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In-Service Teacher Training Programmes that Promote Education for Sustainable Development: A Review of Emerging Literature

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Abstract: Teacher continuous professional development programs have been identified as important tools for integrating education for sustainable development (ESD) into teacher education in South Africa. Research studies have indicated that in-service training for secondary school teachers has been under-resourced and poorly implemented in terms of integrating ESD into teaching and learning in secondary schools. The literature also supports the claim that, in light of climate change and global warming, in-service programs for secondary school teachers do not adequately promote the integration of ESD in South African classrooms. Due to the absence of a suitable professional development program to support the implementation of ESD in secondary schools, efforts to resolve these deficiencies have not had the expected impact. This study examines the challenges in South Africa's in-service teacher development program for integrating ESD. The in-service training program for sustainable development was researched using the systematic literature review methodology. The study argues that inadequate in-service training programs for secondary schoolteachers have hindered the implementation of ESD in South Africa. The literature also revealed the absence of a unified framework that can be used in South Africa to integrate ESD. As a result, it is recommended that combinations of frameworks or models be adopted when designing a unified in-service training program for teachers to promote ESD in South African classrooms.

Keywords: In-service training, sustainable development, teacher development pragrammes.

1. Introduction

Education for Sustainable Development focuses on developing competencies such as critical thinking, foreseeing future situations, and making collaborative decisions (Boeve-de Pauw et al., 2015). In the era of global sustainability, the in-service teacher development program for sustainable development is gaining significant momentum. Over the past few decades, international communities have joined forces under the United Nations to address sustainable development collectively. As a result, Education for Sustainable Development (ESD) has emerged as one of the primary solutions to promoting sustainability. The overarching goal of ESD is to equip students with the necessary skills for sustainability through a holistic interdisciplinary approach to content and learner-centred democratic teaching methodologies. ESD has been implemented globally, thanks to the UN Decade for Education for Sustainable Development, which has brought about curriculum revolutions worldwide (Boeve-de Pauw et al., 2015). Despite this global commitment to ESD as a teaching strategy, there is limited empirical information on its implementation in classrooms and its impact on student outcomes, including knowledge, attitudes, and behaviours towards sustainable development (Boeve-de Pauw et al., 2015). World leaders have stressed the urgent need to integrate environmental and sustainability education to address the pressing issue of climate change. As climate change continues to affect the global environment, the adoption of environmental and sustainability education has become vitally important in combatting these environmental challenges (Abbass et al., 2022; Olawumi et al., 2023). Countries worldwide have endeavoured to incorporate

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environmental and sustainability education into their curricula to empower students with the skills necessary to address ecological issues sustainably (Corpuz et al., 2022; Acosta et al., 2022). Central to this effort is teacher education, which plays a crucial role in promoting Education for Sustainable Development (ESD). The role of teachers in implementing sustainable development education is critical and essential (Rieckmann, 2019; Mavuso et al., 2022). Enhancing the capacity of in-service teachers for sustainable development requires the commitment of all stakeholders to provide continuous professional development programmes.

Teacher education for practising teachers and Education for Sustainable Development (ESD) is crucial in enhancing individual capacities to address societal challenges (Agbedahin, 2019; Holfelder, 2019). This essential role is reflected in the United Nations Sustainable Development Goals (SDGs) number 4 and 5, which emphasise providing inclusive and equitable quality education for all and lifelong learning opportunities (UN, 2015). Achieving this goal necessitates focusing on in-service teacher education or continuous professional development programmes as key drivers of progress toward a sustainable future (United Nations, 2020). In the view of Brundiers et al. (2021), Rieckman (2018), and UNESCO (2017), the primary aim of ESD is to empower learners with the necessary skills needed to address environmental challenges, such as climate change and other environmental issues, by promoting reflective actions that create a sustainable and friendly environment for all (Brundiers et al., 2021; Rieckmann, 2018; UNESCO, 2017). For this study, the terms "in-service teacher development program" and "continuous teacher professional development program" will be used interchangeably.

In South Africa, in-service teachers are critical stakeholders in integrating sustainable and environmental education. However, these teachers often lack adequate professional development in ESD due to gaps in their pre-service training programmes and insufficient professional development opportunities focused on sustainability (Imara & Altinay, 2021). Additionally, many teachers struggle to effectively integrate environmental education due to inadequate content and pedagogical knowledge of climate change and sustainable development. Therefore, stakeholders must develop appropriate strategies to enhance the capacity of in-service teachers to integrate ESD effectively.

The in-service teacher training program comprises a set of activities and practices designed to develop teachers' capacities and improve their classroom practices (Osamwonyi, 2016). This research explores the connection between in-service teacher development programmes and sustainable development. It also seeks to understand how these programmes can support achieving sustainability goals 4, 5, 11, and 13 in South Africa, identify practical approaches to teaching ESD, and address the associated challenges (Osamwonyi, 2016).

