



Education for Sustainable Development Integration in Technical and Vocational Education and Training: A Systematic Literature Review

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ABSTRACT

The integration of Education for Sustainable Development (ESD) into Technical and Vocational Education and Training (TVET) is a key strategy for supporting the achievement of the Sustainable Development Goals (SDGs) by developing graduates who possess both technical competencies and sustainability competencies. This study aims to analyze the state of the research, key themes, and implementation strategies for ESD in TVET. The study employed a Systematic Literature Review (SLR) method in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. A literature search was conducted in the Scopus database using keywords related to ESD and TVET, yielding 63 articles, which were then screened to identify 22 articles that met the inclusion criteria. The analysis was conducted through bibliometric visualization using VOSviewer and thematic synthesis. The results indicate that the implementation of ESD in TVET focuses on five main themes: curriculum integration, the development of sustainability competencies, learning implementation strategies, policy support and partnerships, and implementation challenges. The findings also indicate a shift in research from conceptual approaches toward implementation that emphasizes green skills, the Whole Institution Approach, and curriculum alignment with the SDGs. This study concludes that the implementation of ESD requires a systemic and collaborative approach. Curriculum developers, TVET institutions, and policymakers are recommended to strengthen ESD integration through curriculum innovation, capacity building for educators, partnerships with industry, and the use of digital technology to support sustainable vocational education.

1. Introduction

Sustainable development has become an increasingly urgent global agenda in response to escalating climate change, environmental degradation, natural resource crises, social inequality, and rapid economic transformation. The complexity of these issues demonstrates that development can no longer be measured solely by economic growth but must also take into account the balance among environmental, social, and economic dimensions. Through the Sustainable Development

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Goals (SDGs), the United Nations has positioned education as one of the main pillars in achieving the transformation toward a sustainable society. SDG Target 4.7 specifically emphasizes the importance of every learner possessing the knowledge, skills, values, and attitudes necessary to support sustainable development and foster the emergence of global citizens who are responsible for the future of the Earth (Holst, Grund, et al., 2024). Education is viewed as a strategic instrument capable of building individuals' capacity to understand various sustainability issues while generating solutions that balance economic, social, and environmental aspects (Holst et al., 2020).

Education for Sustainable Development (ESD) has emerged as an educational approach designed to prepare students to face the challenges of sustainable development through the development of knowledge, skills, values, and concrete actions. This approach is not limited to presenting material on environmental issues but also emphasizes transformative learning that builds the ability to think systemically, think critically, be creative, collaborate, communicate, demonstrate social responsibility, and make sustainable decisions (Holst et al., 2020). The implementation of ESD integrates sustainability into the curriculum, the learning process, the learning environment, institutional governance, and the culture of educational organizations, thereby fostering comprehensive behavioral change among both students and the institutions themselves (Holst, Grund, et al., 2024).

Technical and Vocational Education and Training (TVET) plays a highly strategic role in supporting the implementation of ESD, as it prepares a workforce capable of addressing both industry needs and the challenges of sustainable development. The shift toward a green economy, a circular economy, the energy transition, industrial digitalization, and the acceleration of technological innovation require TVET graduates to possess not only technical skills but also green skills, sustainability competencies, adaptability, creativity, and an awareness of the social and environmental impacts of every professional activity (Wickramasinghe & Wickramasinghe, 2026). These conditions make the integration of ESD into the TVET curriculum an increasingly critical necessity so that vocational education graduates can contribute to achieving the SDGs while meeting the demands of the future workforce.

Various studies show that the implementation of ESD in TVET has evolved through a variety of approaches. Curriculum development based on green skills, the circular economy, creative thinking, the Whole Institution Approach, project-based learning, contextual learning, and partnerships with the business and industrial sectors have become widely adopted strategies in various countries (Hamid et al., 2025; Juwitasari, 2024; Li et al., 2022a; Wickramasinghe & Wickramasinghe, 2026). These implementations have proven effective in enhancing creativity, critical thinking skills, problem-solving abilities, collaboration, sustainability literacy, and graduates' readiness to face a workforce transformation that is increasingly oriented toward sustainability (Li et al., 2022b). Integrating circular economy principles into vocational education also contributes to raising students' awareness of responsible consumption and production in line with the SDGs (Hamid et al., 2025).

Implementing ESD in TVET requires not only changes to curriculum content but also comprehensive institutional transformation. Holst, Grund, and Brock (Holst, Grund, et al., 2024) demonstrate that the Whole Institution Approach (WIA) can significantly enhance learning motivation, sustainable behavior, and the empowerment of both students and educators. This approach integrates sustainability into institutional policies, the curriculum, educator training, assessment, the learning environment, organizational culture, and educational governance. These findings reinforce the results of Holst et al. (Holst, Grund, et al., 2024), which indicate that the implementation of ESD in various countries is still predominantly treated as an "add-on" program and has not yet fully become an integral part of the education system. This situation suggests that

the transformation toward sustainable vocational education still requires strengthening in the areas of policy, governance, curriculum development, and educator capacity building.

Research on the integration of Education for Sustainable Development into Technical and Vocational Education and Training has shown a steadily increasing trend over the past decade. This study employs a Systematic Literature Review (SLR) method in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The search identified 63 publications. The identification process did not find any duplicate articles, so all publications proceeded to the screening stage. The screening stage excluded 41 articles because they did not discuss the integration of ESD into TVET, were published before 2020, were not research articles, or were not available as open access. The selection process yielded 22 articles that met all inclusion criteria and were subsequently used as the basis for the synthesis in this study.

