

Educators' Insights on Digital Transformation in Education Through the Lens of the Sustainable Development Goals

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Abstract

The quantitative research aims to investigate the perceptions of Jordanian teachers towards Education for Sustainable Development (ESD) and Digital Transformation of Education aligned with the Sustainable Development Goals (SDGs), specifically SDG 4 “Quality Education”. A total of 232 Amman teachers from public and private schools participated in an online questionnaire consisting of 41 points related to their perceptions of ESD and the quality of digital transformation in education. The instrument had satisfactory reliability ($\alpha = .82$) and excellent content and construct validity. Descriptive information and Multivariate Analysis of Variance (MANOVA) have been applied to check variations by gender, specialization, years of experience, teaching stage, and school type. Significant multivariate effects on subject specialization, type of school, and teaching experience were found. Women and government-school teachers, and those with less than a decade of experience, showed higher awareness and digital competency levels regarding the incorporation of ESD. The results highlight the requirement for specific professional development and institutional support so that teachers’ digital readiness for sustainable education can be enhanced. The study contributes Arab evidence from experience to empirical research, offering policy and practice suggestions for achieving fair and transformative education consistent with SDG 4.

Keywords: Digital transformation in education quality, ESD, quality education, sustainable development, teachers’ perceptions.

Introduction

Given the linked social, economic, and environmental issues and risks, the technological revolution has demonstrated its effectiveness in raising economic, health, and business levels, resulting in an improvement in certain people's standard of living and well-being. The globe is witnessing the development of technological abilities to help people keep up with the genuine developments of the twenty-first century.

Governments today recognize the significance of technology in improving people's living situations around the world while also enriching the natural environment and developing sustainable communities. As a result, they try to improve the technical infrastructure of the educational sector, which is the major sector that provides the labor market with skills and competencies that will work in sectors that use technology to tackle global challenges.

In response, the United Nations launched the Sustainable Development Goals, which were endorsed by world leaders in 2015. It covers 17 Sustainable Development Goals (SDGs) and 169 targets (Bravo et al., 2021). The goals encompass SDG 4, which highlights the importance of education in creating a just, inclusive, and exceptional society, thereby emphasizing the need to strengthen sustainability training by using advanced theoretical and practical information to enable balanced environmental improvement.

According to Abo-Khalil (2024), integrating sustainability principles into the curriculum ensures better preparedness for today's significant environmental and social challenges. Therefore, teachers play a major role in assisting students to achieve their learning objectives. Their effect on society is very apparent because they sensitize students to sustainability, who will, in turn, become future citizens with a strong awareness of sustainability (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2017).

In the same context, studies have confirmed that teachers' conscious initial and ongoing training should be a precondition to solve the global challenge of sustainability. Well-organized educators in environmental and sustainable development are proposed as a precondition to make education an effective pursuit of long-term solutions to global concerns (Llinares et al., 2019). Therefore, teachers should consider themselves as change agents and merge their academic power with environmental and sustainable development. Evans et al. (2016) state that the feeling of self-efficacy in ESD emanates from increased knowledge and awareness of sustainability. The recognition of teachers' perception of sustainable development and Education for Sustainable Development (ESD) is a prerequisite condition for the promotion of Agenda 2030.

Perceptions of ESD and digital transformation by gender, major, type of school, and length of service provide important clues to the mindset of different groups among future teachers towards these initiatives. Therefore, knowledge becomes a basis for educational planners or implementers in framing or reframing their approaches to drive better responsiveness and effectiveness of sustainability and technological interventions in education. However, several studies found a scarcity of content related to sustainability in teacher education. There has been better improvement in the incorporation of this knowledge into teaching guides, but practical application in schools is restricted (Abo-

Khalil, 2024).

The complex environment of education is deeply related to the labor market, industry, society, and sustainable development. It needs extra attention at this point. Therefore, developing university courses aimed at sustainability is difficult because such courses are complex and require interdisciplinarity. Consequently, notions of ESD are different at each university (Moreno et al., 2020). Some universities have adopted sustainability as their guiding principle, while instructors at other institutions are working to integrate sustainability concepts and aims into courses based on their perceptions and awareness of the topic. However, due to low demand, weak publishing policies, and quality assurance, research on the implementation of the SDGs in universities is limited (Stukalo & Lytvyn, 2021).

