Pedagogical Approaches for Teaching Education for Sustainable Development in the Technology Education Curriculum

Princess Blose[a]

a. Department of Science and Technology Education, University of South Africa, Pretoria, South Africa

Email: eblosep@unisa.ac.za

How to cite
Blose, P. (2025). Pedagogical Approaches for Teaching Education for Sustainable Development in the Technology Education Curriculum. *Research in Social Sciences and Technology*, 10(1), 209-232. https://doi.org/10.46303/ressat.2025.12

ABSTRACT

This study investigates pedagogical strategies to teach sustainable development within the Technology curriculum in South African secondary schools, with an emphasis on the Senior Phase. Despite the global acknowledgment of sustainable development as a critical topic, its practical application in the South African Curriculum Assessment Policy Statement (CAPS) is limited. This study seeks to fill this gap by studying the pedagogical tactics used by Technology teachers to build sustainability skills. Eight technology teachers from the Ehlanzeni region in Mpumalanga Province were carefully chosen to participate. Data was collected through observations and interviews, and analysed using content analysis. The findings show that while teachers are aware of sustainable development concepts, converting this understanding into successful classroom implementation presents substantial hurdles. The study identifies teacher collaboration as the primary instrument for incorporating sustainable development principles into the technology curriculum; nevertheless, practical implementation was challenging. This study responds to the requirement of integrating sustainable development into all South African disciplines, notably the Technology curriculum It emphasises the importance of specific interventions to bridge the gap between policy intent and classroom practice.

KEYWORDS

Curriculum Assessment Policy Statement (CAPS), Technology curriculum, Technology Education, pedagogical approaches, education for sustainable development, sustainable development.

INTRODUCTION

The concept of sustainable development has acquired global acceptance in various fields, including higher education institutions (HEIs), general education, research, enterprises, and community outreach. Researchers like Lozano et al. (2017) and Grosseck et al. (2019) have helped to raise its profile. Notably, the United Nations (UN) has identified sustainable development as a critical component of its Agenda 2030, embodied in the 17 Sustainable Development Goals (SDGs). SDG 4 focuses on the provision of quality education when hinged with global standards in particular. From this perspective, the education system plays a critical role in changing away from the traditional development model that is only concerned with economic growth. Instead, it seeks to create a more sustainable society. Education for sustainable development has emerged as a critical strategy for driving positive change in the face of environmental issues. Sustainability education has three key dimensions: environmental, social, and economic. The terms "sustainable development" and "education for sustainable development" are frequently used interchangeably in this article, as are the terms "Technology curriculum" and "Technology Education".

While European governments have been at the forefront of implementing sustainable development plans, other countries, such as Australia, Canada, China, the United Kingdom, and the United States, have also recognised their relevance. These countries have implemented sustainable development principles in various areas, including health, education, organization, energy, food production, and environmental concerns (Hallinger & Chatpinyakoop, 2019). However, based on my observations, the South African curriculum appears to include a few projects that investigate the integration of sustainable development concepts inside schools, particularly in the Technology curriculum. Similarly, Singh-Pillay (2020) emphasizes the lack of study on how education for sustainable development-oriented methodologies is applied in classrooms at teacher training institutions. According to additional studies, the incorporation of sustainable development and education for sustainable development is still under-addressed in schools. Furthermore, disparities are observed across various educational domains, document types, federal regions, and the extent and effectiveness of contextualizing education for sustainable development and related ideas (Holst et al., 2020; Urbańska et al., 2021). Drawing on this background, much of the present research focuses on higher education, leaving the potential for more investigation and integration at the school level. Even though higher education institutions face challenges in translating the rhetoric of Higher Education for Sustainable Development (HEfSD) into practical policies, curriculum, and practice (Franco et al., 2019), there have been notable developments, necessitating a shift toward a focus on schools. The Curriculum Assessment Policy Statements (CAPS) document, primarily for Technology Education, references sustainable development aspects. These references promote ideals that prioritize the environment, social well-being, natural resources, and economic issues. However, including education about sustainable development within the Technology curriculum continues to be a challenge. Interestingly, some higher education institutions tend to

overemphasize sustainability principles without adequately capitalizing on their practical application potential (Hall et al., 2010).

In this context, the article investigates pedagogical approaches to sustainable development in South African school curricula, with a particular emphasis on the technology curriculum. The goal is to provide recommendations for successfully integrating sustainability education into this subject. Globally, education for sustainable development has gained traction, with a prominent position in national policy documents. For example, countries such as Vietnam, the Philippines, South Africa, and Chile have policies that place a premium on climate change initiatives and sustainable development education. While many of these documents emphasize participation in education for sustainable development and reorienting educational curricula, education for sustainable development is primarily integrated into national educational policies and curriculum statements, particularly at the primary and secondary school levels. In 2006, the Organisation for Economic Cooperation and Development (OECD) identified seven nations that lacked national sustainable development strategies: Belgium, Canada, Hungary, Mexico, Spain, Turkey, and the United States. Similarly, Wals and Kieft (2010) argue that most nations lack a defined national policy or strategy addressing education for sustainable development. This assertion is true even in the context of South Africa. While distinctions have been made between education for sustainable development models on other continents, such as Africa, Asia, and Latin America, their implementation remains challenging. As a result, there is no generally applicable blueprint describing the key components of education for sustainable development in many countries around the world.

The United Nations Educational, Scientific, and Cultural Organization (UNESCO, 2016) defines education for sustainable development. Education for sustainable development is founded on the concepts and values that underpin sustainable development, assuring the well-being of the five pillars of sustainability: environment, society, economy, peace, and collaboration. Education for Sustainable Development is a dynamic concept that envisions educating people of all ages to create a sustainable future. It provides people with the knowledge, skills, attitudes, and values required for sustainable living (UNESCO, 2016). Recognizing education as the beginning point, initiatives to improve learning opportunities and combat unsustainable practices are vital. Chapter 36 of Agenda 21 highlights education's role in achieving global sustainability. Gadotti (2009) further underscores the vital role of education in promoting sustainable development and developing skills to address environmental and developmental challenges.

Throughout the world, several governments' educational policies emphasize the integration of education for sustainable development with related themes (Wals & Kieft, 2010). These include "adjectival" education such as climate change, development, health, peace, citizenship, and environmental education. These ideas apply to both formal and informal learning situations. Notably, there has been improvement in recognising the value of education for long-term growth. For example, in 2008, about 78 nations made substantial progress in

creating national coordinating agencies for sustainability education (Wals & Kieft, 2010). Among these countries, Europe and North America have made significant progress in this area.

In Africa, for example, an increasing number of sustainable development initiatives have been conducted in around 28 nations. For example, African nations have implemented a variety of ways to gain sustainable development recognition. South Africa established the South African National Framework for Sustainable Development (NFSD) in 2008 to serve as a framework for recognizing sustainability across the country. Other countries, including Ghana (with the Ghana Poverty Reduction Strategy), Tanzania (with the National Development Vision), and Egypt (with the National Solid Waste Management Strategy), have taken strides in this direction. Drawing influence from the South African framework, the emphasis is on the national goal for sustainable development and strategic actions to guide South Africa towards sustainable living. The NFSD emphasizes collaborative implementation across sectors and stakeholders to protect our resources for future generations. Despite a written framework, South Africa continues to face sustainability difficulties. Notably, the paradigm lacks specific ideas and tangible procedures for sustainable living. Instead of simply offering a national vision, it should outline precise concepts, trends, strategic priorities, and a thorough set of implementation strategies.

