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Literature Review: The Use of Professional Technology in the Integration of ESD (Education for Sustainable Development) in Social Science Learning

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ABSTRACT

Objective: *This study aims to explore the potential of utilizing professional technology in integrating Education for Sustainable Development (ESD) into social science learning.* ***Method:*** *This study employs a literature review method with a descriptive qualitative approach to ten selected articles based on the research objectives. Analysis was conducted through the identification, categorization, and synthesis of findings related to the types of technology used, ESD integration strategies, and their impact on learning.* ***Results:*** *The results of the study indicate that technologies such as digital platforms, artificial intelligence, mobile learning, VR/AR, simulations, and game-based learning can enhance student engagement, motivation, conceptual understanding, critical thinking skills, collaboration, and intelligence regarding sustainable issues in social science learning. The effectiveness of technology integration is influenced by appropriate pedagogical design, teacher readiness, infrastructure support, and cultural and social context suitability.* ***Novelty:*** *This research's novelty lies in the comprehensive synthesis that maps the relationship between professional technology, active learning models, and ESD outcomes in social science learning, while also offering future research directions to address facility limitations, the digital divide, and the lack of teacher training.*

INTRODUCTION

Education for Sustainable Development (ESD) is a multidisciplinary educational approach that aims to develop knowledge, skills, and values to achieve social, economic, and environmental sustainability (Grosseck et al., 2019). The development of the Industrial Revolution 4.0 presents significant opportunities for ESD transformation. The use of technologies such as artificial intelligence, the internet of things, and green technology can strengthen sustainable learning innovation that can improve soft skills and sustainable awareness (Corazza et al., 2022). Therefore, ESD in the era of globalization and the Revolution requires an adaptive and contextual curriculum to balance global perspectives with local needs.

The development of information and communication technology has had a significant impact on various aspects of life, including education. Professional technology is the application of advanced technology and specialized expertise by professionals to create innovative solutions in various industrial sectors and support social and economic progress (Fedotova et al., 2019). Technological developments in the context of education have made professional technology one of the key factors capable of improving the quality of learning (Abdalina et al., 2022). This concept is realized through the idea of professional digital competence, which encompasses technical aspects (technology literacy), pedagogical aspects, content, attitude, and critical

thinking (Hizam et al., 2021). The implementation of technology presents both challenges and opportunities, particularly in the face of globalization and rapid digital transformation.

Based on the results of the 2022 Programme for International Student Assessment (PISA), Indonesia's student performance remains far below the international average. The OECD reported that Indonesian students scored 366 in mathematics, 371 in reading, and 383 in science, whereas the OECD average scores were 472, 476, and 485, respectively. This gap of more than 100 points is equivalent to almost three years of schooling difference compared to students in OECD countries. Furthermore, Indonesian students particularly struggle with tasks that require creative and social problem-solving, which are fundamental aspects of social science learning (OECD, 2024). A systematic review further reveals that such low achievement is influenced by socioeconomic inequality, limited teacher training and quality, and misaligned educational policies, all of which exacerbate disparities in students' mastery of basic competencies (AlAli & Wardat, 2024).

In this context, the growing need to integrate Education for Sustainable Development (ESD) into social science learning is important in response to global challenges. Recent studies indicate that digital innovations can enhance students' awareness of sustainability, engagement, and critical thinking skills when appropriately integrated with pedagogical strategies (García-Hernández et al., 2023; Romero-Rodriguez et al., 2020). However, various systematic reviews emphasize that the effectiveness of such innovations heavily depends on teachers' digital competencies, infrastructure support, and learning designs that align with the socio-cultural context (Galindo-Domínguez et al., 2024). Despite the rapid growth of digital learning initiatives, there remains a gap in mapping the relationship between professional technology, active learning strategies, and ESD outcomes. Therefore, this research is important to provide both theoretical and practical contributions to strengthening quality education in line with SDG Goal 4.

Although technology has the potential to support interactive learning and critical thinking, its use in social science education remains low. Stecula asserts that technology is often used only for accessing information, not for learning innovation (Stecuła & Wolniak, 2022). In Indonesia, teachers recognize the benefits of multimedia and simulations, but are hindered by limited facilities and readiness (Wulandari & Pratiwi Husain, 2025). Globally, the digital divide and lack of training remain major obstacles (Mustafa et al., 2024).