1.1 Conceptualising education for sustainable development

Climate change, disaster risk reduction, biodiversity, poverty reduction, and sustainable consumerism are all examples of significant topics in sustainable development that must be addressed in education. This requires participatory teaching and learning strategies that motivate and empower students to modify their behaviour and take action for sustainable development. Education for Sustainable Development (ESD) develops competencies such as critical thinking, predicting future situations, and making collaborative decisions (Boeve-de Pauw et al., 2015). The concept of ESD gained popularity in the 1960s as people recognised the need to change their attitude toward the environment (Abbass et al., 2022; Agbedahin, 2019). According to them, adaptation and mitigation strategies must be integrated into ESD to address environmental issues and people's poor attitudes toward the environment. Sachs (2012) defines environmental sustainability as preserving the environment, reducing pollution and carbon emissions, and slowing down environmental degradation. However, due to its developing nature and limited awareness within the educational system, ESD is difficult to define (Saleem & Zamir, 2016).

According to UNESCO (2014), the goal of ESD is to empower educators and students to contribute to sustainable development by acquiring the necessary competencies. These competencies include theoretical background, methodological skills, and values that influence decision-making and behaviour (Dlouhá et al., 2019). The fundamental goal of the sustainable development goals is to use sustainable development to create a responsible society. Sustainable development depends significantly on human conduct, responsibility, and socioeconomic, cultural, and environmental circumstances (Dlouhá et al., 2019; Mandikonza & Kavai, 2023). Human interaction with the environment determines sustainable development according to this definition. Education in all domains, from early childhood to adulthood, is essential for sustainable development. The concept of ESD has evolved over time, with its inception in the 1990s when environmental education served as its foundation. ESD has recently been adopted in higher education and schools (UNESCO, 2014).

The goal of ESD is to empower students worldwide to influence sustainable development (Rieckmann, 2018). Its purpose is to facilitate transformation by providing students with the competencies and knowledge needed to achieve the Sustainable Development Goals (SDGs) (UNESCO, 2017). ESD integrates and establishes connections between political, peace, development, and environmental education methods. It aims to clarify the intricate relationships that are harder to understand when priorities are addressed separately. Compared to conventional methods in ecological and developmental education, ESD represents a significant development. Its main goal now is to present various viewpoints and answers to issues rather than pushing students toward specific attitudes and perspectives (Rieckman, 2018).

1.2 In-service teacher development prograamme

This study uses the terms "in-service teacher education program" and "teacher professional development program" interchangeably. These programmes aim to improve classroom practices and enhance learner performance (Ajani, 2019). According to Mansour et al. (2014), teacher professional development pragrammes encompass all learning processes resulting from meaningful interactions, ultimately leading to changes in teachers' professional practices. The goal of these interactions is continuous professional teacher development (CPTD), which involves maintaining and enhancing the knowledge, skills, and experiences related to professional teaching activities and training (Bernadine, 2019). This definition highlights that CPTD is a lifelong, systematic, and planned program to maintain and develop teachers' professional competence throughout their careers.

CPTD is crucial for supporting teachers' skill development in a dynamic environment where knowledge continuously evolves. Traditional professional development practices, such as one- or two-day workshops facilitated by external experts, have proven ineffective in improving classroom practice and student performance (Lauer et al., 2014). The current environmental challenges and the need to integrate education for sustainability into the curriculum necessitate teachers upgrading their teaching practices to meet global demands. A complete overhaul of the current professional development practices is required for effective teaching in Africa. Modern professional development should not be a one-time event but a daily routine integrated into school activities. This does not mean that the duration of the program could determine the impact on participants, but such a program can be designed to provide follow-up and train the trainer's strategies for effectiveness (Tuli, 2017; King, 2016; Lauer et al., 2014).

Recent developments in professional development emphasise collaborative approaches, enabling teachers to engage and work together to enhance their practices beyond what they could achieve alone (King, 2016). Schools should create professional learning communities where teachers can unite, think critically, restructure, and re-culture their institutions (Olivier & Huffman, 2018). This initiative will extend teaching practices beyond the classroom, fostering collaboration among teachers from different schools and communities. Such partnerships will cultivate a culture of shared best practices for enhancing teaching. Principals and school leaders play a significant role in

providing resources, including logistics, for professional learning community initiatives. For teacher professional development to be effective, the government, through school leadership, can assist teachers with the necessary resources, allowing them to actively participate in professional development activities and improve their professional practices (João et al., 2023).

1.3 Continuous teacher professional development programme: South African context

Various studies have been conducted on CPTD in South Africa in recent years, examining teachers' and principals' challenges, expectations, and attitudes regarding CPTD. Mokhele and Jita (2010) identified several challenges teachers face in implementing CPTD and highlighted areas where they need support for effective implementation. One significant challenge is encouraging teacher participation in CPTD pragrammes, crucial for career development and skill enhancement. The study also noted that some principals fail to encourage teacher participation in CPTD due to their incompetence or unwillingness to promote these programmes.

Tsotetsi and Mahlomaholo (2015) explored strategies to strengthen continuing teacher professional development in South Africa, revealing that many professional development pragrammes are not effectively implemented from the teachers' perspectives. Their study, which involved participatory action research in two rural secondary schools in the Free State province, suggested six approaches: establishing a team of all stakeholders, creating a shared vision based on a thorough SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis, prioritising items, developing a strategic plan, monitoring progress, and suggesting improvements based on identified weaknesses.

1.4 Challenges affecting education for sustainable development (ESD)

The foundation of Education for Sustainable Development lies in the convergence of two critical fields - education and sustainable development - which hold significant interest for various stakeholders, particularly the United Nations. Before delving into the challenges affecting ESD, it is essential to define ESD and understand the mechanisms that have influenced its evolution, effectiveness, and global prominence (Agbedahin, 2019). ESD aims to ensure the health of the five pillars of sustainability - the environment, society, economy, peace, and partnership - by integrating these interrelated sectors into education. This integration is grounded in the values and principles of sustainable development (UNESCO, 2016).