Although research on the integration of ESD into TVET has progressed quite rapidly, most studies still focus on the implementation of specific learning models, the development of sustainability competencies, curriculum evaluation in specific national contexts, or the measurement of the effectiveness of individual programs (Juwitasari, 2024; Li et al., 2022b; Wickramasinghe & Wickramasinghe, 2026). Existing studies have not yet provided a comprehensive synthesis of how ESD is integrated into TVET curricula, the implementation strategies employed, the sustainability competencies developed, stakeholder engagement, factors supporting and hindering implementation, and the direction of SDG-based TVET curriculum development across various vocational education contexts. These limitations have resulted in the absence of a complete conceptual framework regarding the patterns of ESD integration in vocational education.

This study offers a more comprehensive synthesis than previous studies by integrating various empirical research findings on the implementation of ESD in TVET from different countries. The analysis is conducted not only to map research trends but also to identify curriculum integration models, implementation strategies, learning approaches, sustainability competencies developed, stakeholder engagement, implementation challenges, and opportunities for the development of SDG-based TVET curricula. The results of this synthesis are expected to produce a conceptual framework capable of explaining the relationship between policy, curriculum, learning processes, graduate competencies, and the transformation of vocational education institutions toward sustainable development.

This study aims to systematically analyze the development of research on the integration of Education for Sustainable Development (ESD) into Technical and Vocational Education and Training (TVET) using the Systematic Literature Review method based on the PRISMA guidelines. This study is expected to provide a theoretical contribution in the form of a mapping of research developments and a conceptual synthesis regarding strategies for integrating ESD into the TVET curriculum. The practical contribution of this research is expected to serve as a reference for curriculum developers, vocational education institutions, policymakers, and researchers in designing TVET curricula that align with sustainable development goals and 21st-century competency needs.

2. Methodology

This study employs a Systematic Literature Review (SLR) approach to systematically identify, evaluate, and synthesize various studies on the integration of Education for Sustainable Development (ESD) into Technical and Vocational Education and Training (TVET). The SLR approach was chosen because it can present a synthesis of scientific evidence in a comprehensive, transparent, and replicable manner, thereby providing a more complete picture of research developments, implementation trends, research gaps, and the direction of future studies in this field. The study was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-

Analyses (PRISMA) guidelines, which provide systematic procedures ranging from literature identification to the synthesis of research findings. The use of the PRISMA guidelines aims to enhance the transparency of the article selection process and minimize potential bias in the preparation of the systematic review.

The literature search was conducted using the Scopus database, which was selected for its extensive coverage of international publications and rigorous journal selection process, making it a widely used primary source in systematic review-based research. The article search was conducted in June 2026 using the following keyword combination: (“education for sustainable development” OR ESD) AND (TVET OR “technical and vocational education and training” OR “vocational education”). This search strategy was designed to identify articles that specifically address the implementation or integration of Education for Sustainable Development within the context of Technical and Vocational Education and Training. All search results were then exported into a spreadsheet to facilitate the process of identifying, screening, and managing the research data.

Article selection was based on inclusion and exclusion criteria established before the review process began. Inclusion criteria included articles discussing the integration or implementation of ESD in TVET or vocational education, published between 2020 and 2026, classified as research articles, available via Open Access or Open Archive, written in English, and featuring a full text. Articles such as review articles, conference papers, book chapters, editorials, or publications that do not directly address the integration of ESD in TVET were excluded from the analysis. These criteria were established to identify relevant, up-to-date articles of sufficient scientific quality to support a comprehensive synthesis.

The literature selection process followed the four main stages outlined in the PRISMA guidelines: identification, screening, eligibility, and inclusion. The identification stage yielded 63 articles based on search results using predetermined keywords. A duplication check revealed no duplicate articles, so all articles proceeded to the screening stage. The screening stage involved reviewing the title, abstract, and keywords of each article. A total of 41 articles were excluded because they did not align with the research focus, were published before 2020, were not research articles, or were not available via Open Access. The eligibility stage involved reading the full texts of the articles that passed the screening process. The evaluation results showed that 22 articles met all inclusion criteria and were subsequently used as the primary sources in the research synthesis process. A flowchart of the article selection process based on the PRISMA guidelines is shown in Figure 1.