The use of technology in social science education is a strategic tool because it provides access to global learning resources, interactive simulations, and cross-cultural collaboration (Shonfeld et al., 2021). Islamah's (2025) research shows that the appropriate integration of technology can improve students' critical thinking, problem-solving, and sustainability awareness skills. Recent research emphasizes that without policy support, professional training, and relevant pedagogical integration, technology tends to be used.

Superficially, it is a presentation tool rather than a means of transforming learning toward ESD goals (Zhang et al., 2024). Therefore, a thorough literature review is necessary to map out effective strategies for utilizing technology in social science education to enhance ESD quality in the era of globalization and the 4.0 Industrial Revolution.

RESEARCH METHOD

This study uses a qualitative descriptive approach that aims to provide an in-depth description of the use of professional technology in the integration of Education for Sustainable Development (ESD) in social science learning. Researchers widely recognize that a qualitative descriptive approach is practical for providing a detailed overview of educational practices and technology integration without direct intervention. This approach allows the researcher to describe phenomena systematically, reveal patterns, and identify contextual challenges in implementing Education for Sustainable Development (ESD) (Alam & Asmawi, 2024). Furthermore, Mukherjee (2025) emphasizes that literature reviews and descriptive methods are essential for synthesizing findings across disciplines, enabling researchers to capture a comprehensive perspective on how professional technology can enhance ESD integration in social science learning.

This approach was chosen because it can explore phenomena contextually and in detail based on relevant literature sources without direct intervention in the field. The principles of qualitative research, which emphasize understanding meaning, contextual relevance, and comprehensive depiction of phenomena, form the philosophical foundation of this study (Alam & Asmawi, 2024). Additionally, the phenomenological framework in qualitative research provides clear guidance in the data collection and interpretation process (Adeniran & Tayo-Ladega, 2024).

The type of research used is a literature review, the results of previous studies related to the topic under review. This literature review was conducted to obtain a complete picture of the trends, approaches, and effectiveness of utilizing professional technology in the integration of ESD in social science learning. The researcher emphasized the latest literature so that the results of the study could provide theoretical and practical contributions. This literature review is not only descriptive but also multidisciplinary, integrating cross-disciplinary perspectives to enrich the synthesis results (Mukherjee, 2025).

The research population includes all scientific articles discussing the use of professional technology in the integration of ESD in social science education. From this population, ten articles with the highest number of citations in the Scopus database and peer-reviewed status were selected, assuming that highly cited articles have significant influence and high relevance. The selection process was conducted using relevant keywords, restricting the publication year to the most recent, and ensuring that all articles had undergone peer review (El Jihaoui et al., 2024; Mukherjee, 2025). The

following is the research design implemented from the beginning to the end of the study.

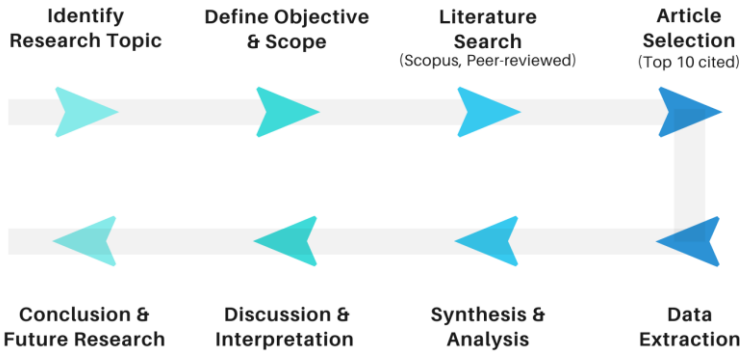

Figure 1. Research design

Data analysis was conducted in eight stages, beginning with identifying the research topic and defining the objectives and scope to determine the boundaries of the study. The next stage involved conducting a literature search through leading databases such as Scopus, followed by selecting the 10 most frequently cited and most relevant articles to the research focus. Next, data extraction was performed to collect essential information from each article, including methods, research focus, and results. The findings were then analyzed and synthesized, where studies were grouped into categories such as the type of technology used, ESD integration strategies, and their impact on social science learning. After that, discussions and interpretations were carried out to relate the results to the theoretical framework critically. The last stage was conclusions and recommendations for future research to provide a comprehensive overview that answers the research questions.