Technology Education plays an important role in imparting education for sustainable development around the world. For example, New Zealand's Technology Education curricula include sustainability education components such as design, manufacturing, and visual communication (Pavlova, 2018). Similarly, Irish syllabi acknowledge opportunities to integrate education for sustainable development into areas such as production and consumption patterns, corporate responsibility, environmental protection, natural resource management, and biological variety (McGarr, 2010). Technology Education can address significant global concerns. Learning outcomes in recycling, product redesign, and conservation techniques enable students to help reduce greenhouse gas emissions and combat climate change. Thus, Technology Education becomes a constructive force in accomplishing long-term development goals (Pavlova, 2018). Pavlova (2011) also conducted a poll of African Technology Education academics, which found overwhelming agreement on the need to address sustainable development through Technology Education. The CAPS Technology document also emphasises the impact of technology in this field, with an emphasis on the environment: social, natural, and economical.

Furthermore, the CAPS Technology document emphasises the significance of technology. For example, in Grade 7, conversations focus on how designers consider societal demands in terms of technology while also examining the influence on society and the environment (Department of Basic Education [DBE], 2011). One architectural concept is to disguise a tower to blend in with the environment and avoid visual pollution (DBE, 2011). These examples highlight numerous options for incorporating education for sustainable development within the Technology curriculum. Technology Education includes key areas of technology use and its impact on society and the environment, such as technological knowledge and skills (Gumbo,

2018; Mapotse, 2012). Despite these prospects, clear pedagogical solutions for effectively teaching sustainability within the Technology curriculum are still elusive. Similarly, Jabareen (2008) worries about sustainability, citing a lack of operational definitions and conflicts about what should be sustained. The concept of emotional commitment is still uncertain, and it is frequently described as "confused" and "fraught with contradictions." As a result, teachers may find it difficult to negotiate sustainability education within the Technology curriculum, particularly given its little recognition in schools. Therefore, it is important to investigate pedagogical ways of teaching education for sustainable development within the Technology curriculum (Chimbunde & Moreeng, 2024; Nkambule & Ngubane, 2023).

The following are the research questions guided by this study:

1. What knowledge do Technology Education teachers possess about education for sustainable development?
2. How does Technology Education content inform the teaching of education for sustainable development?
3. What pedagogical approaches can Technology teachers employ to impart education for sustainable development?

Framework for the study

This study was based on experiential learning theory, which emphasizes direct experience and reflection within a constructivist framework. Bergsteiner et al. (2010), in line with Kolb's experiential learning theory, argue that people generate knowledge via experience rather than through received instruction. This perspective highlights the possibility of excellent education for sustainable development through learner engagement and experience. Kolb's (1984) theory views learning as a cognitive process involving ongoing adaptation and involvement with one's environment, as depicted in Figure 1 below. The cyclical model with four learning styles is derived from the dimensions of concrete-abstract and reflective-active. Kayes (2002) elaborates on these dimensions, claiming that in the first dimension, people acquire knowledge from complex situations (concrete experience) and then abstract and process it (abstract conceptualisation). The second dimension is transformation, in which individuals reflect on their experiences (reflective observation) and participate with their surroundings (active experimentation).

Moreover, from Kolb's experiential learning cycle, Mughal and Zafar (2011) interpret learning as an ongoing process that transcends mere outcomes. Learning is fueled by our experiences, which shape our understanding and growth. Conflict resolution through dialogue is integral to learning, allowing us to reconcile differing viewpoints. A holistic and integrative perspective recognises that learning involves interconnected aspects rather than isolated fragments. Interaction with our environment—people, places, and situations—fuels our learning journey. Ultimately, learning leads to the creation of knowledge, enriching our understanding of the world.

Figure 1.

Kolb's (1984) Experiential Learning Cycle [adapted from Mughal and Zafar (2011:29)]
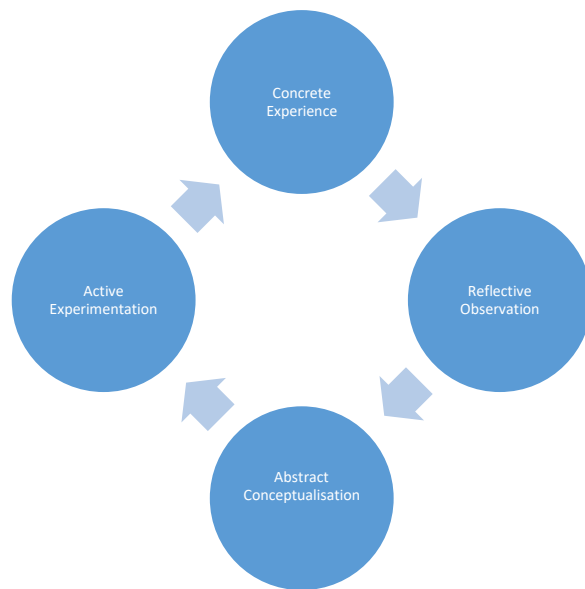
Therefore, drawing from the above, it is observable that the dimensions of experiential learning resonate well with the pillars of education for sustainable development. Education for sustainable development strives to promote sustainability in social, cultural, and economic practices at many levels, i.e., school curricula. Consequently, it is in this understanding that experiential learning theory can help by connecting education to real-world experiences that reflect sustainable living. Correspondingly, the Technology curriculum, which combines abstract concepts with practical applications, is consistent with the principles of sustainable development. Teachers could also use a context-based approach to help learners learn technology. They should draw on sustainable development learnings gained from their native settings, particularly indigenous knowledge - sustainable development practiced by indigenous people. Technology Education lays the groundwork for experiential learning and contributes to sustainable development education by encouraging the synthesis of thought and doing.

METHODS

Study design

This study used a qualitative approach to investigate pedagogical approaches for teaching education for sustainable development in the context of Technology Education. Using this technique, I investigated the social reality of teaching tactics in Technology Education, focusing on interpreting and contextualising meanings generated from teachers' attitudes and behaviors toward sustainability. Qualitative research focuses on comprehending the situation rather than measuring observed qualities (Baskarada, 2014). This study conducted qualitative descriptive case studies to thoroughly investigate numerous aspects of sustainable development education in Technology classrooms. These case studies investigate individuals, groups, or occurrences (Sturman, 1997). Case studies help us grasp the issue better by evaluating different variables of

interest and converging data. The research objectives were met by analysing a group of Technology teachers from the Ehlanzeni District in Mpumalanga Province, South Africa, which was chosen for its diversity and abundance of tourist attractions.

