JOVES (Journal of Vocational Education Studies)
VOL 7, No. 2, 2024, pp. 313-334
pISSN: 2614-7483 pISSN: 2614-7475 https://doi.org/10.12928/joves.v7i2.10416

Exploring Approaches in Green Technical and Vocational Education Training (TVET): A Systematic and Bibliometric Review

[a, 1] Albert Adjei *, [a, 2] Prof. Dr. Budi Mulyanti, [a, 3] Prof. Prof Ade Gafar Abdullah, [b, 4]Theodore Oduro-Okyere [b, 5] Prince Osei- Bonsu

[a] Universitas Pendidikan Indonesia, Indonesia

[b] Cape Coast Technical University, Ghana

Email: [1]albertadjei748@gmail.com *, [2] ade_gaffar@upi.edu, [3] bmulyanti@upi.edu ,
[4]theodoreoduro-okyireh@upi.edu , [5]prinobon@gmail.com

* Correspondence author

ARTICLE INFO

Article history
Received Apr 20, 2024
Revised Jun 20, 2024
Accepted Jun 23, 2024

Keywords
Green TVET
Innovative Approaches
Curriculum Integration
Pedagogical Strategies
Evaluation Methods

ABSTRACT

This study identifies and analyzes the main research areas related to green technical and vocational education training (TVET). It focuses on evaluating the extent of its integration into TVET programs. The research explores the link between green TVET, environmental sustainability, and its impact on human development, drawing on research and data from the past decade (2013-2023). This paper aims to offer readers an in-depth insight into progress and prospective developments, with a specific emphasis on the pedagogical approach in Technical and Vocational Education Training (TVET) and stakeholders' concerns in this domain. To achieve this goal, the study applied the Systematic Literature Network Analysis (SLNA) method, combining bibliometric analysis techniques with a systematic literature review (SLR) using the PRISMA approach. This integrated approach utilizes objective measurements and algorithms to discern emerging themes and subjects to gain a thorough understanding of the current state of green TVET and potential paths for further integration to address environmental issues and enhance human capacity. The paper finds that green TVET positively affects learners' knowledge, skills, attitudes, and behaviors related to environmental sustainability, as well as their employability and career prospects in the green economy. It highlights challenges and gaps in implementing and evaluating green TVET, such as the lack of standardized definitions, indicators, and methodologies, insufficient integration of green competencies, and limited stakeholder involvement. The paper concludes with recommendations for policy and practice and directions for future research.

Introduction

As the world moves towards a more sustainable future, the role of education in fostering environmental awareness becomes increasingly critical. Green Technical and Vocational Education and Training (TVET) emerges as a pivotal element in this transformation, blending traditional skills training with knowledge of sustainable practices (McGrath & Russon, 2023). This integration is vital for preparing a workforce capable of thriving in the green economy, addressing the technical demands and the environmental challenges of contemporary labor markets(Knudsen et al., 2023).

This article explores the incorporation of green TVET into educational programs, examining its impact on equipping individuals with the competencies needed for sustainable careers. By focusing on the synergy between technical proficiency and environmental sustainability, green TVET addresses the evolving needs of today's job market(Ordu, 2022). The discussion highlights innovative teaching strategies and the perspectives of various stakeholders, while also identifying areas where further engagement and research are needed.

Role of Stakeholders in Green TVET

The successful implementation and scaling up of green Technical and Vocational Education and Training (TVET) depend heavily on the active involvement of various stakeholders worldwide, including policymakers, industry partners, educators, and students (Marope et al., 2015). Each group has distinct yet interconnected roles that collectively contribute to the effectiveness and relevance of green TVET programs across different regions.

Policymakers globally play a pivotal role in creating an enabling environment for green TVET by developing supportive policies, providing funding, and fostering public-private partnerships. For example, in Germany, sustainability is incorporated into vocational training standards, ensuring that green competencies are mandated in TVET curricula(von Beckerath, 2021). Similarly, the Philippines allocates budgetary support for green skills training to bolster the country's green economy. Public-private partnerships, such as South Korea's collaboration with the Korea Electric Power Corporation (KEPCO), align training programs with the needs of the green economy, demonstrating how governments can work with industry to support green education (CHA & DUMOND, 2017).

Industry partners worldwide ensure that green TVET programs remain relevant to current market needs and technological advancements (Lamichhane, 2019). For instance, renewable energy companies like Denmark's Vestas offer internships and apprenticeships in wind energy projects, providing students with hands-on experience. In the United Kingdom, sustainable construction

firms collaborate with TVET institutions to design courses on eco-friendly building practices(America, 2013). Companies globally, such as the waste management firm Veolia, provide employment pathways for graduates in recycling and waste reduction initiatives, showing the crucial role of industry in bridging the gap between education and employment.

Educators are at the forefront of delivering effective green TVET programs across the globe. Continuous professional development is essential, with educators attending workshops on the latest sustainable technologies and practices, such as those offered by the Green Building Council. Integrating sustainability across disciplines enhances learning experiences; for example, a project-based module where biology and engineering teachers collaborate on designing a sustainable urban garden demonstrates this interdisciplinary approach(Gu et al., 2011). Innovative teaching methods, including virtual simulations of renewable energy systems, further enrich the educational experience and prepare students for real-world applications.

Students, as the primary beneficiaries of green TVET, play a crucial role through their engagement and feedback. Involvement in curriculum development ensures that the training meets their needs and aspirations. For instance, student feedback through surveys can help refine programs to be more effective. Participation in extracurricular activities, such as green clubs or sustainability projects, provides practical applications of theoretical knowledge, while peer education and advocacy, through organizing workshops to educate peers about sustainability practices, highlight the proactive role students play in green education(Roberts, 2009).

Impact of Green TVET on Employability and Career Prospects

The impact of green Technical and Vocational Education and Training (TVET) on employability and career prospects is significant, providing graduates with the skills and knowledge necessary to thrive in growing green sectors such as renewable energy, sustainable construction, and environmental management (Pavlova, 2017). Despite the clear advantages, there is a need for more comprehensive research to quantify these benefits and optimize green TVET to maximize career opportunities for students globally.