RESULTS AND DISCUSSION

Results

To obtain a comprehensive overview of the use of professional technology in the integration of Education for Sustainable Development (ESD) in social science learning, researchers reviewed ten articles with the highest number of citations indexed in Scopus. The results of the review are presented in the table below, which contains the names of the authors, the number of citations, and SJR journals, as well as the findings and recommendations of the study.

The explanation of the findings in this review is grounded in their direct relevance to the research topic. Each article was selected based on objective criteria—namely, the highest number of citations in Scopus-indexed journals and peer-reviewed status—which ensures academic credibility and influence in the field (El Jihaoui et al., 2024). The categorization of findings was conducted by aligning them with the core dimensions of the study, namely: (1) the type of professional technology applied in education, (2) strategies for integrating Education for Sustainable Development (ESD), and (3) the demonstrated impact on social science learning outcomes. This systematic approach minimizes bias and enhances the validity of the synthesis (Mukherjee, 2025).

As Lenberg et al. (2023) argue, qualitative reviews must rely on thematic relevance and methodological transparency to ensure that conclusions represent the literature accurately, rather than reflecting the reviewers' personal perspectives. Therefore, the findings summarized in the results section are considered robust because they were derived from highly cited, peer-reviewed literature and analyzed through relevance to the research objectives, not subjective preference.

Table 1. Overview of most cited papers in scopus

Author(s)	Citation: SJR	Research Finding and Recommendation
(Al-Thani et al., 2021)	40; 0.688 (Q1)	Targeted professional development for teachers, effective performance evaluations, clear incentives, and adequate understanding of SDGs are essential for quality education. The recommendations emphasize relevant training based on systems and design thinking.
(Salvador et al., 2023)	25; 0.812 (Q1)	The integration of ESD into science curricula can raise students' awareness of sustainability issues, although there are still challenges such as limited resources, lack of teacher training, and incomplete integration of materials. The recommendations of this study are to provide intensive teacher training, develop contextual teaching materials, and strengthen collaboration among education stakeholders.
(Timmis et al., 2024)	20; 1.195 (Q1)	STEM project-based learning effectively improves students' knowledge, critical thinking skills, and awareness of sustainability issues. However, challenges include time constraints, teacher training needs, and curriculum suitability. Recommendations include expanding the application of STEM-based project-based learning, providing adequate teacher training, and adjusting the curriculum to support ESD integration.
(Reyes et al., 2022)	20; 0.596 (Q2)	The use of two quantitative tools, namely DOZN 2.0 and Life Cycle Assessment (LCA) integrated with systems thinking, helps chemistry students compare the sustainability levels of chemical reactions while linking them to SDG points. The results show an increase in scientific communication skills, data-based decision-making abilities, and awareness of the role of scientists in social and environmental responsibility. The recommendation is to utilize a dual-tool approach and systems thinking in science education to cultivate critical skills and sustainability awareness.

Author(s)	Citation: SJR	Research Finding and Recommendation
(Chan & Nagatomo, 2022)	19; 0.688 (Q1)	Inquiry-based learning effectively improves students' critical thinking skills, curiosity, and problem-solving abilities. Challenges include time constraints, lack of teacher training, and limited supporting facilities. This study recommends expanding the application of inquiry-based learning, providing intensive training for teachers, and providing adequate learning resources.
(Antillón et al., 2021)	19; 0.688 (Q1)	The use of two quantitative tools, namely DOZN 2.0 and Life Cycle Assessment (LCA) integrated with systems thinking, can improve scientific communication skills, data-based decision-making abilities, and students' awareness of the interconnection between science and the SDGs. The recommendation is to integrate sustainability analysis tools and systems thinking approaches into learning to foster holistic understanding and critical skills among students.
(Salem et al., 2022)	13; 0.919 (Q2)	The study found that integrating digital technology into ESD-based learning can improve student engagement, conceptual understanding, and awareness of sustainability issues. Challenges include teachers' limited technological skills and access to infrastructure. Recommendations include providing professional technology training for educators, developing contextual digital learning resources, and strengthening educational policy support.
(Lampoltshammer et al., 2021)	13; 0.688 (Q1)	The study found that the use of interactive digital technology in ESD learning effectively increases student engagement, conceptual understanding, and critical and collaborative thinking skills related to sustainability issues. However, challenges include limitations in teachers' technological skills and insufficient integration of technology into the curriculum. Recommendations include providing technology-based professional training for teachers, developing interactive learning media relevant to ESD, and strengthening institutional support.
(Raman et al., 2024)	13; 0.803 (Q1)	The study found that integrating simulation-based technology into ESD learning can improve students' conceptual understanding, problem-solving skills, and awareness of sustainability issues. The challenges faced include limited facilities, lack of teacher training, and resistance to changes in teaching methods. The recommendations are to provide adequate technological infrastructure, offer professional training for educators, and develop simulation content that is relevant to the learning context.