Data collection

This study used a purposive sampling strategy to identify Technology teachers who taught various Grades (7-9) throughout the Senior Phase. Participants were Senior Phase Technology teachers with at least two years of experience teaching the subject. This ensured that the replies reflected the opinions of Senior Phase teachers who had practical experience with diverse teaching circumstances relating to the subject. Purposive sampling was chosen because these teachers were actively involved in their teaching environments, providing a more comprehensive grasp of teaching education for sustainable development.

Table 1.

Demographic information

Pseudonyms	Gender	Years of teaching experience in Technology Education	Age ranges	School context
T1	Female	6	30-40	Urban
T2	Female	2	30-40	Urban
T3	Female	11	30-40	Township
T4	Male	7	30-40	Semi-rural
T5	Male	1	30-40	Township
T6	Male	1	30-40	Township
T7	Male	4	50-60	Township
T8	Female	5	30-40	Township

The study included interviews and classroom observations with eight Technology teachers from Mpumalanga's Ehlanzeni District. Individual semi-structured interviews were conducted at the participants' workplaces and lasted 30-40 minutes. Karatsareas (2022) defines semi-structured interviews as open-ended inquiries that invite participants to delve deeply into their thoughts and experiences, presenting their opinions from personal viewpoints. These interviews enabled me to observe the interview process using a pre-planned technique. According to Brown and Danaher (2019), semi-structured interviews adhere to a set list of themes and questions while allowing for spontaneous, open responses that encourage dynamic exchanges beyond the planned interview schedule. The interviews allowed participants to express their perspectives on education for sustainable development in their own words and to create narratives based on their personal experiences with sustainability concerns.

Furthermore, the interviews allowed Technology teachers to share their experiences and teaching methods connected to sustainable development.

Classroom observations were used to acquire extra data in this study. Its goal was to understand Technology teachers' awareness of the classroom environment as they worked to promote sustainable development. Observational research methods have advantages over other qualitative data collection procedures, particularly when the research aims to understand actions, roles, and behaviors (Walshe et al., 2012). Non-participant observation, in particular, allowed me to directly see the tactics used by Technology teachers in classrooms to teach sustainability. This method records social interactions and activities as they occur spontaneously. Caldwell and Atwal (2005) propose that researchers combine observation with other research methodologies to observe actual behaviours rather than depending exclusively on self-reported or idealised reports. Similarly, Walshe et al. (2012) argue that observational approaches provide insights into people's roles, actions, and behavior, allowing us to understand how these may change over time in response to diverse contexts. Each classroom observation session lasted one hour, and extensive notes were gathered utilising an observational checklist (see Appendix A).

Data analysis

Content analysis is a technique for investigating multiple sorts of data, including visual and verbal information (Harwood & Garry, 2003). Cole (1988) describes content analysis as analysing written, vocal, or visual communication signals. In this study, audio-recorded interviews were transcribed verbatim and analysed with inductive content analysis. The procedure included multiple steps. First, open coding was used to contribute comments and headings to the text while reading. Next, categories were formed by grouping related or different data into larger, higher-order categories. Decisions on which elements belonged in the same category were determined using interpretation. Finally, a general description of the research issue evolved as a result of the abstraction process, which included the formulation of categories. For example, the original coding concentrated on pedagogical practices for teaching education about sustainable development. The categories were collaborative learning and creativity, collaborative learning for sustainability, skill variety in group work, group dynamics, cultural transmission, and collaborative learning with technology. The overarching theme of 'pedagogical approaches for education for sustainable development – collaborative learning' emerged by grouping comparable themes.

In this study, classroom observation data were linked to identified themes. Transcriptions of audio recordings were carefully checked several times to improve comprehension of educational approaches to sustainable development in the Technology curriculum. Non-participant observation data were also cross-referenced to validate the findings from semi-structured interviews. Because of the time differences between interviews and observations, audio transcriptions and observational field notes had to be combined.

In this study, triangulation was used by collecting data using semi-structured interviews and observations. This approach ensured rigor; as Walshe et al. (2012) point out, interviews allow participants to articulate their behaviors, whereas observations immediately disclose what individuals do. With observations, field notes were meticulously documented during and promptly after each observation session. By integrating these strategies, I was able to get insights from various views on education for sustainable development inside the Technology curriculum. Furthermore, member-checking—in which transcribed data is reviewed by participants—was carried out. To improve the study's transferability, participants were selected based on their subject knowledge and demographic features. The group had four males and four females from various racial backgrounds: one Tsonga, one Zulu, one Indian, and the rest were Swati speakers. The study focused on schools in urban, semi-urban, and semi-rural settings. The teachers' experience teaching the subject ranged from one to eleven years. Dependability was achieved through well-defined inclusion criteria based on domain expertise. Finally, confirmability was assured by explaining the rationale for the selected inclusion criteria to the participants.

Regarding ethical considerations, Technology teachers were thoroughly informed about the study's purpose. Written consent was obtained from all participants before data collection, and they willingly participated. Anonymity was maintained throughout the study, and pseudonyms (T1, T2, T3, etc.) were used to protect their identities.

RESULTS

The data was examined using content analysis, which revealed three key themes that arose from narratives about the occurrence. The transcriptions were split down into smaller components, and the data was analysed using the methods indicated in the preceding section on data analysis. When exploring the Pedagogical Approaches to Teaching Education for Sustainable Development in the Technology Education Curriculum, this study found that teachers had

- A knowledge and understanding of the notion of education for sustainable development.
- Ability to Integrate Sustainable Development Education into the Technology Curriculum and
- Pedagogical Approaches for Imparting Education for Sustainable Development in Technology Education.

The above themes are unpacked below.

Teachers' Knowledge and Understanding of Education for Sustainable Development in Technology Education

The classical role of education is widely accepted and is considered crucial in the realization of sustainable development goals. Jasmi et al. (2019) emphasise the importance of green technology implementation in education, emphasizing its function in developing learners' appreciation for the environment. All this need teachers' adequate knowledge and

understanding of the role of education for sustainable development and the application of basic scientific principles enshrined in the Technology curriculum. So, when asked about the knowledge that Technology Education teachers possess about education for sustainable development, teachers demonstrated a comprehensive understanding of education for sustainable development, emphasising the importance of resource preservation and environmentally friendly practices. Figure 1 below depicts some of the emergent themes, subthemes and codes.

Figure 1.