Green TVET prepares students for a wide range of employment opportunities in various green sectors. For instance, a student trained in energy-efficient building techniques is well-suited for jobs in sustainable construction (Ramli et al., 2020). In countries like Germany, where the construction industry increasingly focuses on sustainability, these skills are highly valued. Similarly, those trained in renewable energy technologies can find employment as solar panel installers, wind turbine technicians, or energy auditors. In the United States, the solar industry alone employed over

250,000 workers as of 2020, highlighting the growing demand for green skills as the country works towards its climate goals (Plaskacz, 2009).

Green TVET not only facilitates entry into the job market but also supports career advancement. Continuous professional development in green skills can lead to higher positions within organizations, such as sustainability managers or environmental compliance officers (Mustapha, 2015). For example, in the United Kingdom, professionals with green skills are sought after to help companies meet regulatory requirements and corporate sustainability goals. These roles are increasingly crucial as businesses worldwide recognize the importance of sustainability in their operations and strategies.

Furthermore, green TVET can foster entrepreneurship by equipping students with the skills needed to start their own green businesses (Pirzada et al., 2023). Training in sustainable agriculture, for instance, can enable graduates to establish eco-friendly farms. In Kenya, initiatives like the Kenya Climate Innovation Center support entrepreneurs who focus on sustainable farming practices, demonstrating the potential of green TVET to spur innovation and entrepreneurship (Side, 2021). Similarly, knowledge of green building practices can lead to the creation of companies specializing in sustainable construction. In India, the rise of green building certifications like IGBC (Indian Green Building Council) has created a demand for skilled professionals who can design and construct environmentally friendly buildings (Darko et al., 2013).

In a globalized economy, having green skills enhances the competitiveness of graduates. Countries with robust green TVET programs can position themselves as leaders in the green economy, attracting international businesses and investments. Germany's dual education system, which integrates green skills training, has made it a global leader in renewable energy and sustainable manufacturing. This model serves as an example for other nations looking to bolster their green economies. Similarly, China’s significant investment in green education and training has positioned it as a dominant player in the global renewable energy market(Knuth, 2018).

Green TVET programs also play a critical role in helping countries meet their climate goals. For example, in Denmark, a strong focus on green TVET has supported the country’s ambition to become carbon-neutral by 2050(Stamm et al., 2023). This comprehensive approach includes training in renewable energy, sustainable transportation, and energy-efficient technologies, providing students with diverse career opportunities and supporting national environmental targets.

The impact of green TVET on employability and career prospects is profound, preparing students for various roles in the green economy and supporting career advancement and

entrepreneurship. By equipping students with essential green skills, countries can enhance their global competitiveness, meet climate goals, and foster sustainable economic growth(Aceleanu, 2015). More comprehensive research is needed to fully understand and optimize these benefits, ensuring that green TVET programs continue to evolve and meet the demands of a rapidly changing global economy.

Challenges and Barriers

The implementation of green Technical and Vocational Education and Training (TVET) faces several significant challenges, including lack of policy coherence, inadequate integration of green competencies in curricula, limited stakeholder involvement, and insufficient resources(Marope et al., 2015). These issues create a gap between the idealized vision of green TVET and the current reality, where many programs do not fully integrate practical experiences with sustainable technologies.

One major challenge is the lack of coordinated policies across different levels of government and sectors, which can impede the effective implementation of green TVET. Ensuring that policies are aligned and support comprehensive green skills training is essential for success (Marope et al., 2015). For instance, in many countries, policies related to education, labor, and environmental sustainability are not always synchronized, leading to fragmented efforts and inefficiencies.

Incorporating green competencies into existing curricula is another significant hurdle. This process requires a thorough review and modification of teaching materials, as well as the development of new modules that focus specifically on sustainability. In countries like India, where the TVET system is vast and diverse, integrating green competencies requires substantial effort and coordination across various educational institutions (Souto-Otero, 2023). Additionally, teachers need to be trained to deliver these new modules effectively, which adds another layer of complexity.

Engaging all relevant stakeholders in the design and implementation of green TVET programs is crucial but often lacking (Pavlova & Askerud, 2024). Effective communication and collaboration between policymakers, industry partners, educators, and students are necessary to ensure that the training meets the needs of the labor market. For example, in the United States, some green TVET programs have successfully partnered with local industries to provide hands-on training in renewable energy technologies. However, such partnerships are not yet widespread and need to be scaled up to have a broader impact (Mukul et al., 2024; Sarkar & Mukul, 2024).

Adequate funding and resources are essential for the successful implementation of green TVET. This includes investments in training facilities, teaching materials, and professional development

for educators. Without sufficient resources, it is difficult to provide high-quality training that prepares students for green jobs. In many developing countries, limited financial resources pose a significant barrier to the expansion and enhancement of green TVET programs.

This introduction sets the stage for a comprehensive analysis of the current state and future directions of green TVET, emphasizing its potential as a catalyst for sustainable development(Mancotywa, 2023). By delving into both the integration of sustainable practices into TVET programs and the crucial roles played by various stakeholders, the article aims to provide a holistic view of how green TVET can drive the transition towards a greener economy.

Effective policy coherence is fundamental to the successful implementation of green TVET. Policymakers must work together at local, regional, and national levels to create a unified strategy that supports green skills training. For example, the European Union's Green Deal emphasizes the importance of aligning education policies with environmental goals, promoting a cohesive approach to sustainability across member states.

Incorporating green competencies into curricula requires a collaborative effort between educational institutions, industry experts, and policymakers(Okada & Gray, 2023). This involves not only updating existing curricula but also developing new training programs that address the specific needs of the green economy. For instance, the introduction of renewable energy courses in South African TVET colleges reflects a proactive approach to curriculum development, ensuring that students acquire relevant skills for emerging green jobs.

Stakeholder involvement is key to the success of green TVET(Quan-Baffour & Akpey-Mensah, 2022). Effective communication and collaboration among all parties ensure that training programs are relevant and aligned with industry needs. In Canada, partnerships between TVET institutions and renewable energy companies have led to the development of tailored training programs that provide students with practical experience and improve their employability.

Securing adequate funding and resources is critical for the sustainability of green TVET programs. Investments in state-of-the-art training facilities, modern teaching materials, and continuous professional development for educators are necessary to maintain high standards of education. Countries like Germany and Denmark have made significant investments in their TVET systems, setting a benchmark for other nations to follow(Hendriks et al., 2010).