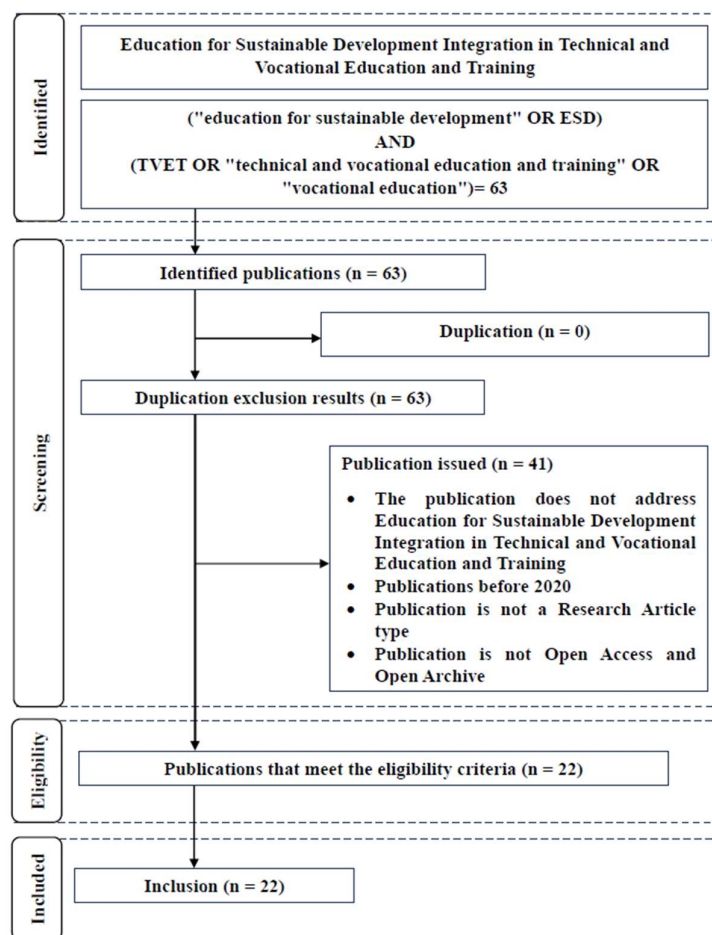


Fig. 1. Flowchart for article selection based on the PRISMA guidelines

Articles that met the inclusion criteria were further evaluated to ensure that all analyzed publications were relevant and of adequate methodological quality. The assessment focused on several aspects, including the alignment of the research objectives with the study topic, the clarity of the research methodology, the comprehensiveness of the presentation of research results, and the study's contribution to the implementation of Education for Sustainable Development in Technical and Vocational Education and Training. This quality assessment process aims to reduce potential bias resulting from the inclusion of articles with low methodological quality, thereby ensuring that the resulting synthesis has a higher level of reliability.

Data from each article were then systematically extracted using a synthesis worksheet prepared prior to the analysis process. The information collected included the authors' names, year of publication, country of study, research context, research methods, focus of ESD implementation, curriculum integration strategies, sustainability competencies developed, learning approaches used, key findings, research recommendations, and research limitations. The data extraction process was conducted consistently across all articles, enabling objective comparisons between studies and facilitating the identification of research patterns and trends.

Data analysis was conducted using thematic analysis through a process of thoroughly reading each article, coding key information, grouping research findings based on common characteristics, and then synthesizing the findings across studies. The analysis focused on several main themes, namely the development of research on ESD in TVET, models for integrating ESD into the curriculum, implementation strategies applied, sustainability competencies developed, learning approaches

used, factors supporting and hindering implementation, and recommendations for developing a TVET curriculum based on sustainable development. A thematic analysis approach was chosen because it allows for the integration of research findings using diverse methodological designs, thereby yielding a more comprehensive understanding of the implementation of Education for Sustainable Development in Technical and Vocational Education and Training.

3. Results

A total of 22 articles met all inclusion criteria based on the PRISMA guidelines, beginning with the identification of 63 articles and followed by a screening process according to the study criteria until relevant articles for analysis were obtained. These articles discuss the implementation of Education for Sustainable Development (ESD) in Technical and Vocational Education and Training (TVET) across various countries using diverse research approaches. The analysis was conducted in two stages: a bibliometric analysis using VOSviewer and a thematic synthesis of all selected articles. The bibliometric analysis aimed to map the development of the research topic, while the thematic synthesis was used to identify trends in the implementation of ESD within TVET curricula.

3.1 Distribution of Publications by Year

The distribution of articles indicates that research on the integration of ESD into TVET increased during the 2020–2026 period. Publications in the early period were still limited and focused more on the basic concepts of Education for Sustainable Development and the urgency of integrating sustainability into vocational education. After 2020, the number of publications increased consistently as the implementation of the Sustainable Development Goals (SDGs) gained momentum, particularly SDG Target 4.7, which positions education as the primary driver of sustainable development. This trend indicates that researchers' focus has begun to shift from conceptual discussions toward curriculum implementation, learning strategies, the development of sustainability competencies, and the evaluation of education policies. Distribution of Publications by Year is shown in Figure 2.

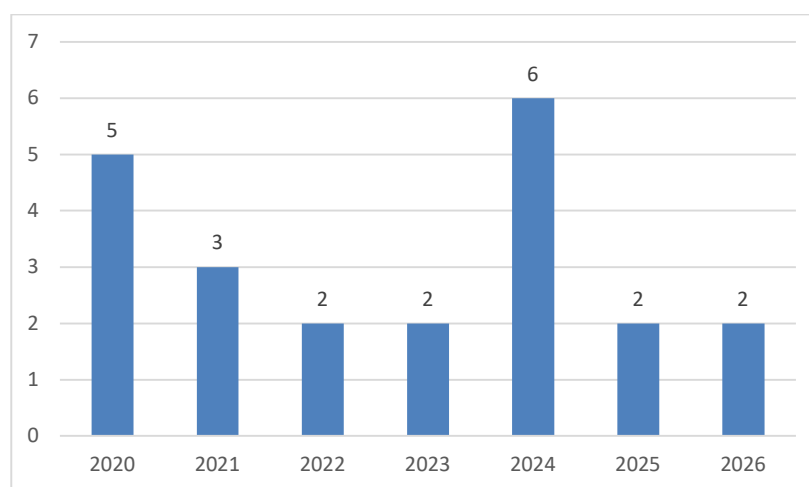


Fig. 2. Distribution of Publications by Year

The visualization also shows the interconnections between education for sustainable development, the Sustainable Development Goals, higher education, and teacher training. This pattern indicates that the implementation of ESD is often examined from the perspectives of education policy, curriculum development, and the enhancement of educators' competencies. In other words, the success of ESD implementation is greatly influenced by the readiness of educational institutions and educators to integrate sustainability values into the learning process.