Codes identified
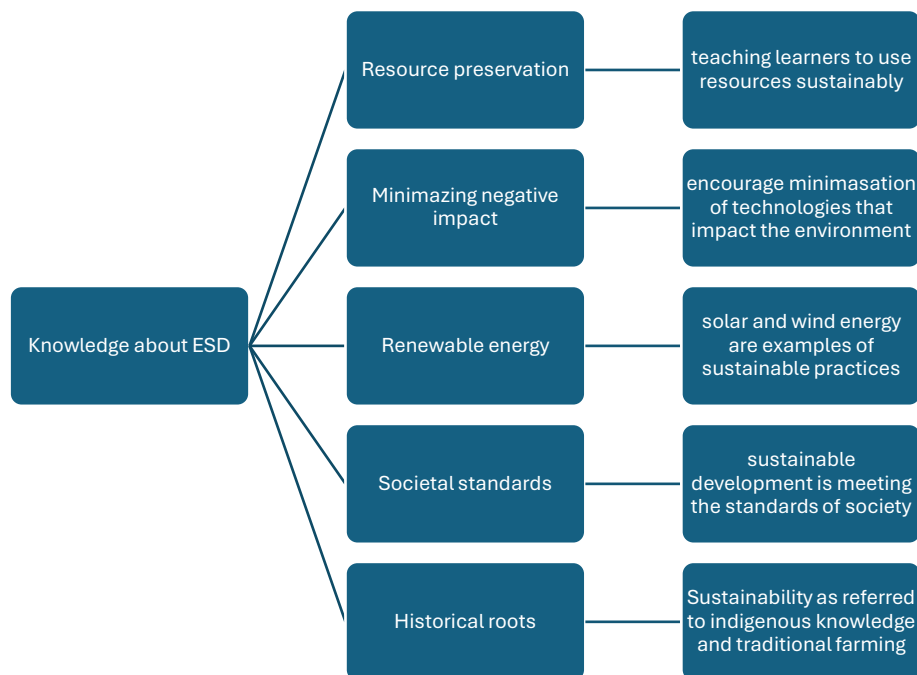
Evidently from the above figure, teachers demonstrated a comprehensive knowledge and understanding of the importance of resource preservation in sustainable development. They showed that they understood what education for sustainable education entails. This was evident in their emphasis that education for sustainable development refers to resource preservation for future use. This showed that teachers know the concept and understand the need to teach learners to use resources in a way that ensures their availability for future generations. These teachers described sustainability as an education that would bring a sense of responsibility to learners, encouraging them to consider the long-term impacts of their actions on the environment. For instance, T1 highlighted the importance of using resources sustainably so that they remain available for future generations. T1 said:

> *"It's about teaching learners to consider using resources in a way that they can be available in the future, that we can still have them in the future for future generations."*

Teachers have also proven their knowledge of education for sustainable development. Their key of knowledge was on the emphasis that the concept encourages minimisation of the negative environmental impacts of technology. They showed that education for sustainable

development emphasises the reduction of the use of technologies that harm the environment and to the development of new methods that mitigate these negative effects. T3 said: *"It has to do with development of new methods that can help in reducing the negative impact of technology"* This perspective underscores the role of education in fostering innovative thinking and problem-solving skills aimed at sustainability.

Teachers also highlighted the use of renewable energy sources as a crucial component of sustainable development. They provided examples such as solar and wind energy technologies, which not only help conserve resources but are also cost-effective. By integrating these examples into the curriculum, teachers showed understanding on to educate learners about the benefits and applications of renewable energy, promoting environmentally friendly practices. T8 said:

> *"Some of them are how we use the sun's energy to create solar power, or we use the wind energy to create electric turbines or even windmills, which is also trying to save is cost-effective for the economy".*

Sustainable development was also pronounced in terms of meeting societal standards within a particular environment. Teachers noted that sustainable development involves ensuring that human activities align with the environmental standards necessary for the well-being of society. T6 said: *"what we were then now this is what we are then what we are must reflect sustainable development".* This perspective highlights the interconnectedness of social and environmental sustainability, emphasizing the need for a holistic approach to education.

Lastly, teachers acknowledged the historical roots of sustainability practices, referencing indigenous knowledge and traditional farming methods. They pointed out that early farming practices, such as pastoralism and crop cultivation by indigenous communities, were inherently sustainable and caused minimal environmental damage. This shows that by incorporating these historical examples into the curriculum, teachers would provide learners with a broader understanding of sustainability and its long-standing significance. T8 stated:

> *"The first farmers made use of pastoralism and growing crops. The San and the Khoi Khoi also hunted and gathered, as well as fished. So, they did very little to damage the environment and that is sustainability".*

While teachers demonstrated understanding during the interview sessions, it was evident that the teaching of the Technology curriculum lacked emphasis on sustainability. Their lessons could not further explain the key aspects of education for sustainable development, i.e., environmental, social, and economic, and their relevance to the learners. There was no use of resources or materials related to education for sustainable development. This deficiency stemmed from the learning environment's failure to facilitate the integration of education for sustainable development concepts. Additionally, their teaching provided insufficient encouragement for acquiring the knowledge and skills necessary to engage learners in learning about the concept of education for sustainable development within the subject.

Drawing from the above, teachers demonstrated a firm grasp of education for sustainable development, emphasising resource preservation and environmentally friendly practices. They

described sustainable development as ensuring resource availability for future generations, citing examples like solar and wind energy technologies. They also highlighted the historical origins of sustainability practices, drawing from indigenous knowledge and traditional farming methods. Despite this understanding, the teaching of the Technology curriculum lacked emphasis on sustainability. The learning environment failed to integrate education for sustainable development concepts, resulting in inadequate encouragement for learners to engage with sustainability topics.

Integrating Sustainable Development Education into the Technology Curriculum: Unlocking Teaching Opportunities

The process of bringing together stakeholders from technology-rich schools, industry, government, and the community to collaboratively develop and implement sustainable and technology-enabled solutions is crucial in contemporary times (Rudinger & O'Neil, 2019). When exploring how Technology Education content informs the teaching of education for sustainable development, teachers identified numerous opportunities within the Technology curriculum for integrating sustainability education. Figure 2 below describes some of the codes identified.

Figure 2.

Codes identified
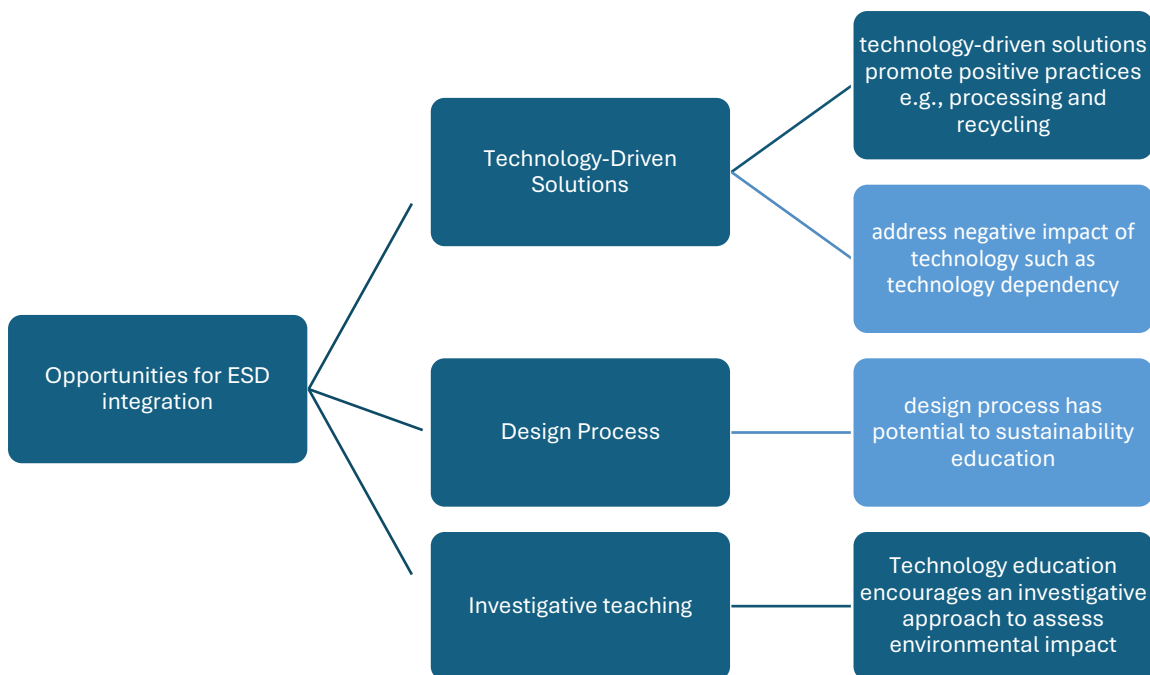
Teachers stated that there are numerous opportunities within the Technology curriculum to incorporate sustainability education. Teachers suggested that the curriculum be adapted to include topics and projects focusing on sustainable practices, such as processing, recycling and environmental conservation. Teachers believed that by embedding these themes into the curriculum, learners could gain a deeper understanding of sustainability and be encouraged to adopt environmentally friendly practices in their daily lives.