While several challenges hinder the implementation of green TVET, addressing these issues through policy coherence, curriculum integration, stakeholder engagement, and adequate funding can significantly enhance its impact (Pavlova & Askerud, 2024). Green TVET has the potential to be

a powerful driver of sustainable development, preparing a skilled workforce that can contribute to the global transition towards a greener economy.

Research Gap

A lack of attention to how Green TVET principles are applied in the actual teaching and learning processes, such as the methods, materials, and assessments used by TVET institutions and practitioners is the main flaw in the existing literature (Chinedu et al., 2023). The present study aims to fill this gap by exploring and proposing innovative approaches and potential areas for improvement in these aspects of Green TVET. It also considers the contextual and cultural factors that affect the implementation and outcomes of Green TVET(Owusu-Agyeman & Aryeh-Adjei, 2024). This gap is important to address because it can help improve the quality and relevance of TVET for sustainable development and a green economy.

Novelty Of Work

This research is unique in its focus on using bibliometric and systematic methods to select existing studies on green Technical and Vocational Education and Training (TVET). Although the methods used are not new, the study seeks to bridge literature gaps by providing a summary of progress in this particular field (McGrath et al., 2020; Muela et al., 2023). The research uses a systematic literature review (SLR) adopting the PRISMA approach to spot trends in green TVET studies and to investigate the standards used by different researchers in their studies(Alqahtani et al., 2023; Yusop et al., 2022). A bibliometric analysis is also performed to offer a more detailed understanding and review of sustainability and green TVET. The main goal of this research is to highlight the changing scope of studies in green TVET, which could aid in the efficient and safe application of eco-friendly practices in educational institutions and the surrounding environment. The research aims to answer the following questions:

Research Questions

1. What are the latest trends in publications and citations regarding the practical application of green TVET, particularly in the context of pedagogical approaches?
2. What are the key variables and terms associated with green TVET that authors frequently use in their research studies?
3. Which are the ten most frequently cited works in the field of green TVET and sustainability?
4. What are the predominant themes, methodologies, and findings in the current literature on Green Technical and Vocational Education and Training (TVET)
5. What specific areas within Green TVET are researchers focusing on, and what key

dimensions or aspects are under investigation?

6. What case studies on Green TVET in various geographical locations, focus on strategies, challenges, and outcomes of integrating environmental sustainability into vocational education programs.

Method

This study conducts a comprehensive review of green Technical and Vocational Education and Training (TVET) literature that spans studies conducted mostly between 2013 and 2024, providing a comprehensive overview of the developments in green TVET and its impact on various sectors to assess its integration, impact, and future trajectories. Employing a systematic literature review (SLR) combined with bibliometric analysis (BA), the research adheres to the PRISMA 2020 guidelines for systematic reviews to maintain transparency and rigor.

The BA examines publication and citation trends from 2003 to 2023, providing a macroscopic view of green TVET research. It excludes studies solely focused on sustainability practices' viability. This component identifies influential works and traces the field's growth through publication counts, citation analysis, and authorship patterns. Simultaneously, the SLR delves into green TVET skills' incorporation and their sustainability impact. It aims to pinpoint best practices and challenges in embedding green skills into TVET curricula. The SLR meticulously selects relevant studies for in-depth analysis, offering insights into green TVET initiatives' effectiveness.

A PRISMA flow diagram visually outlines the review process, detailing study identification, screening, eligibility, and inclusion steps(Cherry et al., 2023). This ensures methodological transparency. By integrating quantitative BA insights with SLR qualitative findings, the study presents a nuanced understanding of green TVET's current state, research gaps, and future research avenues (Saputro, 2024). This dual approach serves as a valuable guide for stakeholders in green TVET's evolution.

Result and Discussion

Data Sources and Search Strategies

This study employed a rigorous methodology to systematically identify and select relevant literature, ensuring the inclusion of high-quality articles and documents that align with the research objectives (Cumming et al., 2023). The process, illustrated in Figure 2, was delineated into two primary phases with specific criteria:

Phase 1: Initial Screening

In Phase 1, precise search terms were crafted aligning with the study's goals and refined using

Boolean operators across databases like PubMed, Scopus, and Web of Science. Initial screening involved reviewing titles and abstracts for relevance, and applying criteria such as publication date, language, study type, and subject relevance while excluding non-peer-reviewed and duplicate entries (Costa et al., 2024).

Phase 2: Full-Text Review

The study's second phase entailed a thorough full-text review of selected articles, evaluating methodology, sample size, data analysis, and findings' validity about the research questions. Quality was appraised using PRISMA and CASP tools, considering design, bias, reliability, and result applicability (Althubaiti, 2023). Key data was extracted for analysis, and articles were vetted for their substantial contribution to the research topic, excluding those with insufficient evidence or relevance.

By adhering to these criteria and systematically applying them, this study ensures a robust and comprehensive review of the literature, thereby enhancing the validity and reliability of our findings (Alam, 2021).

Eligibility Criteria

Data that did not have a full text available and documents that only focused on non-TVET education were eliminated. A selection criterion was also established according to the

research question and objectives of the study(Pacheco et al., 2018; West, 2019). Details of the eligibility criteria are shown in Table 1. providing inclusive and equitable quality education and training to a diverse population for social mobility and economic opportunity through TVET.

Table 1. Criteria for inclusion and exclusion of study

No.	Inclusion criteria	Exclusion criteria
1	Aligned with the context of Green Technical and Vocational Education and Training (TVET):	Not directly in alignment with green TVET.
2	Preferred articles included those reporting on empirical studies, including experiments, surveys, case studies, or field studies.	Those lacking empirical studies and relying on theoretical or speculative content."
3	Articles published within the last 10 years to ensure currency and relevance to recent developments in green TVET.	Articles published more than 10 years ago to ensure relevance to recent developments in green TVET may lack currency and may not reflect the latest advancements in the field.
4	Documents written in English	Documents written in other languages other than English
5	Articles that explicitly discuss the impact of green TVET on individuals, communities, or industries.	Articles that explicitly discuss the impact of green TVET on individuals, communities, or industries.
6	Peer-reviewed articles are included to ensure the quality and reliability of the research.	Non-peer-reviewed sources will be excluded to maintain the quality and rigor of the literature review

A total of 2,700 study papers were selected regarding the focus of this literature review which the author presents in Fig 1. The study articles are sourced from Google Scholar (90 articles), OpenAlex (700 articles), Dimension (1,109), and Semantic Scholar (900 articles).