Important topics and concepts related to sustainable development must be systematically or ad hoc integrated, included, or mainstreamed into all forms and levels of teaching and learning to support ESD (Agbedahin, 2019). These topics include climate change, food security, biodiversity, poverty reduction, disaster risk reduction and management, and other critical environmental-related issues (Poghosyan, 2015). However, several challenges as indicated below, according to Poghosyan (2015) and Agbedahin (2019) hinder the effective implementation of ESD:

- **Curriculum Integration**: Integrating ESD concepts into existing curricula is often inconsistent and lacks coherence. Many educational systems struggle to incorporate ESD comprehensively across different subjects and academic levels.
- **Teacher Training**: There is a significant need to provide the required skills for teachers, like the in-service training program, to teach ESD in the classroom. In-service teachers often lack the resources and support to integrate ESD into their teaching practices.
- **Resource Constraints**: Insufficient funding and resources are significant barriers to implementing ESD. Schools and educational institutions frequently lack the financial support to develop and sustain ESD pragrammes and initiatives.
- **Public Awareness and Support**: There is often a lack of awareness and support for ESD among the public and policymakers. This lack of understanding can lead to insufficient prioritisation of ESD in national and local educational agendas.

- **Assessment and Evaluation**: Measuring the effectiveness of ESD pragrammes is challenging. There is a need for robust assessment and evaluation frameworks to monitor progress and impact, which are currently underdeveloped.

Integrating ESD into teaching and learning is crucial in order to adapt and mitigate the effects of environmental problems. However, achieving these objectives has been hindered by a lack of knowledge regarding the curriculum for integrating ESD. Additionally, there is inadequate training and capacity for in-service teachers to effectively integrate ESD into their teaching. It is important to develop training programmes specifically designed for ESD, as general training for teachers in different knowledge areas is not sufficient. These specific and directly related training programmes for ESD will be both desirable and effective for successful integration. Inadequate resources pose a major challenge to integrating ESD, including a lack of training opportunities focused on ESD. While other training may have a more general outlook, in-service training specifically designed for ESD will greatly support the teaching of ESD by in-service teachers. Poor awareness of ESD, particularly in terms of how it can address environmental problems, is also a significant challenge. ESD teachers who possess content and pedagogical knowledge will be better equipped to facilitate the teaching of ESD in the classroom.

The study aims to achieve the following objectives:

- Explore how the in-service teacher training program supports the implementation of ESD by teachers in the classroom.
- Identify the challenges encountered by in-service teachers in teaching ESD.
- Examine the strategies and frameworks for teaching ESD by in-service teachers.

By addressing these objectives, the study seeks to provide insights and solutions to enhance the implementation of ESD, thereby contributing to a more sustainable future.

1.5 Theoretical framework

The study adopts Shulman's (1986; 2013) model, Shulman's pedagogical content knowledge (PCK), is based on the reasoning that Shulman (1986) proposes of three knowledge categories in a teacher's cognitive development: content, pedagogical content knowledge, and the curricular. According to Shulman, these can be categorised into seven, which include content knowledge, knowledge of pedagogy, curriculum knowledge for teaching a particular subject/topic, pedagogical knowledge of content, knowledge of characteristics of learners, knowledge of the environment where education activities are taking place, and knowledge of aim, purpose, and history of philosophical foundations. Understanding the motivations behind teaching particular content is included in Pedagogical Content Knowledge (PCK) (Grossman, 1990; Almeida et al., 2019). Thus, it entails the teacher's capacity to identify the goals and necessity of discussing a specific subject in class. This kind of understanding necessitates a thorough awareness of how well pupils understand the material that must be taught, considering their backgrounds, beliefs, modes of thought, possible obstacles, and other variables that could affect their learning. Since it entails developing strategies to depict and explain knowledge, this insight is essential for the teacher to promote effective learning experiences. Comprehending the curriculum, including the resources available for teaching a certain subject and the connections between them, is another aspect of PCK. The instructor can successfully plan and organise content by considering the unique teaching and learning situation with the help of this expertise. To make the subject accessible and understandable for students, teachers might offer it in different ways using instructional tactics, such as activities, experiments, metaphors, analogies, and examples (Grossman, 1990; Shulman, 2013). According to this theory, effective integration of sustainable development into classroom teaching would involve knowledge of content, pedagogical content knowledge, and the knowledge of the curriculum by in-service teachers. The in-service teacher's knowledge development in the three domains is crucial to the teaching of sustainable development. The relevance of this theory is that it will assist in-service teacher education providers

in determining the three essential knowledge areas for in-service teachers to integrate sustainable development in the classroom. The theory also indicates the need for practising teachers to acquire knowledge in three domains: content knowledge, pedagogical content knowledge, and the curriculum to teach sustainable development and other school subjects.

2. Material and Methodology

The study, being qualitative research, adopted the systematic literature review methodology for data collection and analysis. According to Keele (2007), a systematic review methodology is an approach that seeks to identify, evaluate, and interpret research that is relevant to addressing a research question, topic, or phenomenon that is interesting to researchers. Data from this research methodology is derived from secondary data (published articles) relevant to the study. The systematic literature review methodology is ideal because it helps to summarise existing empirical literature, identify gaps, and position new areas for further research (Keele, 2007).