What poses a major challenge is the lack of a clear link between the curriculum and the SDGs, in addition to the lack of sufficient knowledge among faculty members on how to teach them, not to mention the lack of adequate administrative support (Chapungu & Nhamo, 2024). In recent years, educators and policymakers around the world have become increasingly interested in the intersection of ESD with the digital revolution. While the global education system aims to develop in accordance with the SDGs of the United Nations – including SDG 4 on inclusive, equitable, and quality education – increasing trends underline attempts at fostering techno-pedagogical innovation, thus increasing awareness about integrating educational practices involving sustainable development.

There is scant literature on how educators in the Arab world, particularly Jordan, given its context within a resource-poor Middle East beset by instability, perceive and apply these topics of ESD and educational technology worldwide, even while that corpus is burgeoning (Alhajahmad & Lockhart, 2017). Sustainability is being enhanced and integrated into institutional practices through individual efforts (Jarrar, 2021).

Teachers are important in implementing policies and ensuring the sustainability of practices through the creation of transformative learning environments, thus making it crucial to understand their perception towards sustainability and digital transformation. However, significant variations may exist in these perceptions across demographic and professional variables such as gender, specialization, or type of school; level at which they teach; years of experience, among others (Aikens et al., 2016).

This research paper presents the views of 232 teachers on ESD and digital transformation in education. It attempts to find out how these views vary by demographic parameters that include gender, specialization, type of school, age group taught by instructors (teachers), and years of experience. The study analyzes variables to provide insight into different Jordanian instructor perspectives on the role of sustainability and technology in enhancing educational quality and effectiveness, and to offer primary data to policymakers in the education sector so that they can identify gaps and implement policies for transformative change in education in accordance with sustainability goals.

This paper supports the necessity to understand educators' awareness of sustainability and their perception of quality education. An analysis at the level that teachers consider the quality of education they provide allows the identification of related issues. Understanding how teachers see their role in fostering sustainable practices

helps build tactics that align with their ideas and experiences. Therefore, the following questions are the focus of the current research:

1. 1. Which resources do Jordanian educators initially use when learning about ESD?
2. 2. What are teachers' perceptions of ESD and digital transformation in education quality as one of the SDGs?
3. 3. Do the teachers' perceptions about ESD and digital transformation in education quality differ according to their gender, specialization, school type, age group taught by teachers, and years of experience?

Quality of ESD

Education that encourages changes in knowledge, skills, values, and attitudes to build a more sustainable and equitable society for all is sometimes referred to as education for sustainable development. It has been described as "a process of learning how to make decisions that consider the long-term future of the economy, ecology, and equity of all communities" (UNESCO, as cited in Kagawa, 2007). By addressing the economic, social, and environmental facets of sustainable development in a balanced and integrated manner, ESD aims to empower and equip current and future generations to meet their requirements.

McKeown (2002) stated that "education and the dissemination of knowledge are essential for achieving sustainability" (p. 2). Before comprehending ESD principles, students must first acquire a foundational grasp of the natural sciences, humanities, and social sciences because ESD spans the environment, economics, and society (McKeown, 2002). Once learners have the necessary knowledge and abilities, they can choose their behavior in the environment accordingly (Scott & Oulton, 1998). Individual traits can be changed to make our world less harmful, more comfortable, and healthier. Consequently, the standard of living will improve. It demands a holistic strategy and unique material that is closely tied to sustainable development.

ESD empowers learners to address challenges and make improvements towards sustainable development values, abilities, and competence acquisition towards a developmental approach (UNESCO, 2014). In the meantime, digital transformation is about implementing new technologies for enhancements in educational practices and results. Therefore, these two components stand at the core of realignment between educational practice and SDGs within the requisitioning world that addresses educators towards emerging needs.

The objective of long-term development is to improve the quality of education. SDG 4 relates mainly to significantly increasing the number of qualified teachers, especially through international cooperation on teacher training in developing and least developed countries. It also aims at ensuring equal access for both men and women to affordable technical, vocational, and higher education of good quality that can include university courses as well (United Nations, 2015).