Fig 1 illustrates the rigorous selection process of articles for a systematic literature review in the field of Technical and Vocational Education and Training (TVET), as per the PRISMA guidelines. The 'Identification' phase began with sourcing documents from Google Scholar (90), Dimensions (1,100), and OpenAlex (700), totaling 2,799 records. The 'Screening' phase involved meticulous examination, leading to 2,799 exclusions based on non-relevance to green studies and an additional 1,320 exclusions for non-education-related reasons. The 'Eligibility' phase saw 75 articles being thoroughly assessed, which then proceeded to the 'Included' phase where all 75 were selected for the final review due to their pertinence to TVET-related research. This flow chart encapsulates the structured methodology employed to ensure only the most relevant and high-quality studies were included in the review.

Ultimately, the 'Included' section highlights that all 75 assessed articles met the stringent criteria and were incorporated into the final review. The diagram also elucidates reasons for exclusion at various stages, ensuring transparency in the research methodology.

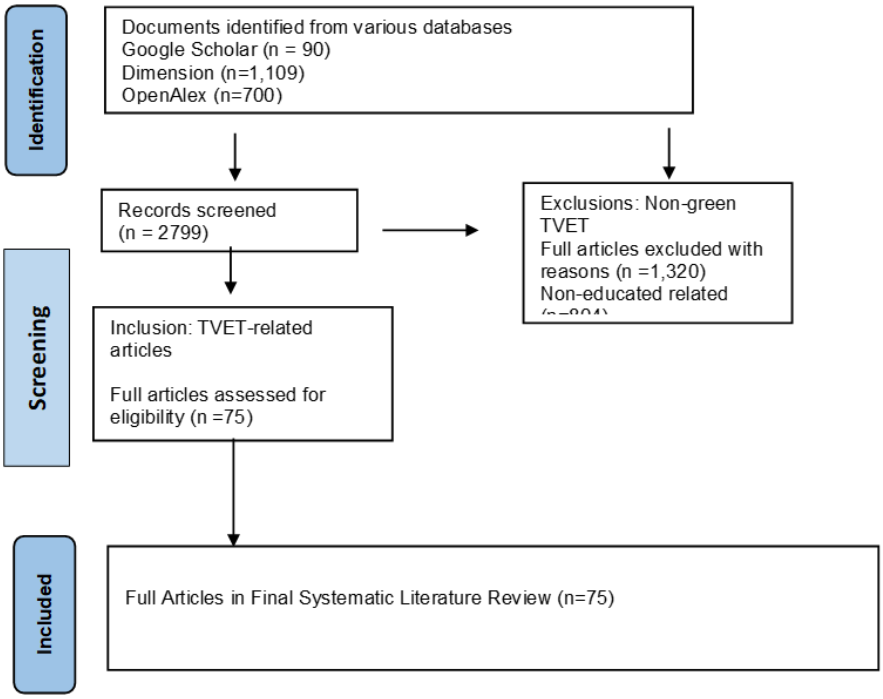

Fig 1: The PRISMA flow chart

Research development on Green Technical and Vocational Education and Training (TVET) involves the exploration and analysis of initiatives focused on environmentally sustainable skills and practices within the TVET sector (Pavlova & Chen, 2019). Scholars in this field investigate topics such as renewable energy, eco-friendly technologies, and sustainable development integrated into vocational education. Through bibliometric analysis, researchers identify key themes, trends, and gaps in the literature related to Green TVET, aiming to advance our understanding of how technical and vocational training can contribute to environmental sustainability. This research is crucial for informing policies and practices that promote green skills development and align TVET with the needs of a more sustainable and environmentally conscious future.

Trends in Green TVET Publications

Fig 2 The graph provided is a line graph that represents the number of published papers on Green TVET over the years from 2002 to 2023. From 2002 to around 2018, there was a gradual increase in the number of published papers. The count of papers increased from 7 in 2002 to 45 in 2018, suggesting a steady but slow growth in interest and research in Green TVET during this period. However, post-2018, there is a significant spike in publications, with the count increasing rapidly from 45 to 177 by 2023. This indicates a growing interest or developments in Green TVET during these years, suggesting that the field has gained more attention and possibly seen significant advancements or breakthroughs. In a nutshell, the graph shows a trend of increasing research and publications in Green TVET, with a significant acceleration in recent years. This could be indicative of the growing importance and recognition of Green TVET in the academic and professional world.