2.1 Data collection

We researched "In-service teacher development and Education for sustainability" using the Web of Science and Scopus databases. The two databases have an extensive collection of articles, with approximately 50 million to 70 million research documents. We opted for Scopus due to its large volume of research documents and the fact that most of the papers from the Web of Science are also indexed in the Scopus database. The researchers collected data for the study from the Scopus database. We limited the search to only the Scopus database from 1999 to 2023, which resulted in the discovery of 137 articles related to the study. The search words used were "in-service teacher" and "ESD." The articles selected were based on in-service teacher education and education for sustainable development from 2010 to 2023. However, we limited the search criteria by removing book chapters, conference proceedings, and books that are not peer-reviewed from the review. A total of 26 articles were finally selected and reviewed by the authors. The results of the initial selection of 137 articles are described below.

Figure 1: *Documents by years*

Figure 1 shows the time series plot of the data, demonstrating an upward trend in the number of articles published from 1999 to 2023. The publication reached its peak in 2023, with 20 documents published in Scopus journals. As indicated by the time series plot, this suggests an increase from 2017

to 2023. However, a downward trend was observed between 2010 and 2012. This indicates an increase in research on sustainability and in-service teacher education in recent years.

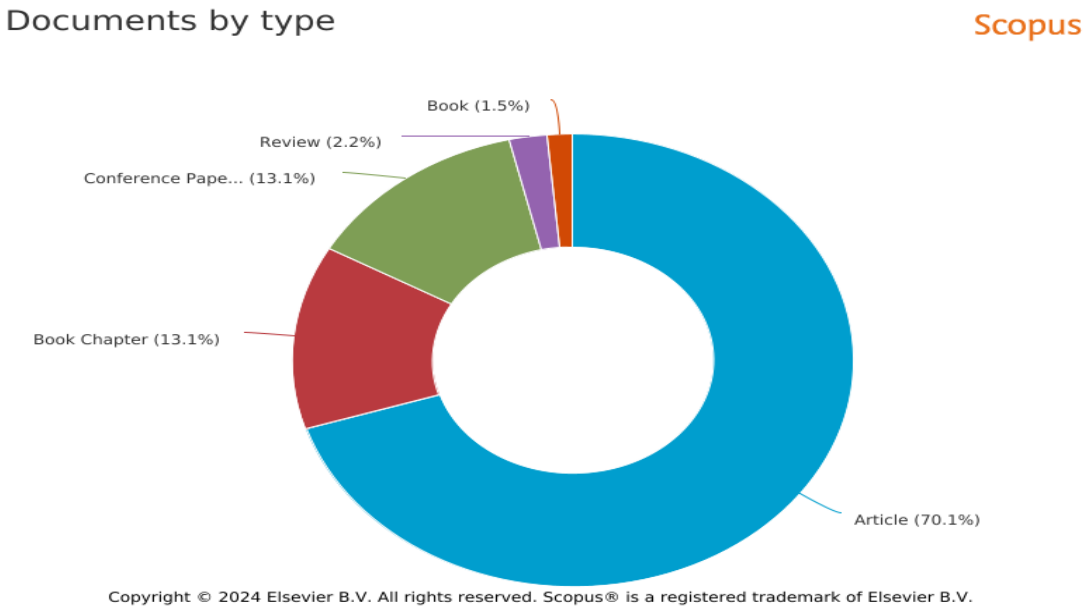

Figure 2: *Document by type*

Figure 2 indicates that 70.1% of the initially searched documents are journal articles. Book chapters and conference papers represent 13.1% of the total, while review papers account for 2.2% and books make up 1.5%. This trend suggests that the majority of sustainability and in-service teacher education publications are in the form of journal articles.

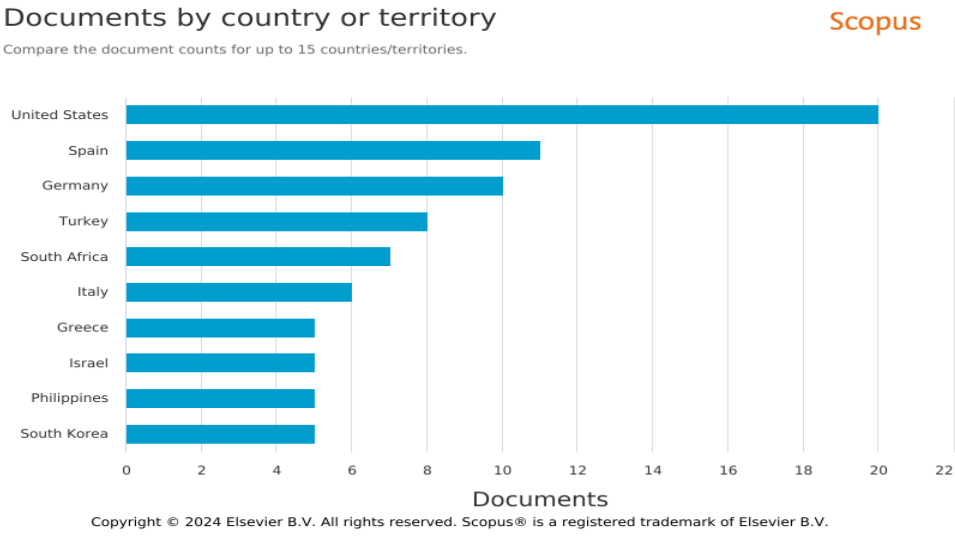

Figure 3*: Documents by country or territory*

The data from Figure 3 indicates that authors from the United States published the highest number of articles on in-service teacher education and sustainable development, followed by authors from Spain and Germany. Among the top ten countries publishing articles on sustainable development and in-service teacher education, only South Africa appears in the ranking. This suggests that South