Author(s)	Citation: SJR	Research Finding and Recommendation
(Addo et al., 2022)	12; 0.664 (Q1)	The use of case study methods in SDG learning and effective social development enhances students' contextual understanding, critical thinking skills, collaboration, and problem-solving abilities through real-world scenarios. Various case study formats, such as written narratives, films, and discussions with experts, can help students explore the interconnections between SDGs and their contextual factors. The recommendation is to integrate case studies with a constructivist approach that encourages active engagement and deep thinking.

Discussion

Overall, the literature shows that the integration of digital technology has great potential to expand access to learning, personalize the learning experience, and support understanding of SDG issues. However, its successful implementation depends heavily on the use of pedagogically designed technology, which facilitates critical thinking, collaboration, and reflection, rather than merely serving as a tool for delivering material. Consistent findings across various studies highlight that technology is only effective when accompanied by meaningful instructional design and teacher capacity support. This aligns with the conclusions of recent studies on digital learning and Universal Design for Learning (UDL), which emphasize the importance of integrating technology within an inclusive and adaptive pedagogical framework to achieve SDG 4 (Quality Education) (Bucheli et al., 2024; Parmaxi et al., 2024; Zou et al., 2025).

The review results show that digital technology can help improve access to learning, provide a more personalized learning experience, and make it easier for students to understand SDG issues that cover various fields of study. Examples include the use of digital learning platforms, AI technology with adaptive learning systems, and mobile learning that supports continuous and lifelong learning. However, the success of this technology heavily depends on how it is utilized to support meaningful learning activities, such as analyzing problems, collaborating with peers, and reflecting on learning experiences (Trevisan et al., 2024).

Recent research shows that interactive technologies such as VR/AR, simulations, game-based learning, and XR can provide engaging and immersive learning experiences. VR/AR technology provides immersive experiences that deepen understanding of complex concepts, such as scientific simulations in STEM (Science, Technology, Engineering, Mathematics) (González-pérez & Ramírez-montoya, 2022). This technology can enhance motivation, conceptual understanding, and students' awareness of sustainability issues. In social science education, the use of multimedia and simulation games or case studies can help students see how social and economic systems are interconnected. This encourages them to think across disciplines and make decisions based on data (Shadiev et al., 2024).

Based on existing research, the most suitable interactive technology to use with 21st-century interactive technology is project-based learning (PBL), case-based learning with additional audits or simulations (audit-based case learning), as well as inquiry-based or flipped classroom approaches. PjBL and audit-based case learning provide students with real-world learning experiences that connect social theory with direct action (Sánchez-García & Reyes-de-Cózar, 2025). Meanwhile, inquiry-based or flipped classroom learning supplemented with simulations helps develop critical thinking, collaboration, and reflection skills, all of which are essential in ESD. Therefore, the use of interactive technology within the framework of PjBL, inquiry, or case-based learning aligns well with recent research findings.