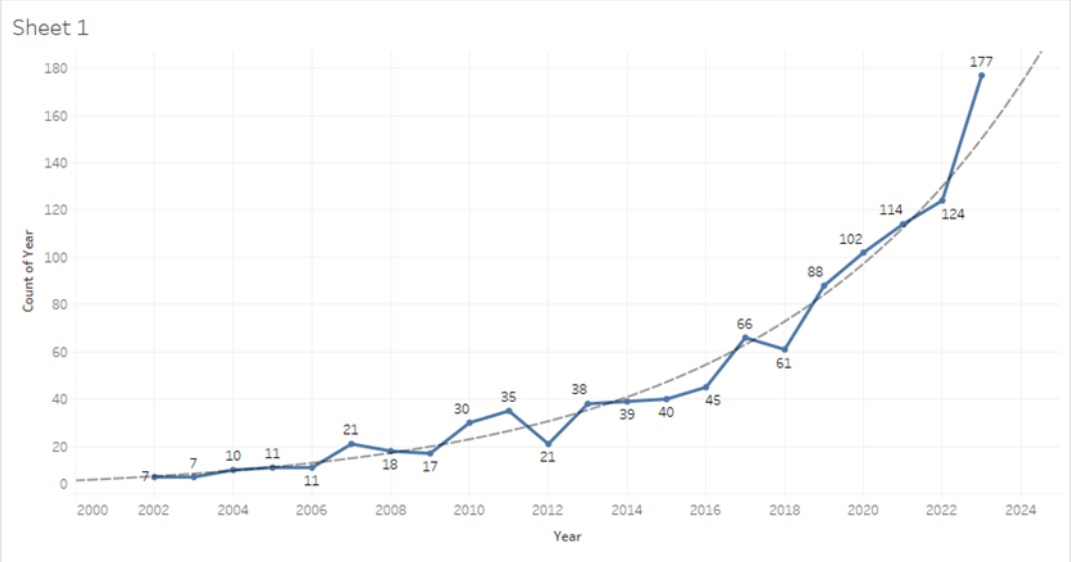

Fig 2: Yearly Publications of Number of Articles on The Study

Visualization of Green TVET Keywords

Fig 3 shows databases stored in a CSV file containing information on green TVET (Technical and Vocational Education and Training) and utilized in Vosviewer to generate a visualization of keywords (Aliu et al., 2023). The resulting visualization offers insights into the prominent and interconnected terms associated with green TVET, enhancing the understanding of relevant concepts and relationships within the dataset. This graphical representation aids researchers in exploring and analyzing key themes in the field of environmentally sustainable technical and vocational education and training.

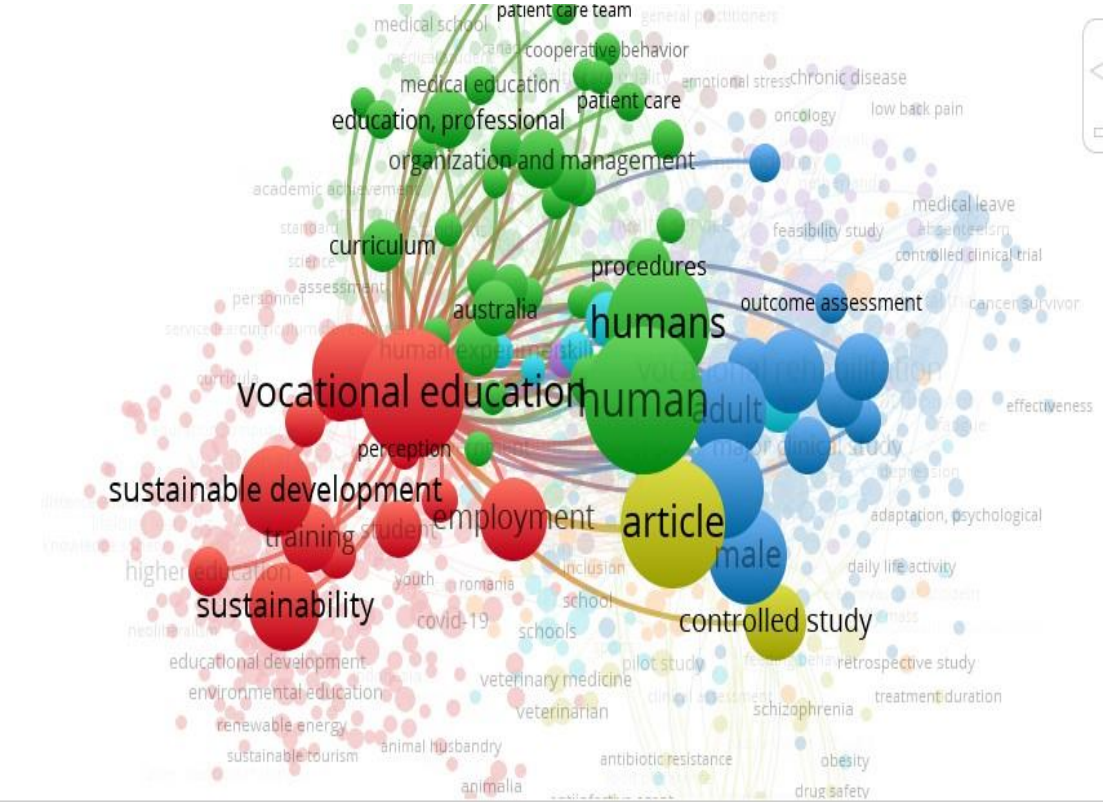

Fig 3: Visualization of the network of each term of keywords

Analysis of Keyword Occurrences and Link Strengths

Table 2 highlights “Vocational education” as the dominant theme in a network map, with keywords like “Technology and Vocational Education” and, “green skills,” and, "Sustainable employment", and "Education for sustainable development" appearing as relevant and interconnected concepts. Their high occurrences and link strengths suggest they are key areas of focus within the map.

Tabel 2. Keywords and their occurrences with their total link strength

Keyword	Occurrences	Total Link Strength
Vocational Education	**233**	**2708**
Humans	**304**	**5134**
Green Skills	**14**	**17**
Curriculum	**7**	**25**
Education For Sustainable Development (Esd)	**5**	**29**
Technology And Vocational Education (TVET)	**31**	**53**
Sustainable Employment	**9**	**61**
Skill	**22**	**359**
Methodology	**19**	**392**
Climate Change	**20**	**200**
TVET	**31**	**58**
Teaching	**33**	**330**
Learning System	**5**	**11**
Industry 4.0	**5**	**7**

Green TVET Paper Citations Over Time

Fig 4 shows a fluctuating trend in the number of citations. The citations increased steadily until around 2010, experienced a significant spike around 2012, decreased, and remained relatively stable until another peak in 2020, followed by a sharp decline. In detail, the citations appear to have significant peaks around the years 2012 and just before 2022. This could suggest that certain papers or topics in Green TVET gained substantial attention during these periods. However, the sharp decline in citations after 2022 might indicate a shift in research focus or a decrease in the relevance of previously popular topics. It's also possible that more recent papers haven't had as much time to accumulate citations. The dashed black trend line shows an overall increase in citations over time, indicating that despite the fluctuations, the general trend is towards more citations. This could be indicative of the growing recognition and impact of research in Green TVET.