Africa is the only African country featured among the top 10 countries with the highest number of scientific publications. These results indicate that the majority of articles were published in America and Europe, with fewer publications coming from Africa and Asia.

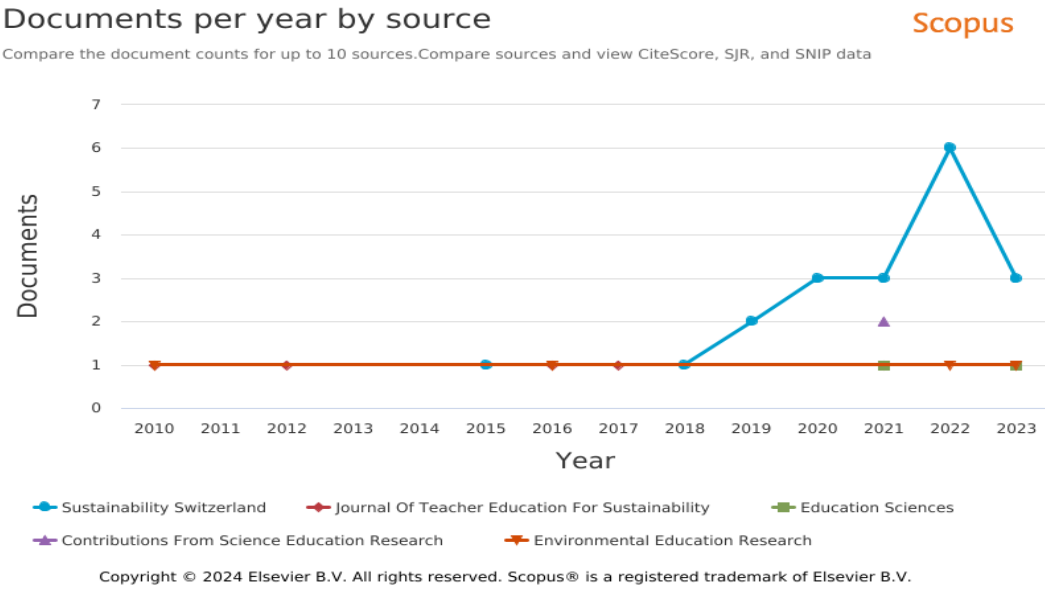

Figure 4: *Documents per year by source*

Data in Figure 4 indicate that articles on ESD and in-service teacher education from 2010 to 2013 were mostly published by Sustainability, followed by the Journal of Teacher Education for Sustainability and Education Science in that order.

2.2 Inclusion and exclusion criteria for the selection of review articles

The article must be peer-reviewed and reviewed, selected from the Scopus index, and aligned with the topic of the study, which is in-service teacher education and education for sustainable development. It should be published between 2009 and 2023. Book chapters, conference proceedings, and books that are not peer-reviewed should be excluded from the review.

After the initial search result, (1) the researchers reviewed articles selected by reading the title, abstract, and content to select only those related to the topic; (2) articles found not relevant or unrelated according to the inclusion and exclusion criteria were excluded; (3) the authors carefully studied the articles starting from the abstract, introduction, methods, results, discussion, and conclusion; (4) this was followed by reviewing the selected articles that were aligned with the objectives of the study; (5) finally, the results of the reviewed articles were written, along with the discussion.

2.3 Selection of samples

The authors considered selecting articles from Scopus-indexed international journals. The samples consist of twenty-six articles published in high-impact journals. The researchers considered articles focusing on sustainable development education and the in-service teacher education program. These 26 articles are divided into quintile 1 (Q1), quintile 2 (Q2), and quintile 3 (Q3). Q1 consists of 19 articles (73%); Q2 consists of 4 articles (15%); Q3 consists of 3 articles (12%). The analysis indicates that the articles selected for review are of high quality and published in high-impact journals. The analysis of the articles chosen for review is shown in Table 1.

Table 1: *Article selection table*

S/N.	Name of Journal	Year	Index by	Total Article
1	Journal of Teacher Education	2022	Scopus Q1	1
2	Sustainability	2017, 2019, 2019, 2019, 2020, 2021, 2021, 2022, 2023	Scopus Q1	9
3	Journal of Cleaner Production	2018	Scopus Q1	1
4	Environmental Science Europe	2021	Scopus Q1	1
5	Sustainability: Science, Practice and Policy	2012	Scopus Q1	1
6.	International Journal of Sustainability in Higher Education	2020	Scopus Q1	1
7.	The Journal of Environmental Education	2019	Scopus Q1	1
8	Africa Education Review	2019	Scopus Q3	1
9.	Journal of Teacher Education for Sustainability.	2016, 2015	Scopus Q2	2
10.	Education Sciences MPDI	2023	Scopus Q2	1
11.	South African Journal of Education	2010	Scopus Q3	1
12.	Environmental Education Research	2014, 2023	Scopus Q1	2
13.	Infant and Young Children	2015	Scopus Q3	1
14.	International Journal of Science and Mathematics Education.	2022	Scopus Q1	1
15.	Journal of Adventure and Outdoor Learning.	2019	Scopus Q2	1
16.	Chemistry Education Research and Practice.	2013	Scopus Q1	1
			Total	**26**