The teachers emphasized the potential of technology to raise environmental awareness and promote positive practices. They highlighted how technology can be leveraged to develop solutions that address environmental issues, such as waste management and renewable energy. T3 said: *"Technology-driven solutions in the subject can raise environmental awareness and promote positive practices, such as processing and recycling."* Thus, by integrating these technology-driven solutions into the curriculum, learners would learn about the practical applications of technology in promoting sustainability. Moreover, teachers believe the technology-driven solutions would assist in addressing the negative impacts on the environment brought by technology.

Thus, while acknowledging the benefits of technology, teachers also emphasized the need for responsible usage to mitigate its potential negative impacts. They pointed out that technological dependency can have adverse environmental effects, so, it is important to promote responsible usage among learners. T3 said: *"I think technology it can help because if you can check, people are now dependent on a lot of things that make life easier."* Consequently, by educating learners about the responsible use of technology, the curriculum can help to minimize its environmental footprint and encourage sustainable practices.

The design process inherent in Technology Education was recognized as particularly conducive to sustainability education. Teachers stated that this process fosters creativity and innovation, encouraging learners to use recycled materials and think critically about the environmental impact of their designs. So, the design process has the potential to help learners develop sustainable products and solutions, thereby contributing to environmental conservation. For example, T8 stated: *"Learners can make stationery holders, which plays a major role in sustainable development."*

Technology Education encourages an investigative approach, which is crucial for assessing the environmental impact of various projects. The study's findings reveal that teachers noted that learners are trained to investigate the environmental implications of their projects, promoting a deeper understanding of sustainability. This investigative approach helps learners to critically evaluate their designs and make informed decisions that support sustainable development. T1 in this case, stated:

> *"During the design process, learners start by investigating before they design any products. So, in this stage, learners have to investigate if whatever they are planning to do, does it impact the environment or does not."*

It is noticed that teachers recognised opportunities within the Technology curriculum to integrate sustainability education. They emphasised that technology-driven solutions sustain the environment and promote positive practices like processing and recycling. The design process was highlighted as conducive to sustainability education. This was because they believed it fosters creativity and innovation, especially in utilising recycled materials. Also, the investigative teaching was found to be crucial in sustainability practices in the Technology curriculum.

Nonetheless, teachers acknowledged the negative environmental impacts of technological dependency.

Despite the opportunities presented by the teachers, their actual teaching failed to take advantage of the stated opportunities claimed during the interviews. Accordingly, no topics emphasised sustainable design and/or education for sustainable development. However, two exceptions were two teachers, one teaching Grade 7 and the other Grade 8 tried to bring the aspects of recycling and biodegradable and non-biodegradable materials. Although that was done, there were no links that emphasised the education for sustainable development concept to the learners.

Pedagogical Approaches for Imparting Education for Sustainable Development in Technology Education

The demonstration in Figure 3 shows some examples of codes identified during data analysis. The codes generated mainly from RQ3: What pedagogical approaches can Technology teachers employ to impart education for sustainable development?

Figure 3.

Codes identified
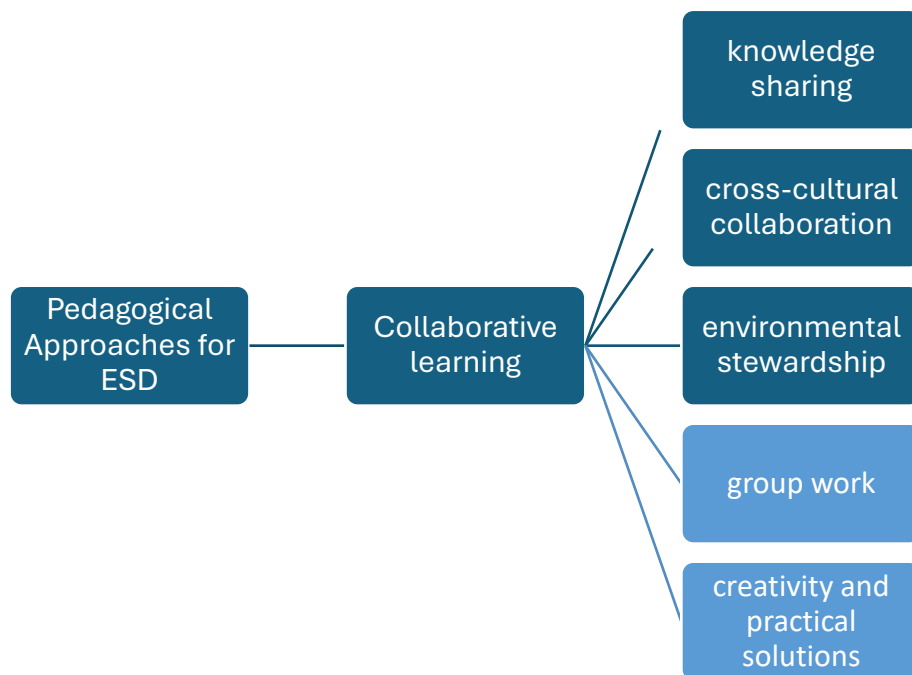
Teachers highlighted collaborative learning as a promising approach for promoting sustainability education within the Technology curriculum. Teachers emphasized the benefits of group interactions in facilitating knowledge-sharing and problem-solving. Accordingly, learners can combine their diverse perspectives and expertise by working together, fostering creativity, and developing practical solutions to real-world challenges. This collaborative approach enhances learning outcomes and prepares learners to work effectively in diverse teams. T2

claimed: *"So, as they work together, they get more knowledge on how things are done, so it is easy for them to combine the knowledge of different points."*

Consequently, group work was identified as an effective method for approaching problems from different perspectives. Teachers noted that when learners collaborate in groups, they can explore various ways of tackling a challenge, leading to more innovative and comprehensive solutions. As stated by T4: *"So, you find that in a group maybe they four learners solving a particular challenge then they come with different ways of approaching a problem."* This method encourages critical thinking and allows learners to learn from each other, enhancing their problem-solving skills and ability to apply sustainable practices in technology projects.