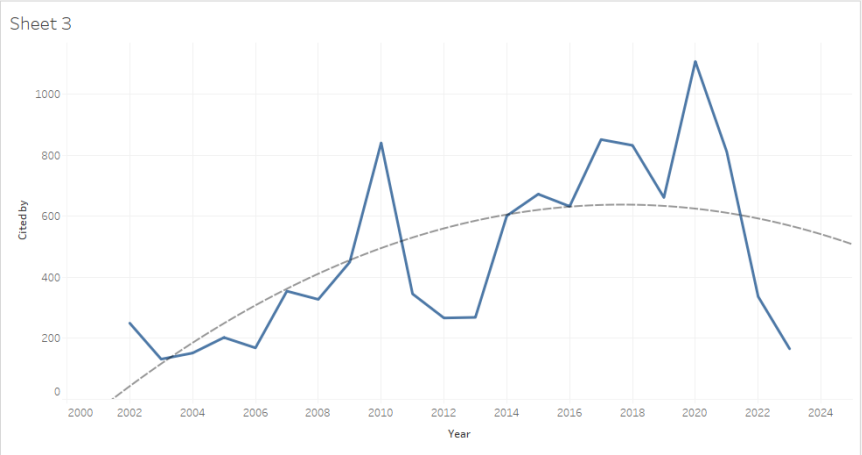

Fig 4: Green TVET Paper Citations (2002-2023)

Synthesis Of Existing Study on The Subject

Focus areas of previous study

The focus of the research that has been carried out is in the following areas: 1). Technical and vocational education 2). Students 3). Green environment 4). sustainability, 5). Curriculum 6). Experience 8). Training 9). recycling, 10). Skills 11). policy makers 12). Employability and 13). soft skills. The third aspect is the pivotal point to the rest of the points. All are interrelated. and a path to the researcher's results and all these aspects were covered in the selected working articles.

In Sweden, the implementation of Education for Sustainable Development (ESD) has encountered challenges, necessitating collaboration among educators and discipline-specific training(Hogan & O'Flaherty, 2021). The variability in teachers' understanding of sustainable development, contingent upon their subject areas, influences the integration of holistic perspectives into the curriculum. Meanwhile, a study in Bihar, India, delves into climate-smart agriculture, identifying five primary farming system types with potential implications for enhancing agricultural productivity and sustainability in the region.

In Norway, a comprehensive framework for waste management systems has been established, emphasizing considerations of environmental, economic, and social dimensions(Falcone & Imbert, 2018). This approach is particularly relevant for vocational development programs, catering to the long-term unemployed. Similarly, in West Java, Indonesia, a study sheds light on the understanding of green skills among teachers in agricultural vocational schools. Despite limited knowledge, teachers acknowledge the importance of green skills, underscoring the need for further training and curriculum development.

Globally, there is a resounding call to transform Vocational Education and Training (VET) with

a focus on human and sustainable development. This transformative approach aims to equip students with the requisite skills for the emerging green jobs of the future(Mthembu, 2022). In European urban forestry, the Uforest project promotes cross-sectoral alliances to develop innovative training programs, bridging urban planning, architecture, forestry, and urban ecology.

Examining green skills in Thai firms underscores the influence of the national education and skill-formation system on the development of these skills. This is recognized as pivotal for Thailand's transition to a low-carbon sustainable economy. Additionally, horticultural programs have been observed to positively impact juvenile offenders, reducing aggression and fostering adaptability in school life(Taimur & Sattar, 2020).

While specific studies on Zimbabwe were not found, the COVID-19 crisis globally has underscored the importance of green skills for economic recovery and resilience. In Australia, the status of green jobs is on the rise, with sustainability managers, ecologists, and geologists emerging as the fastest-growing green job titles. The development of green skills is deemed critical for individuals aspiring to excel in these roles.

In Finland, proposals for a Centre of Vocational Excellence aim to facilitate the transfer of green skills, aligning with global efforts. China's role in green growth emphasizes the significance of vocational education in fostering the necessary skills. In Malaysia, studies focus on the integration of green skills into Polytechnic curricula and the exploration of green skills in the electrical/electronics sectors(Messina, 2023).

In Nigeria, comprehensive studies investigate the integration of green building practices, the development of green skills modules, and the exploration of essential generic green skills across various sectors. A collective call resonates to refocus technical vocational teacher education in Nigeria, prioritizing green skill acquisition for sustainable development. These diverse studies collectively underscore the intricate connections between education, sustainable development, and the cultivation of green skills, emphasizing their critical role in addressing environmental challenges and advancing sustainable development globally(Redman & Larson, 2011).

Focus areas of previous study

To gain a deeper understanding of green Technical and Vocational Education and Training (TVET), it's crucial to delve into the roles of stakeholders and the significant impacts of green TVET on employability and career prospects within a broader global context. Stakeholders involved in green TVET, including policymakers, industry partners, educators, and students, each play essential roles in shaping and implementing effective green education initiatives(Ngubane et al., 2020).

Policymakers are instrumental in creating the regulatory frameworks and incentives necessary to integrate green skills into TVET curricula. They establish guidelines that align educational objectives with the evolving needs of green sectors such as renewable energy, sustainable agriculture, and environmental management(Arnold, 2014). By fostering policy coherence and allocating resources, policymakers ensure that green TVET programs are responsive to industry demands and contribute meaningfully to sustainable development goals.

Industry partners contribute invaluable practical insights and opportunities for hands-on training and job placements. Collaborations between TVET institutions and businesses in green industries provide students with real-world experience, enhancing their readiness for employment in environmentally sustainable fields(Tikly, 2013). These partnerships not only bridge the gap between education and industry but also ensure that graduates possess the specific skills and knowledge needed to succeed in green jobs.

Educators are at the forefront of delivering effective green TVET, requiring ongoing support and professional development. They play a critical role in integrating environmental sustainability into teaching practices across various disciplines(Brown, 2013). By updating curricula, adopting innovative teaching methodologies, and incorporating green technologies, educators prepare students to address complex environmental challenges and contribute to sustainable solutions in their future careers.

Students themselves are pivotal stakeholders in green TVET. Their engagement in program development ensures that educational initiatives reflect their interests and aspirations. Student involvement can lead to the creation of sustainability projects, eco-friendly campus initiatives, and participation in green-focused extracurricular activities(Marope et al., 2015). These experiences not only enrich their educational journey but also equip them with leadership skills and practical insights into environmental stewardship.