3. Presentation of Results

Results of the 27 articles reviewed were presented and analysed in tabular form. The table was based on the integration of ESD into teaching by in-service teachers, challenges affecting the effective integration of ESD, and strategies for teaching ESD by in-service teachers. We summarised the findings of the 27 articles related to in-service teacher education and education for sustainable development in Tables 2 to 4.

Table 2: *Distribution of study results related to Integration of ESD into teaching by In-service Teachers*

S/N.	Study	Research Approach	No. of Participants/ Sample	Result

1.	Fischer et al (2022)	Qualitative-	Literature	The results demonstrate the expanding field of teacher ESD and propose five categories of inquiry: creating a learning environment, comprehending the characteristics of learners, assessing learners' performance, advocating for systemic change, and furthering the field's vision.
2.	Leal Filho et al (2021)	Qualitative	Universities from 45 countries	The outcome emphasises how crucial it is to include climate change in various courses and academic fields, highlighting particular curricular gaps and areas of strength for focused improvement. Further training pragrammes for academic workers are also desperately needed.
3.	Murphy (2012)	Qualitative	Literature	Findings suggest the expansion of social pillars to incorporate a stronger emphasis on environmental, international, and intergenerational dimensions. The study also indicates that sustainable development initiatives should be expanded.
4.	Montenegro de Lima et al (2020)	Qualitative	745 literatures	The findings reveal the interrelatedness of education to several SDG goals numbers (4,15,16 and 17). Education, the focus of SDG goal number 4, played a crucial role in implementing sustainable development in university courses and curricula.
5.	Redman et al (2018)	Qualitative	246 K-12 in-service teachers from across the USA	The evaluation results of the CPD program show that participation in the program led to increased sustainability knowledge, self-efficacy perception, the incorporation of sustainability in the classroom, modeling of sustainable conduct, and connecting action to information.
6.	Álvarez-García (2019)	Quantitative	274 pre-service teachers	The findings show that the acquisition of the competencies above was highly impacted by gender, the student's usual domicile, the kind of leisure activities they engaged in, and certain educational aspects.
7.	João et al (2023)	Qualitative	14 Basic education teachers.	The questionnaire's content analysis results show that in-service teachers' planning and creation of didactic materials on science subjects from a Sustainable Development viewpoint has improved. The study also suggests adapting in-service teacher

				education pragrammes to other themes related to educational issues.
8.	Ono & Ferraira (2010)	Qualitative	Literature	The findings reveal improvement in mathematics and science teaching in Mpumalanga Secondary Schools' initiative by implementing a continued professional development program for teachers.
9.	Letouzey-Pasquier et al. (2023)	Qualitative	Researchers, teachers, and a pedagogical advisor.	The focus group study revealed a shift in the perspectives held by ESD teachers. The potential of the strategies used to assist instructors in beginning the process of conceptualising knowledge in terms of ESD is highlighted by the study of the teachers' remarks.
10.	Dunst et al. (2015)	Qualitative	Document analysis	The findings also demonstrate how practitioner assessments of social validity mediate between these outcomes and the essential components of in-service professional development. Additionally, there are two types of effects that in-service professional development can have on the outcomes of parents and children: direct effects that are mediated by the fidelity of practitioners to the early childhood intervention methods that are the main emphasis of in-service training and indirect effects.

Table 2 shows an increased awareness of ESD among in-service teachers. The level of knowledge of content and pedagogical content knowledge among in-service teachers is determined by their attitude towards teaching ESD, the availability of resources, in-service training, and resources availability. Continuing professional development will assist in-service teachers in acquiring the competence to teach ESD. The distribution of study results related to challenges affecting the teaching of ESD can be seen in Table 3.

Table 3: *Distribution of study results related to challenges affecting the effective integration of ESD*

S/N.	Study	Research Approach	No. of Participants /Sample	Result
11.	Lowe & Prout (2019)	Qualitative	Literature	The results show that the country's present in-service training program does not address more fundamental problems with Kenyan teaching professionalism.