In addition, several keywords appearing in shades of yellow to orange—such as artificial intelligence, competence, telecommunications, circular economy, carbon, and entrepreneurial education—point to relatively new directions in research. The emergence of these topics indicates that recent research is beginning to integrate issues of digital transformation, the circular economy, decarbonization, and technological innovation into the implementation of ESD in TVET. This shift demonstrates that research is no longer solely focused on fostering environmental awareness but also on developing 21st-century skills that support the transition toward a green economy and sustainable industries.

Overall, this co-occurrence map shows that research on the integration of ESD in TVET is evolving from foundational themes such as education, learning, and curriculum development toward more complex issues, namely digital transformation, green competencies, the circular economy, and the strengthening of educational institutions' capacity. These findings indicate that the implementation of ESD in TVET is increasingly moving toward a holistic, multidisciplinary, and adaptive approach to the challenges of sustainable development in the era of the Fourth Industrial Revolution and the transition to a green economy.

3.3 Density Visualization

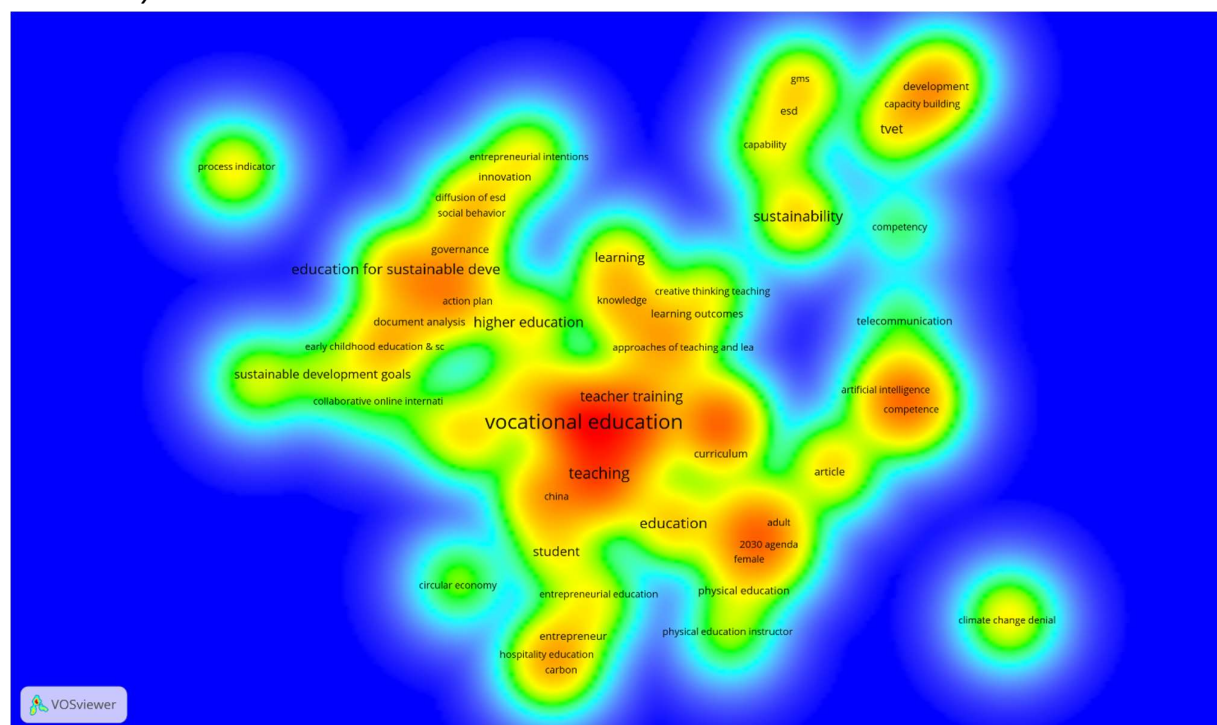


Fig. 4. Density Visualization of the VOSviewer Analysis Results

Figure 4 shows the results of a density visualization using VOSviewer for 22 articles discussing the integration of Education for Sustainable Development (ESD) into Technical and Vocational Education

and Training (TVET). This visualization illustrates the density of keyword occurrences based on frequency and the relationships between keywords. The red areas indicate the most frequently studied topics with the strongest interconnections, while the green to blue areas indicate topics that have been relatively less discussed and thus hold potential as directions for future research.

The analysis results show that “vocational education” is the keyword with the highest density, marked by the color red. This finding indicates that vocational education is the focal point in research on the implementation of ESD. Surrounding this keyword are several others—such as “teaching,” “teacher training,” “education,” “curriculum,” and “student”—which form areas ranging from red to orange. This suggests that most research still focuses on developing learning processes, enhancing educator competencies, curriculum development, and building student competencies as key strategies for integrating sustainability principles into TVET. This finding is consistent with various studies stating that the transformation of vocational education toward sustainability must begin with changes to the curriculum, learning methods, and the capacity building of educators.