The impact of green TVET on employability and career prospects is profound and multifaceted. Graduates with green skills are highly sought after in sectors experiencing rapid growth due to increasing environmental awareness and regulatory requirements(Paryono, 2017). These sectors offer diverse career opportunities, from roles in renewable energy installation and energy efficiency auditing to sustainable construction and green technology innovation. Green TVET not only prepares graduates for entry-level positions but also supports career advancement by fostering continuous learning and adaptation to evolving industry standards and technological advancements.

On a global scale, green TVET faces challenges such as disparities in access to quality education, inadequate funding for infrastructure and training facilities, and the need for standardized green competencies across different regions(Pavlova, 2019). Addressing these challenges requires concerted efforts from stakeholders to promote equitable access to green education, enhance investment in educational resources, and establish global standards for green skills development.

Despite these challenges, green TVET presents significant opportunities for fostering innovation and sustainability on a global scale. Initiatives like digital learning platforms, international collaboration, and public-private partnerships can enhance the effectiveness and reach of green education initiatives(Pavlova & Askerud, 2024). By leveraging these opportunities and addressing challenges through collaborative efforts, stakeholders can ensure that green TVET continues to play a pivotal role in preparing a skilled workforce capable of driving sustainable development and addressing the challenges of climate change and environmental degradation effectively(Ordu, 2022).

Conclusion

The findings from the past decade extensively examines green Technical and Vocational Education and Training (TVET), emphasizing its critical role in preparing individuals for green economy careers and promoting environmental sustainability. Challenges identified include inconsistent definitions and insufficient integration of green competencies in curricula. Recommendations propose enhancing curriculum innovation, adopting effective teaching methods, and improving assessment practices. Collaboration among policymakers, educators, and industry stakeholders is crucial for advancing green TVET to meet sustainability goals.

Implications for Policy and Practice

Effective policies should integrate green skills into TVET curricula and incentivize eco-friendly practices with financial support. Public-private partnerships are essential for aligning training with industry needs. Ongoing professional development for educators is vital to effectively teaching green technologies, and investment in modern facilities is necessary to prepare students for sustainable careers.

Recommendations.

Future research should prioritize longitudinal studies to assess the lasting impact of green TVET programs, comparative studies to identify best practices across different contexts, and feedback from employers to refine curriculum content. There's a need for further exploration of cross-

sectoral partnerships and policy impacts on green TVET implementation. Additionally, exploring technological innovations like virtual reality could revolutionize green skills training.

References

Aceleanu, M. I. (2015). Green jobs in a green economy: Support for a sustainable development. Progress in Industrial Ecology, an International Journal, 9(4), 341–355.

Aliu, J., Oke, A. E., Kineber, A. F., Ebekozien, A., Aigbavboa, C. O., Alaboud, N. S., & Daoud, A. O. (2023). Towards a New Paradigm of Project Management: A Bibliometric Review. Sustainability, 15(13), 9967.

Alqahtani, T. M., Yusop, F. D., & Halili, S. H. (2023). Content validity of the Constructivist Learning in Higher Education Settings (CLHES) scale in the context of the flipped classroom in higher education. Humanities and Social Sciences Communications, 10(1), 1–12.

Althubaiti, A. (2023). Sample size determination: A practical guide for health researchers. Journal of General and Family Medicine, 24(2), 72–78.

America, N. (2013). Advancing TVET for Youth Employability and Sustainable Development.

Arnold, M. A. (2014). Exploring notions of assessment through three vocational education sites in the Western Cape. Stellenbosch: Stellenbosch University.

Bodolica, V., & Spraggon, M. (2018). An end-to-end process of writing and publishing influential literature review articles: Do's and don'ts. Management Decision, 56(11), 2472–2486.

Brown, M. (2013). The development of green skills through the local TAFE Institute as a potential pathway to regional development. International Journal of Training Research, 11(1), 27–43.

CHA, D. R. V. D., & DUMOND, M. (2017). KOREANPIVOT.

Cherry, G., Boland, A., & Dickson, R. (2023). Doing a Systematic Review: A Student' s Guide.

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, 15(3), 2543.

Costa, W. P. da, Fernandes, M. da S. V., Memon, A. R., Noll, P. R. E. S., Sousa, M. de M., & Noll, M. (2024). Factors influencing the work of researchers in Scientific Initiation: A systematic review protocol. Plos One, 19(1), e0297186.

Cumming, M. M., Bettini, E., & Chow, J. C. (2023). High-quality systematic literature reviews in special education: Promoting coherence, contextualization, generativity, and transparency. Exceptional

Children, 89(4), 412–431.

Darko, E., Nagrath, K., Niaizi, Z., Scott, A., Varsha, D., & Vijaya, K. (2013). Green building: case study. Shaping Policy for Development. Overseas Development Institute, London.

Falcone, P. M., & Imbert, E. (2018). Social life cycle approach as a tool for promoting the market uptake of bio-based products from a consumer perspective. Sustainability, 10(4), 1031.

Gu, C. C., Gomes, T., & Brizuela, V. S. (2011). Technical and vocational education and training in support of strategic sustainable development.

Hendriks, M. A., Luyten, H., Scheerens, J., Sleegers, P., & Steen, R. (2010). Teachers' professional development: Europe in international comparison. Office for Official Publications of the European Union.

Hogan, D., & O'Flaherty, J. (2021). Addressing education for sustainable development in the teaching of science: The case of a biological sciences teacher education program. Sustainability, 13(21), 12028.

Knudsen, M., Caniëls, M., Dickinson, P., Hery, M., Könnölä, T., & Lotz-Sisitka, H. (2023). Futures of green skills and jobs in Europe in 2050: scenario and policy implications.

Knuth, S. (2018). "Breakthroughs" for a green economy? Financialization and clean energy transition. Energy Research & Social Science, 41, 220–229.

Lamichhane, R. (2019). Greening TVET for a Sustainable Future: A New Initiative. ICTVET-2019, 18.

Mancotywa, Y. L. (2023). Repurposing rural technical vocational education and training in South Africa. University of Nottingham.

Marope, P. T. M., Chakroun, B., & Holmes, K. P. (2015). Unleashing the potential: Transforming technical and vocational education and training. UNESCO Publishing.