12.	Kang (2019)	Qualitative	Korean secondary school teachers	The outcome shows a few hurdles: individual barriers, individual and class-driven structural barriers combined, and personal and structural barriers alone. The study also demonstrates how taking ESD affects teachers' pre-service teacher education and in-service training, which are important indicators of their ability to instruct ESD.
13.	Álvarez-García (2015)	Qualitative	Literature	The result from the study indicates a lack of environmental competencies among pre-service teacher students and the gaps in the teacher training curriculums regarding environmental education.
14.	Imara & Altinay (2021)	Qualitative	Literature	The findings indicate that there has been a greater focus over the past ten years on creating a set of ESD competencies for instructors, which highlights the lack of a cohesive framework for these competencies. However, it is still unclear to what extent teacher training effectively incorporates these competencies.
15.	Bascope et al (2019)	Qualitative	Literature	The study highlights a few obstacles and the necessity for educational systems to actively support science-based citizenship education in the direction of sustainable development. This involves encouraging early action to change the local context and raise public awareness of the world's environmental, social, and economic issues in the twenty-first Century.
16.	Borg et al. (2014)	Quantitative	3229 Swedish upper secondary school teachers and 297 Upper secondary schools.	According to their self-evaluation, instructors who recently graduated from college have a poorer comprehension of sustainable development than teachers with more experience. Since more than 70% of the instructors surveyed felt they required more training in sustainable development, the study emphasises the need for greater training in this area.
17.	Basheer et al (2023)	Quantitative	Two hundred seventy-one pre-and in-service	The results show a poor level of general sustainability and green chemistry awareness among teachers. It was discovered that pre-service science instructors knew less about sustainability and

			teachers in Israel.	green chemistry than in-service science teachers. Interestingly, compared to teachers with less experience, in-service science teachers with over ten years of classroom experience exhibited more knowledge.
18.	Aksland & Rundgren(2019)	Qualitative	Grade 5-10 students and teachers	The findings reveal that outdoor teaching was scarcely linked to sustainable development.
19.	Burmeister (2013)	Qualitative	16 Chemistry Teachers	These findings demonstrate that instructors' opinions toward incorporating sustainability and ESD issues into their lessons are positive. The results also show that instructors' knowledge of the theoretical underpinnings of ESD and sustainability is rudimentary.
20.	Scherak (2020)	Mixed method	Lecturers and students teachers.	The findings indicate that while all 12 RSP abilities are pertinent to teaching in higher education, there is little chance of incorporating them into a staff development program. The development of ESD capabilities can benefit from and need various trigger points and circumstances. Higher education has limited opportunities to adopt ESD approaches if such prerequisites are unmet.

Table 3 study results show combinations of barriers that affect in-service teachers' effective teaching of ESD. Some of the challenges are structural, class drives, and individual. The lack of a unified framework and competencies of in-service teachers constitute barriers to the implementation of ESD. Studies also noted that the poor implementation of ESD in higher institutions, inadequate experience of newly qualified teachers on ESD, outdoor teaching not linked to ESD, and poor knowledge of theory are some challenges affecting ESD. The distribution of studies on strategies for teaching ESD can be seen in Table 4.

Table 4: *Distribution of results relating to the teaching ESD by In-service teachers*

S/N.	Study	Research Approach	No. of Participants/Sample	Result
21.	Lozano et al (2017)	Qualitative	Literature	The study reveals the importance of providing students with complete sustainability competencies. Also, the study findings showcase the interrelationship between pedagogy approaches and competencies in the context of sustainable development.
22.	Filho et al (2018)	Qualitative	Students and faculty	The result indicates that incorporating education for

			members from higher education institutions from 7 countries.	sustainable development into the transformation framework within higher education institutions has been lacking. It noted that fostering sustainability within curricula requires academics to adopt collaborative strategies.
23.	Malandrakis et al (2019)	Quantitative	924 primary school students, 88 in-service primary school teachers	The study recommends that in-service teachers apply knowledge and approaches from different disciplines in teaching education for sustainable development. Findings from the study also indicate that teacher self-efficacy for sustainable development is needed for in-service teachers to fulfill their pedagogical role.
24.	Kabadayi (2016)	Quantitative	133 pre-school teachers	The findings reveal the importance of in-service teacher education for the professional development of teachers. The in-service education training model should be constructed according to the needs of teachers.
25.	Asghar et al (2022)	Quantitative	629 in-service teachers	The findings from the study reveal a direct relationship among the four levels of the Kirkpatrick model, including the reaction, learning, behavior, and result. The findings suggest that in-service training pragrammes should be tailored to the Kirkpatrick training model.
26.	Vieira et al (2021)	Mixed method	1775 in-service teachers	The findings indicate a successful implementation of lifelong learning in vocational education and training (VET) for in-service teachers on sustainable development in Albania. The findings also reveal key success factors for successful implementation in context, content, commitment, capacity, and client.
27.	Su et al. (2023)	Qualitative	Sixteen articles from Scopus, WOS, and SciELO databases.	The findings emphasise the importance of carrying out more research and creating practical plans for incorporating ESD into math teachers' ongoing professional development. Current studies involving active and pre-service teachers provide insights into the prevalent trend of incorporating ESD into

	mathematics instruction through ESD aspects and didactic abilities.

Results in Table 4 suggest the need for a collaborative approach to teaching ESD. Additionally, transformative frameworks have been advocated as a strategy for teaching ESD through the professional development of in-service teachers. The results also indicate that the professional development of teachers must be tailored along the Kirkpatrick training model in line with the prevailing trend in ESD.

4. Discussion of Findings

This section presents the findings of this study, and the presentation is made in response to the research questions raised earlier. Hence, the following three themes emerged: Integration of ESD into teaching by In-service Teachers, Challenges affecting the effective integration of ESD, and Strategies for teaching ESD by In-service teachers.

4.1 Integration of ESD into teaching by In-service Teachers

The findings reveal increased awareness of ESD by in-service teachers. The level of knowledge of content and pedagogical content knowledge by in-service teachers is determined by their attitude towards teaching ESD, in-service training, and availability of resources. Continuing professional development will assist in-service teachers in acquiring the competence to teach ESD.