Ministry of Education programs – a remedial learning program, teacher training, and technical and vocational education and training (TVET) initiatives – are components of the government's key agenda towards achieving SDG 4. Between efforts to increase

access to early childhood education, primarily in KG2, and continued international support, pre-primary enrollment increased dramatically from 27 % in 2000 to 59 % by 2019 (United Nations Children's Fund [UNICEF], 2021). The National Plan for Remedial Education aims at addressing learning loss and gaps, but students in rural and refugee areas continue to face challenges due to outdated teaching methods and a lack of resources (Ministry of Education, 2022). Education Reform for Knowledge Economy (ERfKE) focuses on inclusion/special education, mainly implemented in rural areas, with patchy implementation, though reported as implemented (Queen Rania Teacher Academy [QRTA], 2021). Furthermore, Tamheed's career program and other curriculum initiatives have created Technical and Vocational Education and Training (TVET) links with the labor market among integration gains. However, a gap in skills alignment, full private sector participation, and budget constraints remain growth impediments (ETF, 2020; World Bank, 2022).

Educational organizations and administrators work on increasing the awareness of sustainability among teaching staff because it is reflected in the procedures and methods required to implement sustainable strategies (Al Khayal et al., 2019). Al Khayal et al. (2019) analyzed the awareness of faculty members towards sustainability, emphasizing how crucial it is to spread awareness by introducing ideas of sustainability at the college level to include sustainability across all institutions.

Recent research has highlighted the critical role of universities in successfully implementing sustainability policies; Albattah and Bande (2023) performed a survey to assess the student awareness of environmental sustainability on university campuses, as well as the effectiveness of course materials for students who studied in person and online. The findings demonstrated the necessity of increasing awareness by delivering the sustainability concept at the institutional level and incorporating the idea of sustainability into academic courses.

Peedikayil et al. (2023) discovered that high school teachers had a positive attitude towards ESD. Baroudi's study examined how a sustained professional development program affected United Arab Emirates (UAE) teachers' views on evaluation techniques and professional advancement (Baroudi, 2023). In another context, Filippaki contended that sustainable education policy should be linked to teacher education theory and practice (Filippaki, 2023). According to Kriewaldt et al. (2022), Australian pre-service teachers have a strong understanding of sustainability and are willing to act to safeguard the environment. A study in Jordan revealed that green human resource management practices could significantly improve an organization's environmental performance (Rawashdeh, 2018). Similarly, another study demonstrated that the implementation of green practices in emerging economies, such as Jordan, remains a challenge for employers and organizations (Gill et al., 2021).

ESD is essential as it improves and supports the ability of individuals, groups, associations, institutions, and countries to assess and identify preferences for sustainable development. However, various obstacles impede the achievement of quality tertiary education to satisfy the SDGs, such as unawareness of development and its cost benefits, and poor prioritizing (Mhlanga et al., 2022). Many people, including students and educators, may not completely comprehend the significance and consequences

of adopting sustainable practices in education; this negatively affects progress in development measures and the achievement of its goals. Therefore, teachers need to be properly informed or motivated to integrate sustainable development principles into their teaching curricula, which creates a major hurdle. Overcoming this challenge requires first examining teachers' perceptions to determine the size of the gap between theory and reality, and then making efforts to raise awareness, provide training, and demonstrate the real benefits of implementing sustainable practices in education.

Digital Transformation in Education Towards Sustainability

There is mounting evidence that the COVID-19 pandemic has led to a better climate shift. In fact, those who work and learn from home consume less oil because they do not need as much transportation. The digital transformation in education entails using digital tools, platforms, and resources to offer educational content while facilitating communication and cooperation between students and educators. The digital transformation in education has acquired substantial attention and potential in recent years, with many institutions implementing digital technologies in their instructional processes. The digital transformation of the sector of higher education contributes to the development of sustainable curricula, the digitization of education, increased innovation, and enhancements in student performance (Zhanguzhinova, et al., 2023). Furthermore, this transition may add to sustainability in educational institutions by assuring sustainability capabilities, implementing smart and sustainable campus practices, and conceptualizing sustainability in educational institutions.

With global concerns on the rise, the demand for university graduates with collaborative and transdisciplinary abilities is increasing. Higher education institutions are urged to go digital in recognition of the value of Information and Communication Technology (ICT) skills (International Society for Technology in Education [ISTE], 2016), emphasizing the vital necessity to equip people with digital skills. Higher levels of ICT skills are associated with increased salaries (Falck et al., 2021). As a result, higher education institutions are responsible for implementing digitalization initiatives that promote 21st-century competencies and empower students to use technology efficiently.

Recent international empirical research contradicts previous ideas regarding the present generation's intrinsic ICT skills. As a result, there is an increasing demand for additional study on educators' perspectives on technology integration and utilization (Organisation for Economic Co-operation and Development [OECD], 2018). This research is required before executing comprehensive institutional policies efficiently. A review analyzing over 30 peer-reviewed studies indicated that technology was commonly used for convenience rather than to improve pedagogy, and without proper training and support, teachers were unable to incorporate technology tools and resources into their lessons effectively (Strom, 2021).