The next area of high density is centered on the keywords “sustainability,” “higher education,” “education for sustainable development,” and “learning.” This indicates that the research not only addresses the implementation of ESD at the vocational education level but also links it to higher education, the learning process, and the development of sustainability competencies. The close relationship among these keywords suggests that ESD is viewed as a cross-level learning approach that requires a comprehensive transformation of the education system.

The visualization also highlights several areas of moderate density, such as TVET, development, capacity building, competency, learning outcomes, and creative thinking in teaching. Although they have not yet become a primary focus, these topics have shown an upward trend in recent years. Research is beginning to highlight the importance of developing green competencies, enhancing institutional capacity, and implementing innovative learning models to support the achievement of sustainable development goals.

On the other hand, several keywords—such as artificial intelligence, circular economy, carbon, entrepreneurial education, telecommunications, process indicators, and climate change denial—fall within the green to blue zones, indicating a low level of density. This suggests that these topics are still relatively new and have not been extensively explored in the context of ESD integration in TVET. Yet, these issues are highly relevant to the development of the Fourth Industrial Revolution, digital transformation, the circular economy, and the transition to a green economy. Therefore, these topics present significant opportunities for future research.

Overall, the Density Visualization shows that the research landscape on ESD integration in TVET is still dominated by pedagogical themes, namely curriculum, learning processes, vocational education, and teacher competency development. Meanwhile, research linking ESD to digital technology, artificial intelligence, the circular economy, sustainability evaluation indicators, and industrial innovation remains limited. These findings indicate the existence of a research gap that can serve as a basis for further research, particularly in designing TVET curriculum models capable of integrating sustainability with digital transformation and the 21st-century demand for green skills.

3.4 Thematic Synthesis of ESD Implementation in TVET

A synthesis of 22 articles shows that the implementation of Education for Sustainable Development (ESD) in Technical and Vocational Education and Training (TVET) can be grouped into five main themes. The grouping was based on similarities in research focus, implementation strategies, competencies developed, and recommendations presented in each article.

Table 1. Thematic Synthesis of ESD Implementation in TVET

Theme	Synthesis Focus	Key Findings	Implications for TVET
Integration of ESD into the Curriculum	Integrating sustainability principles into the TVET curriculum	Integration is carried out through a horizontal approach (incorporation into existing courses) and a vertical approach (development of new courses). The curriculum has begun to incorporate the SDGs, a green curriculum, the circular economy, and sustainability competencies.	The TVET curriculum needs to be designed to be flexible and adaptive so that it can integrate the principles of sustainability into all learning programs.
Development of Sustainability Competencies	Competencies Required of Graduates	The competencies most frequently developed include systems thinking, critical thinking, problem solving, creativity, collaboration, communication, ethical responsibility, green skills, and environmental awareness.	TVET needs to develop 21st-century competencies that align with the needs of a sustainable industry.
ESD Implementation Strategy	Learning Approaches	Implementation is carried out through Project-Based Learning, Problem-Based Learning, experiential learning, work-based learning, creative thinking, Kaizen, interdisciplinary learning, and the Whole Institution Approach.	Learning should be oriented toward real-world experiences, collaboration, and sustainable problem-solving.
Policy Support and Partnerships	Factors supporting implementation	The success of implementation is influenced by institutional policies, leadership, teacher training, partnerships with industry, and multi-stakeholder collaboration.	The implementation of ESD requires institutional transformation, not just curriculum changes.
Challenges and Directions for Development	Barriers to implementation	The main challenges include limited teacher competencies, uneven integration of the SDGs, a lack of evaluation of implementation, and low utilization of digital technology and artificial intelligence in ESD.	Future research should develop an ESD integration model that leverages digital technology, AI, micro-credentials, and the strengthening of green skills.

3.5 Thematic Framework of Education for Sustainable Development Integration in Technical and Vocational Education and Training

A synthesis of 22 articles resulted in a thematic framework that illustrates the relationships among key factors in the implementation of Education for Sustainable Development (ESD) in Technical and Vocational Education and Training (TVET). This framework was developed through a thematic analysis of all articles that met the inclusion criteria and is visualized in the form of a mind map, as shown in Figure 5. This visualization provides a comprehensive overview of the main themes that consistently emerge across various studies while illustrating the relationships between these themes in fostering the implementation of ESD within the TVET context.