McGrath, S., Ramsarup, P., Zeelen, J., Wedekind, V., Allais, S., Lotz-Sisitka, H., Monk, D., Openjuru, G., & Russon, J.-A. (2020). Vocational education and training for African development: a literature review. Journal of Vocational Education & Training, 72(4), 465–487.

McGrath, S., & Russon, J.-A. (2023). TVET SI: Towards Sustainable Vocational Education and Training: Thinking beyond the formal. Southern African Journal of Environmental Education, 39.

Messina, N. (2023). Sustainable Development: A Comparison between the Finnish and the Italian Education Systems. Sustainability, 15(10), 8077.

Mthembu, M. J. (2022). A comparative analysis of technical vocational education and training as an

instrument for prosperity attainment in South Africa.

Muela, I., Ventura-Lucena, J. M., Navas, J. F., & Perales, J. C. (2023). The associative learning roots of affect-driven impulsivity and its role in problem gambling: A replication attempt and extension of Quintero et al.(2020). Journal of Behavioral Addictions, 12(1), 201–218.

Mukul, Taneja, S., Özen, E., & Bansal, N. (2024). Challenges and Opportunities for Skill Development in Developing Economies. Contemporary Challenges in Social Science Management: Skills Gaps and Shortages in the Labour Market, 1–22.

Mustapha, R. B. (2015). Green and sustainable development for TVET in Asia. The International Journal of Technical and Vocational Education. Invotec XI, 2, 133–142.

Ngubane, P., Mncube, D. W., Mabusela, M. S., & Olaniran, S. O. (2020). Exploratory study of tvet stakeholders' experiences of implementing work-based education in rural ecology. Academy of Entrepreneurship Journal, 26(1), 1–12.

Okada, A., & Gray, P. (2023). A Climate Change and Sustainability Education Movement: Networks, Open Schooling, and the 'CARE-KNOW-DO'Framework. Sustainability, 15(3), 2356.

Ordu, P. (2022). THE KEYNOTE CONVERSATION ON STRENGTHENING TECHNICAL AND VOCATIONAL EDUCATION AND TRAINING (TVET) SKILLS DEVELOPMENT FOR A GREEN ECONOMY. Journal of Association of Vocational and Technical Educators of Nigeria, 28(1).

Owusu-Agyeman, Y., & Aryeh-Adjei, A. A. (2024). The development of green skills for the informal sector of Ghana: towards sustainable futures. Journal of Vocational Education & Training, 76(2), 406–429.

Pacheco, C., García, I., & Reyes, M. (2018). Requirements elicitation techniques: a systematic literature review based on the maturity of the techniques. IET Software, 12(4), 365–378.

Paryono, P. (2017). The importance of TVET and its contribution to sustainable development. AIP Conference Proceedings, 1887(1).

Pavlova, M. (2017). Green skills as the agenda for the competence movement in vocational and professional education. Competence-Based Vocational and Professional Education: Bridging the Worlds of Work and Education, 931–951.

Pavlova, M. (2019). Emerging environmental industries: impact on required skills and TVET systems. International Journal of Training Research, 17(sup1), 144–158.

Pavlova, M., & Askerud, P. (2024). A Euro-Asian look at challenges to innovation and the greening of

industries: implications for TVET and strategic policy formulation. Journal of Vocational Education & Training, 76(2), 381–405.

Pirzada, G., Naz, M., & Jamil, M. (2023). Incorporating Green Skills in Vocational Education & Training in Pakistan: The Educators' Perspectives. Journal of Social Sciences Review, 3(1), 42–52.

Plaskacz, A. (2009). THE CLEAN ENERGY MANUFACTURING JOB MARKET AND ITS ROLE IN THE UNITED STATES ECONOMY.

Quan-Baffour, K. P., & Akpey-Mensah, T. L. (2022). Responsive Curriculum for Sustainable TVET Colleges in South Africa: Quo Vadis? In Reimagining Development Education in Africa (pp. 109–128). Springer.

Ramli, S. A., Yunus, J., & Tajul, M. T. I. M. (2020). Green Retrofit: The Potential of Reducing the Knowledge Gaps of Building Professionals and Homebuyers. CHANGING LIVES IN BRILLIANT WAYS, 26.

Redman, E., & Larson, K. (2011). Educating for sustainability: Competencies & practices for transformative action.

Roberts, N. S. (2009). Impacts of the National Green Corps Program (Eco-Clubs) on students in India and their participation in environmental education activities. Environmental Education Research, 15(4), 443–464.

Saputro, I. N. (2024). Literature Review of The Development of a Green Campus Teaching Factory-Based Learning Model in Vocational Schools in Indonesia. QALAMUNA: Jurnal Pendidikan, Sosial, Dan Agama, 16(1), 65–76.

Sarkar, O. T., & Mukul, S. A. (2024). Challenges and Institutional Barriers to Forest and Landscape Restoration in the Chittagong Hill Tracts of Bangladesh. Land 2024, 13, 558.

Side, R.-H. (2021). JOURNAL OF AFRICAN EMPLOYMENT, ENTREPRENEURSHIP AND SKILLS DEVELOPMENT (JAEESD).

Souto-Otero, M. (2023). Six principles to advance technical and vocational education for sustainable development. Panorama, 183–195.

Stamm, A., Altenburg, T., Strohmaier, R., Oyan, E., & Thoms, K. (2023). Green hydrogen: Implications for international cooperation. With special reference to South Africa (Issue 9/2023). IDOS Discussion Paper.

Taimur, S., & Sattar, H. (2020). Education for sustainable development and critical thinking

competency. Quality Education, 238–248.

Tikly, L. (2013). Reconceptualizing TVET and development: A human capability and social justice approach. Revisiting Global Trends in TVET: Reflections on Theory and Practice, 1.

von Beckerath, M. (2021). Collaborations between public and private actors in promoting sustainable transitions.

West, S. (2019). The College: The Struggle For Survival and Transformation In Neocolonial Trinidad 1997-2018. University of Sheffield.

Yusop, S. R. M., Rasul, M. S., Yasin, R. M., Hashim, H. U., & Jalaludin, N. A. (2022). An Assessment Approaches and Learning Outcomes in Technical and Vocational Education: A Systematic Review Using PRISMA. Sustainability (Switzerland), 14(9). https://doi.org/10.3390/su14095225