This study explores the review of literature on in-service teacher development programs and ESD. The in-service teacher education program is a new area of study that generates conversation among stakeholders (Glasser & Hirsh, 2016; Fischer et al., 2022; Kang, 2019; Letonzey-Pasquier et al., 2023). Fischer et al. (2022) suggest different strategies in-service teachers can use to teach ESD. Rather than teachers being limited to only one approach to teaching ESD, Fischer et al. (2022) suggest combining approaches and innovations that emphasise socio-environmental challenges and appropriate methodologies to engage with knowledge diversity. The findings show that appropriate pedagogical content and content knowledge are essential for ESD teachers (Nousheen et al., 2024). Research indicates a strong connection between content knowledge and pedagogical content knowledge with ESD (Nousheen et al., 2024); hence, teacher participation in in-service teacher education will increase teacher capacity and competencies (Redman et al., 2018). The literature also emphasises the importance of resources and training programs on ESD for in-service teachers. Training programs must align with the discipline and be interdisciplinary and transdisciplinary. To enhance their capacity and update their knowledge in line with the dynamic nature of sustainability (Leal Filho et al., 2021; Dunst et al., 2015), teacher education and ESD programs should be a catalyst for the adequate performance of in-service teachers to develop their competencies and address the challenges of ESD.

4.2 Challenges affecting the effective integration of ESD

The lack of a unified framework and competencies of in-service teachers constitutes barriers to the implementation of ESD. Also emerging from the findings are the poor implementation of ESD in higher institutions, the inadequate experience of newly qualified teachers in ESD, outdoor teaching not linked to ESD, and poor knowledge of theory. These challenges affect the implementation of ESD.

Studies have indicated the importance of ESD amid global environmental challenges, including those faced by Africa. According to Holst et al. (2024), the implementation of ESD at all levels of education has been affected by various challenges, and researchers have attempted to find solutions to them (Lowe & Prout 2019; Kang 2019). Kang (2019) notes that some of these challenges are structural, class-driven, and individual, and they impact the teaching of ESD by in-service teachers. One of the challenges in Kenya's experience was the failure of in-service teacher education to address fundamental issues like sustainability (Kang 2019). The literature also highlights the lack of a unified

framework that can be adopted for teaching ESD by in-service teachers. While different approaches have been proposed for teaching ESD, a clear and unified approach would facilitate the teaching and learning of ESD. Therefore, researchers and stakeholders need to work towards designing a unified framework that all in-service teachers can adopt to teach ESD in the classroom. The framework for teaching ESD should be multidisciplinary, transdisciplinary in focus and context, and content-focused to achieve student performance. Furthermore, the literature reveals that the poor implementation of ESD in higher education institutions, inadequate experience of newly qualified teachers in ESD, outdoor teaching not linked to ESD, and poor knowledge of theory are challenges that affect the implementation of ESD (Imara & Altinay 2021; Aksland & Rundgren 2019).

4.3 Strategies for teaching ESD by In-service teachers

The findings suggest that in-service teachers can adopt transformative and collaborative frameworks as strategies for teaching ESD. The results also show that the professional development of teachers must be tailored along the Kirkpatrick training model to align with the prevailing trend in ESD. According to the literature, a collaborative approach to teaching ESD has been recommended (Filho et al., 2018). This approach allows in-service teachers to adapt to different contexts and situations in the curriculum. By adopting various approaches, the interrelationship between pedagogies and competencies in sustainable development can be showcased (Lozano et al., 2017). This will enable teachers to connect ESD to their specific context, enhancing students' understanding and performance. However, in-service teachers need to have knowledge of both content and pedagogy. The transformative approach to teaching ESD assists learners in modifying their behaviour towards the environment, aligning with Shulman's pedagogical content knowledge (PCK) (Shulman, 2006). PCK emphasises the importance of in-service teachers having knowledge of pedagogy and content to effectively teach ESD.

ESD aims to bring about a change in behaviour and transform people's thinking about the environment. The literature also highlights the need to tailor professional development for in-service teachers to reflect the prevailing trend and follow the Kirkpatrick training model, including the reaction, learning, behaviour, and result (Asghar et al., 2022). When designing a framework for the implementation of ESD by in-service teachers, a combination of models can be considered. The Kirkpatrick model can help practitioners and other stakeholders develop a unified framework for teaching ESD, which can be combined with other models. This demonstrates that a combination of different models is desirable and supports in-service teachers in teaching ESD effectively.

5. Conclusions

This review focuses on in-service teacher education programmes and ESD from 2010 to 2023. The articles selected for this review were obtained from the Scopus database and were published in high-impact journals. Currently, there is a growing conversation around the in-service teacher education programme for sustainable development, given the global need for sustainability. However, a unified framework for teaching ESD by in-service teachers is lacking, which poses a challenge to its effective implementation. Inadequate in-service teacher development has also been identified as a hurdle. To address these challenges, it has been suggested that an in-service teacher development programme that specifically targets sustainability be introduced. The study concludes that a combination of context-based approaches could effectively support teacher effectiveness in teaching sustainability and improve students' performance. While various methods for in-service teacher development have been proposed, the study advocates for the use of the Kirkpatrick model, which can be combined with other approaches to ensure effective ESD implementation.

6. Declarations

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