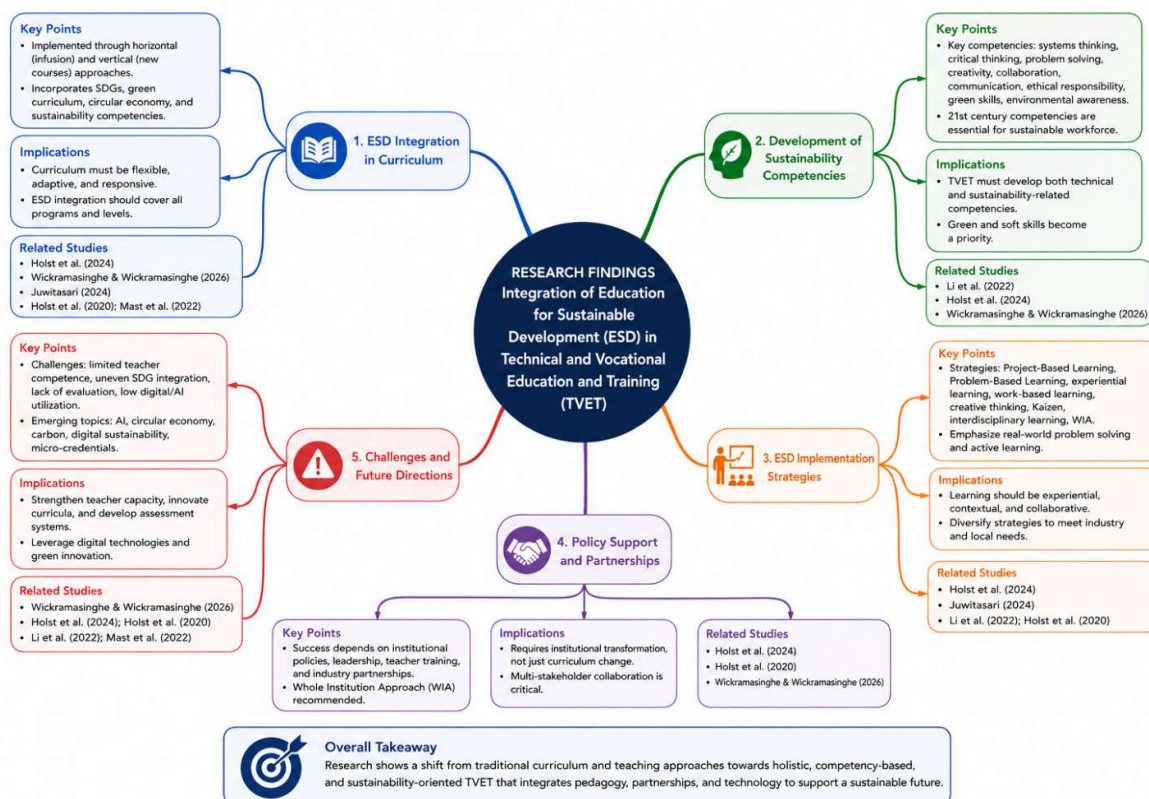


Fig. 5. Thematic Framework of Education for Sustainable Development Integration in Technical and Vocational Education and Training

Based on Figure 5, the implementation of ESD in TVET is built on five main components: ESD Integration in the Curriculum, Development of Sustainability Competencies, ESD Implementation Strategies, Policy Support and Partnerships, and Challenges and Future Directions. These five components form an interconnected system and demonstrate that the success of ESD implementation is not only determined by curricular changes but is also influenced by learning strategies, human resource readiness, institutional support, and the institution's ability to address various implementation challenges.

The first theme, ESD Integration in the Curriculum, positions the curriculum as the primary foundation for implementing sustainable development education. The synthesis findings indicate that most studies integrate ESD principles through two approaches: horizontal integration incorporating sustainability content into existing courses and vertical integration developing new courses or programs specifically focused on sustainability. This integration includes alignment with the Sustainable Development Goals (SDGs), the development of a green curriculum, the application of circular economy concepts, and the strengthening of sustainability competencies. This approach demonstrates that TVET curricula must be designed to be flexible and adaptive in order to respond to changing labor market needs and the sustainable development agenda.

The second component, "Development of Sustainability Competencies," describes a shift in the orientation of vocational education from the mastery of technical skills toward the development of sustainability competencies. The synthesis results show that the most commonly developed competencies include systems thinking, critical thinking, problem solving, creativity, collaboration, communication, ethical responsibility, green skills, and environmental awareness. These

competencies are viewed as 21st-century competencies that TVET graduates must possess in order to adapt to industrial transformation toward a green economy and sustainable development.

The third component, ESD Implementation Strategies, indicates that implementing ESD requires a transformation of the learning process. Various studies have applied Project-Based Learning, Problem-Based Learning, Experiential Learning, Work-Based Learning, Creative Thinking, Kaizen, interdisciplinary learning, and the Whole Institution Approach as key strategies. These approaches focus on solving real-world problems, contextual learning experiences, and collaboration with industry, thereby making learning more relevant to the needs of society and the workforce.

The fourth component, Policy Support and Partnerships, emphasizes that ESD implementation cannot rely solely on changes in learning but requires comprehensive institutional support. The synthesis indicates that the success of implementation is influenced by institutional policies, leadership, educator training, partnerships with industry, and multi-stakeholder collaboration. The Whole Institution Approach (WIA) is one of the most consistently recommended strategies in the literature because it effectively integrates sustainability into the curriculum, governance, organizational culture, and the learning environment as a whole.

The final section, “Challenges and Future Directions,” highlights that the implementation of ESD in TVET still faces a number of challenges. The most frequently reported barriers include limited educator competencies, uneven integration of the SDGs into the curriculum, a lack of implementation evaluation systems, and low utilization of digital technology and artificial intelligence in learning. Recent research is beginning to focus on the development of artificial intelligence, micro-credentials, digital sustainability, the circular economy, and green innovation as future directions for vocational education. These trends indicate that the implementation of ESD will be increasingly influenced by technological advancements and evolving labor market needs.

Overall, the thematic framework in Figure 5 demonstrates that the implementation of ESD in TVET constitutes an interconnected system. The curriculum serves as the primary foundation, supported by innovative learning strategies, the development of sustainability competencies, conducive institutional policies, and collaboration with various stakeholders. The integration of all these components is expected to produce TVET graduates who possess green skills, sustainability competencies, the ability to adapt to industrial changes, and the readiness to contribute to the achievement of the Sustainable Development Goals (SDGs).