More so, teachers believed that collaborative learning would allow for cross-cultural collaboration, enabling the promotion of environmental stewardship and integrate indigenous knowledge. They highlighted the value of learning from different cultural practices and traditional knowledge systems, which can offer unique insights into sustainable living. Therefore, by incorporating cross-cultural perspectives into the curriculum, teachers can broaden learners' understanding of sustainability and encourage them to appreciate and apply diverse approaches to environmental conservation.

T5 relates:

> *"In technology content, we talked about some of the resources that are biodegradable and non-biodegradable, which means even the indigenous knowledge of farming or planting our crops; we can use natural material to plant our crops".*

Furthermore, promoting environmental stewardship and understanding interdependence is crucial in sustainability education. T7 said: *"After all, they can know that they're not existing as an individual and that there are other people."* Teachers emphasized the importance of helping learners realize that they are part of a larger community and that their actions have an impact on the environment. Teachers believe that this unique pedagogical approach, whose recognition could foster a sense of responsibility and stewardship, where teachers can encourage learners to adopt sustainable practices and contribute positively to their communities and the planet.

Encouraging creativity and the development of tangible, practical solutions is another key pedagogical approach. Teachers emphasized allowing learners to bring their creative ideas to life through hands-on projects. This approach helps learners to see the real-world applications of their ideas and understand the impact of their innovations on sustainability. Then, by fostering creativity, teachers can inspire learners to develop new and effective ways to address environmental challenges.

T2 indicated:

> *"Okay, because with technology, in my understanding is to bring the creativity of a learner to bring in that creativity becomes something that you can touch and feel is not only that, visual or imagination is visible."*

Despite recognising the importance of collaborative learning during interviews, teachers' classroom practices did not always reflect the effective implementation of this approach, compromising learners' learning experiences. The teaching approach for all teachers primarily relied on demonstrations, which may not have adequately demonstrated the collaborative learning environment essential for fostering education for sustainable development, as suggested by the teachers. However, I firmly believe that if this approach is effectively utilised in teaching the subject, it has the potential to instil the necessary knowledge, values, and skills conducive to promoting education for sustainable development within the subject.

Teachers highlighted collaborative learning as a promising approach within the Technology curriculum thus group interactions facilitate knowledge sharing, problem-solving, and creativity. Also, teachers recognised the potential of cross-cultural collaboration. This approach is believed to promote environmental stewardship and disease-free crop cultivation. Despite recognising collaborative learning's importance, teachers' classroom practices did not always reflect it. Demonstrations were the primary teaching approach, missing the collaborative learning environment. Therefore, I strongly believe that effectively utilising collaborative learning could instil essential knowledge and values for sustainable development.

DISCUSSION

The study indicates that teachers demonstrate extensive knowledge of sustainable development, as evidenced by their detailed responses elucidating the concept. This suggests that sustainable development is a familiar topic among teachers. Glavič (2020) contends that despite rapid advancements across economic, social, and environmental fronts, teachers often lack modern and effective content for teaching sustainability. This underscores the interdisciplinary nature of sustainability education, which extends beyond specific subjects.

Aligned with the views of Leal Filho et al. (2009), Technology Education emerges as a potential avenue for addressing the challenges of sustainable development. Notably, the study findings highlight the importance of resource utilisation and design considerations in promoting sustainability within the curriculum. Pavlova (2018) identifies strands such as design, manufacturing, and visual communication as integral to fostering sustainable development within Technology Education. Moreover, Technology Education, as emphasised by Gumbo (2018) and Mapotse (2012), encompasses critical aspects concerning technology's societal and environmental impacts. Despite teachers acknowledging the historical roots of environmental stewardship, the sustainability principles integration into the Technology curriculum remains limited.

The study reveals various avenues for incorporating sustainability into Technology Education. Pavlova (2011) underscores the importance of addressing sustainable development through topics like processing and recycling, effectively anchoring the concept within the subject. Furthermore, collaborative learning emerges as a promising approach for sustainability education within the subject, echoing the findings of Saitua-Iribar et al. (2020) and Schnitzler

(2019). However, despite the potential of collaborative learning, observations indicate a lack of emphasis on this approach during classroom observations. Rojo and Dudu (2017) caution against individualistic approaches to sustainable development, emphasising the need for collaborative efforts. Hence, I align with Rojo and Dudu (2017) in asserting that practical approaches for education for sustainable development within the Technology curriculum lie within collaborative learning. This approach would facilitate the establishment of sustainable knowledge within learners' environments and background understanding.

Additionally, the study highlights the potential for integrating indigenous perspectives into sustainability education within the Technology curriculum. Nölting et al. (2020) emphasise the importance of sustainability transfer and cooperation across diverse societal subsystems. This aligns with the emphasis on cooperative skills outlined in educational documents like the CAPS (DBE, 2011).

As suggested by Saitua-Iribar et al. (2020), incorporating technological tools and innovative approaches can enhance learners' understanding of abstract concepts while respecting their cultural backgrounds. Blose (2023) further emphasises the benefits of collaborative learning in promoting education for sustainable development and facilitating knowledge sharing among learners. Nonetheless, upon observation, it becomes evident that the demonstration and lecture methods are primarily employed in teaching the subject, offering teachers a platform to integrate sustainability concepts. Nevertheless, teaching sustainability within the Technology curriculum finds its stronghold in collaborative approaches. The practical nature of the subject facilitates a comprehensive exploration of environmental, social, and economic aspects, as reflected in the criteria for the teaching and assessment of design traits outlined by the (DBE, 2011). These criteria encompass considerations such as safety, value for money and ergonomics, inclusivity, and environmental impact, emphasising the holistic approach required in teaching sustainability within the realm of Technology Education.

In summary, while there are opportunities for integrating sustainability into the Technology curriculum, challenges persist in implementation. Therefore, the study underscores the importance of interdisciplinary collaboration, indigenous knowledge, and innovative pedagogical approaches in effectively teaching sustainability within the subject.

Limitations of the study

The article was limited to two circuits in a single district of Mpumalanga Province, South Africa. While this technique gave valuable insights, broadening the study to include additional provinces would have allowed for a more in-depth understanding of how teachers view and teach sustainability in the Technology curriculum. Furthermore, the study only used qualitative research methods to investigate pedagogical approaches to teaching education for sustainable development in the Technology curriculum. Incorporating both qualitative and quantitative approaches could have resulted in a more thorough knowledge of how the subject is taught, especially within the notion of sustainability. Data was gathered using individual semi-structured interviews and classroom observations, and the study focused on the Senior Phase,

analysing teachers' experiences teaching sustainability in Technology Education. Exploring the notion in subsequent phases, particularly the Intermediate Phase, would have provided a clear picture of the teaching on the concept of sustainability at school levels i.e., Technology Education in particular.

