzed 321 learning exercises from these workbooks across diverse senior high school subjects, selected for their interdisciplinary relevance and incorporation of AI tools like generative AI for content creation or adaptive features. Inclusion criteria targeted exercises that explicitly or implicitly addressed any of the 17 SDGs through elements such as problem-solving tasks, case studies, or reflective questions. The coding and SDG mapping phase involved applying a framework to each exercise, identifying explicit SDG mentions (e.g., direct references to SDGs or terms like "sustainability" and "climate action") alongside implicit alignments (e.g., poverty reduction in math problems or gender equality in literature). Exercises were then classified against the UN's official SDG indicators, allowing multiple linkages where relevant. Data analysis encompassed frequency analysis to quantify SDG distribution and highlight overrepresented or underrepresented goals, thematic analysis to uncover integration patterns (such as standalone activities versus cross-curricular links), and an evaluation of AI's influence on content depth or creativity (e.g., AI-generated case studies compared to teacher-designed scenarios). Finally, validation ensured inter-coder reliability through independent coding by two researchers on a subset of exercises, with discrepancies resolved via discussion. Limitations included the focus solely on teacher-created, AI-assisted workbooks, which may not generalize to all materials, and the observational nature of AI's role without experimental contrasts to non-AI content.

Findings

The analysis of 321 learning exercises from AI-assisted senior high school workbooks revealed notable disparities in the representation of the 17 Sustainable Development Goals (SDGs). The results indicate that SDG 4, which promotes Quality Education, dominated the content, appearing in 35.83% (115) of the total activities. While this aligns with the academic setting, it also suggests a potential overemphasis on education-related themes at the expense of other critical dimensions of sustainability. SDG 3, which addresses Good Health and Well-being, was the second most represented, present in 15.89% (51) of the exercises, reflecting its close connection to student wellness and science-related curricula.

Figure 1
Percentage of Distribution per SDG



Moderately represented SDGs included SDG 9 (Industry, Innovation, and Infrastructure), which appeared in 9.97% (32) of the activities, and SDG 5 (Gender Equality), with 5.92% (19) of the exercises. These indicate some level of interdisciplinary integration. Other goals, such as SDG 8 (Decent Work and Economic Growth), SDG 11 (Sustainable Cities and Communities), and SDG 16 (Peace, Justice, and Strong Institutions), were present in about 5% of the workbook content. This suggests occasional but unsystematic inclusion of themes outside the education and health domains.

However, the study also highlighted a concerning underrepresentation of several critical SDGs. SDGs such as No Poverty (SDG 1), Zero Hunger (SDG 2), Clean Water and Sanitation (SDG 6), Affordable and Clean Energy (SDG 7), Responsible Consumption and Production (SDG 12), Climate Action (SDG 13), Life Below Water (SDG 14), and Life on Land (SDG 15) each appeared in fewer than 2% of the exercises. These gaps reflect missed opportunities to address pressing global and local challenges, particularly those related to environmental and socioeconomic issues. SDG 17 (Partnerships for the Goals), which emphasizes global collaboration and community action, was represented in only 2.8% (9) of the activities, indicating a limited focus on cooperative and solution-oriented approaches.

Discussion

The role of artificial intelligence in the creation of these workbooks shows both potential and limitations. While AI-assisted materials demonstrated thematic breadth, the depth of integration varied. For example, many SDG 4-related exercises were generic and descriptive, such as essay writing on the value of education, without moving toward more action-oriented or experiential tasks. On the other hand, AI-generated content showed promise in introducing innovative case studies for goals like SDG 9, yet these were sometimes lacking in localized context. For instance, activities related to SDG 2 did not sufficiently reflect real agricultural challenges in the Philippine setting.

Key gaps were particularly evident in the environmental and socioeconomic dimensions of sustainability. Environmental goals such as SDGs 6, 7, and 12 through 15 were severely underrepresented despite the Philippines' vulnerability to climate-related disasters and its rich biodiversity. Similarly, SDGs related to poverty, hunger, and inequality (SDGs 1, 2, and 10) were minimally addressed, pointing to a disconnect between classroom content and real-

world community concerns. Furthermore, interdisciplinary integration remained weak. Subjects such as Mathematics and Filipino rarely incorporated relevant SDG themes—for example, math problems involving data on poverty (SDG 1) or literature exploring gender narratives (SDG 5) were notably absent.

While the exercises met institutional requirements, many lacked meaningful connections to real-world contexts. There was limited emphasis on encouraging learners to engage with current economic, social, and environmental challenges at the national and global levels. Moreover, important societal issues such as corruption in the Philippines were not sufficiently integrated into the workbook activities, indicating opportunities for further enhancement.

Conclusion

To enhance SDG integration in AI-assisted workbooks, several strategies are recommended. First, a more balanced representation of the SDGs is necessary. Curriculum designers should prioritize the inclusion of underrepresented goals by developing targeted learning activities. These could include math problems involving clean energy data for SDG 7, science experiments focused on local biodiversity to support SDG 15, and classroom debates simulating climate policy discussions for SDG 13. Second, AI can be more effectively leveraged to contextualize content. Tools should be used to generate examples that reflect Philippine realities—such as challenges in rice farming for SDG 2—and to produce multimedia learning materials like infographics on SDG 14 (Life Below Water).

Third, capacity-building among teachers is essential. Conducting training workshops would help educators recognize SDG connections in their respective subjects and encourage interdisciplinary collaboration. For instance, English and Social Studies teachers could jointly develop persuasive writing activities linked to SDG 16 (Peace and Justice). Finally, implementing regular assessment and feedback mechanisms is crucial. Periodic audits using SDG mapping tools and pilot testing student responses to SDG-related tasks can guide improvements and ensure content relevance and impact.

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Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

ChatGPT (OpenAI) and Grammarly were used solely for language editing and proofreading. It was not involved in data generation, analysis, or interpretation. Full responsibility for the content rests with the author.

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