In line with the United Nations' Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education), the integration of digital technology in learning should not only aim to improve academic outcomes but also to foster competencies that support sustainable development. Education for Sustainable Development (ESD) equips learners with critical thinking, problem-solving, and collaborative skills that are essential for addressing global sustainability challenges (UNESCO, 2024). Recent research emphasizes that technology-supported ESD is most impactful when pedagogical approaches are explicitly linked to sustainability-oriented outcomes, such as environmental literacy, social responsibility, and systems thinking (Salvador et al., 2023). Furthermore, digital innovation in education can act as a catalyst to reduce inequality in learning opportunities, thereby contributing to SDG 10 (Reduced Inequalities), while simultaneously enhancing cross-cultural understanding and collaboration (Shonfeld et al., 2021). By embedding professional technology within an ESD framework, educational practices can move beyond surface-level digital adoption toward creating transformative learning experiences that directly contribute to achieving the SDGs.

Based on the gaps identified from the review and international research, there are several suggestions for future research, which are to evaluate how effective the use of certain technologies (such as VR/AR, simulations, or AI tutors) combined with ESD learning models is on student learning outcomes, including knowledge, attitudes, and skills. This study also has several limitations. Although it provides a clear picture of how technology can support active learning for Education for Sustainable Development (ESD), most of the studies reviewed are still small in scale and conducted in specific contexts. This means that the results cannot yet be generalized to all learning situations. Nevertheless, this study provides valuable insights for teachers and policymakers.

CONCLUSION

Fundamental Finding : A literature review shows that the use of professional technology in social science learning has great potential to strengthen ESD outcomes (knowledge, attitudes, and skills for sustainability), especially when combined with active pedagogical approaches such as project-based learning, inquiry-based learning, and case-based learning. Interactive technologies such as VR/AR, simulations, game-

based learning, and adaptive digital platforms have been proven to enhance student engagement, conceptual understanding, critical thinking skills, and sustainability awareness. **Implication :** These findings confirm that technology is not enough to be introduced in the classroom; it must be integrated with pedagogical strategies that are relevant to the ESD context. Teachers need to have professional digital competence that includes technological literacy, pedagogical skills, and critical awareness of sustainability issues. **Limitation :** Most of the reviewed studies are still case studies or limited implementations, so caution is still needed when generalizing the results to various educational contexts. **Future Research :** Further research is recommended to evaluate the effectiveness of specific technologies (VR/AR, simulation, AI tutors, mobile learning) when combined with ESD learning models on students' cognitive, affective, and conative achievements.

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AUTHOR CONTRIBUTIONS

Wildan Fitroni played a major role in formulating the research idea, developing the conceptual framework, and designing the research flow so that this research had a clear direction and purpose. **Yasinta Salsabilah Ramadani** contributed to the in-depth writing of the background by reviewing various relevant literature and conducting data analysis to produce valid and reliable findings. **Mukhammad Rafly Eka Rosyadi** played a role in the research data collection process by ensuring that the procedures were carried out systematically. **Rendy Dwi Cahya** was responsible for managing references, ensuring citations adhered to academic standards. **Noval Maleakhi Hulu** was adapting the manuscript to the format and template of the target journal. During the revision stage, all authors actively collaborated in responding to reviewer feedback, improving the manuscript content, and refining key sections to prepare the article for publication.

CONFLICT OF INTEREST STATEMENT

The authors declare that this study was conducted independently and objectively. There are no conflicts of interest, whether financial, personal, or professional, that could have influenced the research process, the interpretation of the findings, or the preparation of this article. All stages of the study, from data collection to the writing of the manuscript, were carried out solely for academic purposes without any external pressure.

ETHICAL COMPLIANCE STATEMENT

This manuscript complies with established standards of research and publication ethics. The authors affirm that the work presented is original, carried out with academic integrity, and entirely free from unethical practices, including plagiarism, data

fabrication, or falsification. All sources have been properly acknowledged, and the study was conducted solely for scholarly purposes in adherence to ethical guidelines.

STATEMENT ON THE USE OF AI OR DIGITAL TOOLS IN WRITING

The authors acknowledge the use of digital tools, including artificial intelligence (AI)-based technology, as support in the research and writing stages of this article. Specifically, NotebookLM was used to help organize literature and summarize reviewed articles. All outputs generated through digital assistance have been critically reviewed, verified, and revised to ensure academic accuracy and compliance with ethical standards. The final responsibility for the content and integrity of this manuscript rests solely with the authors. In this study, the author also used Mendeley to manage references and automatically compile the bibliography used in this study.

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