Implications of the study

The study highlights that teachers possess in-depth knowledge of sustainable development, as evidenced by their detailed responses. This suggests that sustainable development is a familiar and well-understood topic among teachers. Therefore, teachers can play a crucial role in disseminating sustainable development concepts to learners, fostering awareness and action. The fact that sustainable development knowledge extends beyond specific subjects underscores its interdisciplinary nature. Integrating sustainable development principles into various subjects can enhance learners' holistic understanding and encourage cross-disciplinary collaboration. Aligned with Leal Filho et al. (2009), Technology Education emerges as a promising avenue for addressing sustainable development challenges. Incorporating sustainability content within Technology curricula can equip learners with practical skills and awareness regarding resource utilisation, design, and societal impacts. The study emphasises the importance of resource utilisation and design in promoting sustainability within educational contexts. Curriculum designers and teachers should prioritise teaching learners about responsible resource management and sustainable design practices. Technology Education encompasses critical aspects of technology's societal and environmental impacts, as emphasised by Gumbo (2018) and Mapotse (2012). Integrating sustainability principles into Technology Education can empower learners to address real-world challenges and contribute to a more sustainable future. Despite acknowledging the historical roots of environmental stewardship, the study reveals that sustainability principles remain limited in Technology curricula. Efforts are needed to bridge this gap by comprehensively infusing sustainability concepts into educational programs. Pavlova (2011) emphasises the importance of addressing sustainable development through topics like processing and recycling within the subject. Curriculum designers can explore innovative ways to anchor sustainability concepts within Technology Education, fostering practical application. As stated by Schnitzler (2019) and Saitua-Iribar et al. (2020), collaborative learning emerges as a promising approach to sustainability education within Technology Education. Encouraging collaborative projects and problem-solving can enhance learners' engagement and deepen their understanding of sustainability. In summary, the study provides valuable insights for teachers, policymakers, and curriculum developers to enhance sustainable development education. We can empower future generations to create positive change by leveraging Technology Education and addressing current limitations.

Recommendations for further research

Drawing from the findings of the study the following were the recommendations. This study recommends a teaching approach that would encourage value transformation rather than treating sustainability as a standalone topic; integrating it holistically across the curriculum will

be of assistance. Technology teachers need to encourage value transformation among learners, emphasising responsible citizenship and the need for a sustainable future. Also, there should be a need for teachers to highlight the importance of resource utilisation within Technology Education. For instance, teaching learners how Technology can contribute to sustainable practices, such as efficient use of materials and energy. Teachers should integrate strands related to design and manufacturing, which would force learners to explore sustainable design principles, particular economic concepts, and eco-friendly production methods. Technology teachers should also ensure that they address sustainable development through practical topics like processing and recycling. Furthermore, they should teach learners how Technology can contribute to waste reduction, recycling, and responsible consumption. In their teaching, this study recommends encouraging collaborative learning experiences where learners can collaborate to explore real-world sustainability challenges, propose solutions, and engage in hands-on projects. Moreover, the teaching of Technology Education promotes critical thinking and problem-solving. Therefore, teachers should engage learners in critical discussions about technology's impact on society and the environment. Encourage them to analyse complex sustainability dilemmas and propose innovative solutions. Further studies that will look at the practical incorporation of the highlighted recommendations above can be explored. Moreover, a study exploring the pedagogical strategies from the two approaches, i.e., qualitative and quantitative, is required.

REFERENCES

Baskarada, S. (2014). Qualitative case study guidelines. *The Qualitative Report, 19*(40), 1-25. https://doi.org/10.46743/2160-3715/2014.1008

Bergsteiner, H., Avery, G. C., & Neumann, R. (2010). Kolb's experiential learning model: critique from a modelling perspective. *Studies in Continuing Education, 32*(1), 29-46. https://doi.org/10.1080/01580370903534355

Blose, P. (2023). *The incorporation of education for sustainable development in Technology Education for an indigenous context.* Doctoral theses. Pretoria: University of South Africa. https://uir.unisa.ac.za/handle/10500/30606

Brown, A., & Danaher, P. A. (2019) CHE Principles: facilitating authentic and dialogical semi-structured interviews in educational research, *International Journal of Research & Method in Education, 42*(1), 76-90. https://doi.org/10.1080/1743727X.2017.1379987

Caldwell, K., & Atwal, A. (2005). Non-participant observation: using video tapes to collect data in nursing research. *Nurse Researcher, 13*(2), 42-54. https://doi.org/10.7748/nr.13.2.42.s6

Chimbunde, P., & Moreeng, B. B. (2024). The Sustainability of Curriculum Reform and Implementation Through Teacher Participation: Evidence from Social Studies Teachers. *Journal Of Curriculum Studies Research, 6*(1), 83-98. https://doi.org/10.46303/jcsr.2024.6

Cole, F. L. (1988) Content analysis: process and application. *Clinical Nurse Specialist 2*(1), 53-57. https://doi.org/10.1097/00002800-198800210-00025

Department of Basic Education. (2011). National Curriculum Statement: Curriculum and Assessment Policy Statement (CAPS) Technology Grades 7 – 9. Pretoria: Government Printers.

Franco, I., Saito, O., Vaughter, P., Whereat, J., Kanie, N., & Takemoto, K. (2019). Higher education for sustainable development: Actioning the global goals in policy, curriculum and practice. *Sustainability Science*, *14*, 1621-1642. https://doi.org/10.1007/s11625-018-0628-4

Gadotti, M. (2009). Eco-pedagogy: extending the educational theory of Paulo Freire to sustainability. *Young people, education, and sustainable development: Exploring Principles, Perspectives, and Praxis*, 107-112. https://doi.org/10.3920/9789086866915_013

Glavič, P. (2020). Identifying key issues of education for sustainable development. *Sustainability, 12*(16), 1-18. https://doi.org/10.3390/su12166500

Grosseck, G., Țîru, L. G., & Bran, R. A. (2019). Education for sustainable development: Evolution and perspectives: A bibliometric review of research, 1992–2018. *Sustainability, 11*(21), 6136. https://doi.org/10.3390/su11216136

Gumbo, M. T. (2018). Addressing the factors responsible for the misunderstanding of Technology Education with other subject fields. *Perspectives in Education*, *36*(1), 128-144. https://doi.org/10.18820/2519593X/pie.v36i1.9

Hall, J. K., Daneke, G. A., & Lenox, M. J. (2010). Sustainable development and entrepreneurship: Past contributions and future directions. *Journal of Business Venturing*, *25*(5), 439-448. https://doi.org/10.1016/j.jbusvent.2010.01.002

Hallinger, P., & Chatpinyakoop, C. (2019). A bibliometric review of research on higher education for sustainable development, 1998–2018. *Sustainability*, *11*(8), 1-20. https://doi.org/10.3390/su11082401

Harwood, T. G., & Garry, T. (2003). An overview of content analysis. *The Marketing Review*, *3*(4), 479-498. https://doi.org/10.1362/146934703771910080

Holst, J., Brock, A., Singer-Brodowski, M. & De Haan, G. (2020). Monitoring progress of change: Implementation of Education for Sustainable 195 Development (ESD) within documents of the German education system. *Sustainability, 12*(10): 1-19.

Jabareen, Y. (2008). A new conceptual framework for sustainable development. *Environment, Development and Sustainability*, *10*, 179-192. https://doi.org/10.1007/s10668-006-9058-z

Jasmi, N., Kamis, A., & Farahin, N. (2019). Importance of green technology, Education for Sustainable Development (ESD) and environmental education for students and society. *Journal of Engineering Research and Application*, *9*(2), 56-59.