4. Discussion

The findings of this synthesis indicate that the implementation of Education for Sustainable Development (ESD) in Technical and Vocational Education and Training (TVET) has shifted from an approach focused on the mastery of technical skills toward a more holistic development of sustainability competencies. The integration of ESD is no longer viewed as an add-on but has become an integral part of the curriculum, the learning process, and the management of educational institutions. This finding is supported by the results of a bibliometric analysis, which indicate that the focus of research in recent years has shifted from conceptual studies toward curriculum implementation, competency development, and institutional capacity building. This trend aligns with the findings of Holst et al. (Holst et al., 2020), who emphasize that the successful implementation of ESD requires a comprehensive transformation of the education system through a Whole Institution Approach, as well as the research by Wickramasinghe and Wickramasinghe (Wickramasinghe & Wickramasinghe, 2026), which highlights the increasing integration of the SDGs, green curricula, and micro-credentials into vocational education.

A synthesis of the research also indicates that the success of ESD implementation is influenced by the interrelationship between the curriculum, learning strategies, educator competencies, and

institutional support. Curriculum integration through both horizontal and vertical approaches enables sustainability values to be applied consistently throughout the learning process. Learning approaches such as Project-Based Learning, Problem-Based Learning, Experiential Learning, and Work-Based Learning have been proven to develop systems thinking, critical thinking, creativity, collaboration, and problem-solving skills—all of which are part of sustainability competencies (Li et al., 2022b). These findings reinforce Juwitasari's (Juwitasari, 2024) view that vocational education must strike a balance between technical competencies, sociocultural values, and environmental awareness to produce graduates who are relevant to the needs of sustainable development.

The findings of this study also indicate that the implementation of ESD cannot be achieved through curriculum changes alone but requires policy support, institutional leadership, enhanced educator competencies, and partnerships with the business and industrial sectors. The Whole Institution Approach is one of the most widely recommended strategies because it integrates sustainability into the curriculum, governance, organizational culture, and the learning environment simultaneously (Holst, Grund, et al., 2024). The involvement of various stakeholders is also a critical factor in ensuring that TVET curricula remain adaptable to technological advancements, industry needs, and the demands of achieving the Sustainable Development Goals.

The results of the Overlay Visualization and Density Visualization analyses show that research on the integration of ESD in TVET is still dominated by themes such as curriculum, learning, vocational education, and teacher training. Topics such as artificial intelligence, digital sustainability, the circular economy, green innovation, and micro-credentials are beginning to emerge as new research directions, but the intensity of research in these areas remains relatively low. This situation indicates opportunities for further research to develop ESD implementation models that integrate digital transformation with the development of sustainability competencies, thereby enabling vocational education to respond more adaptively to changing labor market needs (Wickramasinghe & Wickramasinghe, 2026).

This study contributes a thematic framework on the integration of ESD into TVET, demonstrating that the implementation of sustainable education is a systemic process. Curriculum, learning, competencies, policies, partnerships, and institutional innovations are interrelated in shaping a sustainability-oriented vocational education ecosystem. This framework can serve as a reference for curriculum developers, vocational education institutions, and policymakers in designing more comprehensive ESD implementation strategies, as well as a foundation for future research to develop implementation models tailored to the characteristics of vocational education in various national contexts.

5. Conclusions

This study successfully synthesized 22 articles on the integration of Education for Sustainable Development (ESD) into Technical and Vocational Education and Training (TVET) using a Systematic Literature Review (SLR) approach based on the PRISMA guidelines. The results show that the implementation of ESD in TVET has evolved from strengthening technical skills toward developing sustainability competencies through curriculum integration, learning innovations, capacity building for educators, as well as policy support and partnerships. Bibliometric analysis and thematic synthesis identified five key components of ESD implementation: curriculum integration, development of sustainability competencies, implementation strategies, policy support and partnerships, and future development challenges. These findings underscore that the successful implementation of ESD requires a systemic and collaborative approach so that TVET can produce graduates who possess technical competencies, green skills, and a sense of responsibility toward sustainable development. This study provides a thematic framework that can serve as a reference for curriculum developers,

TVET institutions, and policymakers, while also opening opportunities for further research on the integration of digital technology and artificial intelligence, as well as the evaluation of ESD implementation in vocational education.