Karatsareas, P. (2022). Semi-Structured Interviews. In R. Kircher & L. Zipp (Eds.), *Research Methods in Language Attitudes* (pp. 99–113). chapter, Cambridge: Cambridge University Press. https://doi.org/10.1017/9781108867788.010

Kayes, D. C. (2002). Experiential learning and its critics: Preserving the role of experience in management learning and education. *Academy of Management Learning & Education, 1*(2), 137-149. https://doi.org/10.5465/amle.2002.8509336

Kolb, D. A. (1984). *Experiential Learning: Experience as the Source of Learning and Development.* Englewood Cliffs, NJ: Prentice-Hall.

Leal Filho, W., Manolas, E., & Pace, P. (2009). Education for sustainable development: Current discourses and practices and their relevance to technology education. *International Journal of Technology and Design Education, 19*(2), 149-165. https://doi.org/10.1007/s10798-008-9079-z

Lozano, R., Merrill, M., Sammalisto, K., Ceulemans, K., & Lozano, F. (2017). Connecting competences and pedagogical approaches for sustainable development in higher education: A literature review and framework proposal. *Sustainability, 9*(10), 1-15. https://doi.org/10.3390/su9101889

Mapotse, T. A. (2012). *The teaching practice of Senior Phase Technology Education teachers in selected schools of Limpopo province: An action research study.* Doctoral thesis. Pretoria: University of South Africa.

McGarr, O. (2010). Education for sustainable development in technology education in Irish schools: A curriculum analysis. *International Journal of Technology and Design Education, 20*, 317-332. https://doi.org/10.1007/s10798-009-9087-7

Mughal, F., & Zafar, A. (2011). Experiential learning from a constructivist perspective: Reconceptualizing the Kolbian cycle. *International Journal of Learning and Development, 1*(2), 27-37. https://doi.org/10.5296/ijld.v1i2.1179

National Framework for Sustainable Development. (2008). Department of Environmental Affairs and Tourism: A National Framework for Sustainable Development in South Africa. Available at: https://www.gov.za/sites/default/files/gcis_document/201409/nationalframeworkforsustainabledevelopmenta0.pdf.

Nkambule, B., & Ngubane, S. A. (2023). Eradicating a Culture of Public Mistrust in TVET College Education in South Africa: A Manifesto for the Sector's Sustainability Ahead of 4IR. *Research in Social Sciences and Technology, 8*(4), 301-329. https://doi.org/10.46303/ressat.2023.44

Nölting, B., Molitor, H., Reimann, J., Skroblin, J. H., & Dembski, N. (2020). Transfer for sustainable development at higher education institutions—Untapped potential for education for sustainable development and for societal transformation. *Sustainability, 12*(7), 2925. https://doi.org/10.3390/su12072925

Organisation for Economic Cooperation and Development. (2006). *Good Practices in National Sustainable Development Strategies of OECD Countries.* OECD: Paris [online]. Retrieved May 12, 2023, from http://www.oecd.org/dataoecd/58/42/36655769.pdf

Pavlova, M. (2011). ESD through Technology Education: Contextualisation of approaches. *African Journal of Research in Mathematics, Science and Technology Education, 15*(3), 41-55. https://doi.org/10.1080/10288457.2011.10740717

Pavlova, M. (2018). Sustainability as a transformative factor for teaching and learning in Technology Education. In de Vries, M. (Ed.). *Handbook of Technology Education* (pp. 827-842). Springer International Handbooks of Education. Springer, Cham. https://doi.org/10.1007/978-3-319-44687-5_57

Rojo, T., & Dudu, S. (2017). Los videojuegos en la implementación de políticas de mitigación del cambio climático. *Ámbitos,* 37, 1-25. https://doi.org/10.12795/Ambitos.2017.i37.02

Rudinger, B. J., & O'Neil, J. K. (2019). Technology-Enhanced Learning and Education for Sustainable Development. In Leal Filho, W. (Eds.), *Encyclopedia of Sustainability in Higher Education.* Springer, Cham. https://doi.org/10.1007/978-3-030-11352-0_368

Saitua-Iribar, A., Corral-Lage, J., & Peña-Miguel, N. (2020). Improving knowledge about the sustainable development goals through a collaborative learning methodology and serious game. *Sustainability*, *12*(15), 1-11. https://doi.org/10.3390/su12156169

Schnitzler, T. (2019). The bridge between education for sustainable development and transformative learning: Towards new collaborative learning spaces. *Journal of Education for Sustainable Development*, *13*(2), 242-253. https://doi.org/10.1177/0973408219873827

Singh-Pillay, A. (2020). Pre-service Technology teachers' experiences of project-based learning as pedagogy for education for sustainable development. *Universal Journal of Educational Research, 8*(5):1935-1943.

Sturman, A. (1997). Case Study Methods. In J. P. Keeves (Ed.). *Educational Research, Methodology and Measurement: An International Handbook* (2nd ed.). (pp. 61–66). Oxford: Pergamon.

United Nations (1992). Agenda 21. In *United Nations Conference on Environment and Development* (pp. 1–351). Rio de Janeiro: United Nations.

United Nations Educational, Scientific and Cultural Organization (2016). *Global education monitoring report-place: Inclusive and sustainable cities.* Paris: UNESCO.

Urbańska, M., Charzyński, P., Gadsby, H., Novák, T.J., Şahin, S. & Yilmaz, M.D. (2021). Environmental threats and geographical education: Students' sustainability awareness—evaluation. *Education Sciences, 12*(1): 1-15.

Wals, A. E. J., & Kieft, G. (2010), "Education for Sustainable Development, Research Overview", *Sida Review,*13, Stockholm. Retrieved June 12, 2023, from http://www.sida.se/publications

Walshe, C., Ewing, G., & Griffiths, J. (2012). Using observation as a data collection method to help understand patient and professional roles and actions in palliative care settings. *Palliative Medicine*, *26*(8), 1048-1054. https://doi.org/10.1177/0269216311432897

APPENDIX A: OBSERVATION TOOL

Observer Information Observer Name: Date: Time: Location: Grade:	
Teacher Information Teacher Name: Years of Experience: Qualifications:	

Actual observation: During the Lesson Presentation

Categories	**Indicators**	**Notes**
Teachers' knowledge about Education for Sustainable Development (ESD)	Integration of ESD principles in lessons (e.g., sustainability, environmental impact, social responsibility) Teacher's ability to explain the relevance of ESD to learners Use of resources and materials related to ESD	
Technology Education Content Informing the Teaching of ESD	Inclusion of ESD topics in the curriculum (e.g., renewable energy, sustainable design) Examples of content that incorporates ESD Alignment of content with ESD concept	
Pedagogical Approaches for Imparting ESD	Use of active learning strategies (e.g., project-based learning, collaborative activities)	

	Encouragement of critical thinking and problem-solving related to ESD	
	Inclusion of real-world examples and case studies	
	Assessment methods that evaluate learners' understanding of ESD	
General Observations		