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References

- Asikainen, E., & Tapani, A. (2021). Exploring the connections of education for sustainable development and entrepreneurial education—A case study of vocational teacher education in Finland. *Sustainability (Switzerland)*, 13(21). <https://doi.org/10.3390/su132111887>
- Budi, A. H. S., Juanda, E. A., Indrawan, D., Henny, H., & Masek, A. (2024). Integration of Sustainable Development Competency Points into the Telecommunication System Subjects at Vocational High School. *Journal of Technical Education and Training*, 16(3), 232–237. <https://doi.org/10.30880/jtet.2024.16.03.016>
- Chinedu, C. C., Saleem, A., & Wan Muda, W. H. N. (2023). Teaching and Learning Approaches: Curriculum Framework for Sustainability Literacy for Technical and Vocational Teacher Training Programmes in Malaysia. *Sustainability (Switzerland)*, 15(3). <https://doi.org/10.3390/su15032543>
- Chinedu, C. C., Wan Mohamed, W. A., & Ajah, A. O. (2018). A systematic review on education for sustainable development: Enhancing the teacher training programme. *Journal of Technical Education and Training*, 10(1), 109–125. <https://doi.org/10.30880/jtet.2018.10.01.009>
- Chiu, W.-K. (2025). Innovations and Technologies in Education for Sustainable Health and Development: Challenges, Opportunities, and Implications for Future Research. *Open Public Health Journal*, 18. <https://doi.org/10.2174/0118749445393719250509071008>
- Hamid, N. A., Kamaruzaman, F. M., Suradin, S., Rasul, M. S., & Othman, N. N. J. N. (2025). Integrating Circular Economy Through Refuse, Rethink and Reduce in Vocational Education for Sustainable Development. *Journal of Technical Education and Training*, 17(3), 92–105. <https://doi.org/10.30880/jtet.2025.17.03.007>
- Holst, J., Brock, A., Singer-Brodowski, M., & de Haan, G. (2020). Monitoring progress of change: Implementation of Education for Sustainable Development (ESD) within documents of the German education system. *Sustainability (Switzerland)*, 12(10). <https://doi.org/10.3390/su12104306>
- Holst, J., Grund, J., & Brock, A. (2024). Whole Institution Approach: measurable and highly effective in empowering learners and educators for sustainability. *Sustainability Science*, 19(4), 1359–1376. <https://doi.org/10.1007/s11625-024-01506-5>
- Holst, J., Singer-Brodowski, M., Brock, A., & de Haan, G. (2024). Monitoring SDG 4.7: Assessing Education for Sustainable Development in policies, curricula, training of educators and student assessment (input-indicator). *Sustainable Development*, 32(4), 3908–3923. <https://doi.org/10.1002/sd.2865>
- Igberaharha, C. O. (2021). Improving the quality of Technical Vocational Education and Training (TVET) for sustainable growth and development of Nigeria. *Journal of Education and E-Learning Research*, 8(1), 109–115. <https://doi.org/10.20448/JOURNAL.509.2021.81.109.115>
- Juwitasari, R. (2024). Education for Sustainable Development (ESD) in Post-modernity: A Case Study of Japanese Value Manifestation in Vocational Education in Greater Mekong Sub-Region Country. *Journal of Technical Education and Training*, 16(3), 216–231. <https://doi.org/10.30880/jtet.2024.16.03.015>
- Lambini, C. K., Goeschl, A., Wäsch, M., & Wittau, M. (2021). Achieving the sustainable development goals through company staff vocational training—the case of the federal institute for vocational education and training (Bibb) inebb project. *Education Sciences*, 11(4). <https://doi.org/10.3390/educsci11040179>
- Lehmann, T., Iyer-Raniga, U., & Mahoney, K. (2025). Learning for sustainability: Adult transformative learning through sustainability and culturalism perspectives. *Social Sciences and Humanities Open*, 11. <https://doi.org/10.1016/j.ssaho.2025.101523>
- Li, X.-Z., Chen, C.-C., & Kang, X. (2022a). Research on the cultivation of sustainable development ability of higher vocational students by creative thinking teaching method. *Frontiers in Psychology*, 13. <https://doi.org/10.3389/fpsyg.2022.979913>
- Li, X.-Z., Chen, C.-C., & Kang, X. (2022b). Research on the cultivation of sustainable development ability of higher vocational students by creative thinking teaching method. *Frontiers in Psychology*, 13. <https://doi.org/10.3389/fpsyg.2022.979913>

- Mkhatshwa, I., Madikida, P., & Uleanya, C. (2026). Quality education for sustainable development: Perceptions of technical, vocational, education and training leaders. *International Journal of Education and Practice*, 14(2), 186–197. <https://doi.org/10.18488/61.v14i2.4882>
- Scott, W. A. H., & Gough, S. R. (2010). Sustainability, learning and capability: Exploring questions of balance. *Sustainability*, 2(12), 3735–3746. <https://doi.org/10.3390/su2123735>
- Singer-Brodowski, M., Etzkorn, N., & von Seggern, J. (2019). One transformation path does not fit all-insights into the diffusion processes of education for sustainable development in different educational areas in Germany. *Sustainability (Switzerland)*, 11(1). <https://doi.org/10.3390/su11010269>
- Wickramasinghe, G. L. D., & Wickramasinghe, V. (2026). Implementation of sustainability into training, upskilling, and reskilling curricula of technical and vocational education and training in south and southeast Asia. *Discover Sustainability*, 7(1). <https://doi.org/10.1007/s43621-026-02917-3>
- Yang, B., Wu, F., Dong, S., Wang, J., Zhang, Q., Hu, H., Wu, X., Jin, J., Cai, Y., & Luo, P. (2026). The Impact of the Sand Table Simulation Teaching Method on Secondary Vocational Students' Sustainable Practical Competencies: An Empirical Study on Engineering Bidding Instruction. *Sustainability (Switzerland)*, 18(3). <https://doi.org/10.3390/su18031544>
- Yang, W., Chinedu, C. C., Chen, W., Saleem, A., Ogunniran, M. O., Ñacato Estrella, D. R., & Vaca Barahona, B. (2024a). Building Capacity for Sustainability Education: An Analysis of Vocational Teachers' Knowledge, Readiness, and Self-Efficacy. *Sustainability (Switzerland)*, 16(9). <https://doi.org/10.3390/su16093535>
- Yang, W., Chinedu, C. C., Chen, W., Saleem, A., Ogunniran, M. O., Ñacato Estrella, D. R., & Vaca Barahona, B. (2024b). Building Capacity for Sustainability Education: An Analysis of Vocational Teachers' Knowledge, Readiness, and Self-Efficacy. *Sustainability (Switzerland)*, 16(9). <https://doi.org/10.3390/su16093535>