However, Heitink et al. (2016) found that the majority of the 157 teachers used technology to convey knowledge in the classroom. Teachers are more inclined to employ technology in situations when the emphasis is on the teacher. This is due to the nature of instructors' attitudes towards technology and their determination to include it in their

instruction, in addition to the extent to which they believe in the predicted benefits of technology. As a result, measuring teachers' conceptual understanding of sustainability is crucial for ensuring the breadth and depth of their expertise.

Teachers are key actors in diffusing sustainability concepts within the school environment. On the other hand, gender may influence how teachers perceive technology and sustainability. According to UNESCO (2017), differences in priorities between males and females account for most of the differences in perception towards ESD. For example, women mostly address community- and relationship-based aspects of sustainability. Scherer et al. (2019) found that female teachers emphasized pedagogical and social aspects concerning the use of technology, while their male colleagues felt much more confident about using technologies and showed a significantly higher positive attitude towards using them.

Teachers' perceptions of ESD are related to their disciplines. For example, STEM (Science, Technology, Engineering and Mathematics) teachers may associate and prefer digital tools and technologies more firmly by considering them part of modern education. On the other hand, humanities teachers might be more focused on the ethical and social aspects of ESD (Vukelić et al., 2025). According to UNESCO (2021), since it involves social justice, global citizenship, and ethical reasoning, ESD is easier to integrate into the humanities courses.

Another aspect to consider is that teachers in private schools usually have better access to digital tools and training on how to use such tools, therefore shaping their attitude positively towards digital transformation. Public school teachers, particularly those who cannot acquire sufficient resources, struggle with using digital tools (Tondeur et al., 2017). According to Wals and Benavot (2019), the general perception among rural educators is that ESD addresses local sustainability problems.

According to Prestridge (2012), beginner teachers become keener on using digital technology as they feel more comfortable with technological use, while doubting experienced teachers. However, conflicting results have also been found in other studies. For example, Tondeur et al. (2017) found that pedagogically veteran teachers try to employ their experience for advanced levels of integration, whereas Kimmons et al. (2020) found a lack of deep integration due to a lack of experience among early career teachers. However, Scherer et al. (2019) found no overall differences between the two groups, suggesting that both groups face different challenges. Such contradictory results show that the relationship between teaching experience and digital transformation is a highly complex one and thus intensifies the need for customized professional development to prepare both experienced and novice teachers in successfully implementing and integrating digital technologies.

Methodology

Participants

A quantitative study technique was used to explore teachers' perceptions of ESD and the impact of digital transformation on educational quality. Purposive sampling was used to choose 232 teachers in Amman – the capital of Jordan – across multiple disciplines.

There were 216 females and 16 males.

A randomly selected sample of the teachers was contacted via email to complete the questionnaire, and a 74.8% response rate was obtained from the 310 surveys completed. The teachers represented diverse disciplines and varying teaching experiences. The sample included a small number of male teachers, which reflects the demographic reality of the teaching profession in many educational contexts. This includes Jordan, where female teachers make up the majority of the workforce, especially in school education. However, caution should be taken when interpreting the findings concerning gender.

Participants were separated into two groups: 168 teaching humanities (the Arabic language, Islamic education, English language, art education, and physical education) and 64 teaching science streams (science and math, instructional technology, and preschool education). They were teaching grades pre-K through 12 at public and private schools in Jordan (see Table 1).

Table 1
The Demographic Information of the Study Sample (Sample size: N = 232)

Category	Subcategory	n (%)
Gender	Male	16 (6.9%)
	Female	216 (93.1%)
The subject being studied	Humanities stream	168 (72.4%)
	Science stream	64 (27.6%)
Teaching experience	Less than 5	80 (34.5%)
	5–10	32 (13.8%)
	More than 10	120 (51.7%)
School type:	Private school	80 (34.5%)
	Government school	152 (65.5%)
Grade levels do you primarily teach	Primary	16 (6.9%)
	Middle	120 (51.7%)
	Secondary	96 (41.4%)

Instrument

The study used a questionnaire to collect teachers' perspectives on ESD and the digital transformation of education quality. The questionnaire was organized into four sections. These sections and items were created after reviewing the literature and conducting preliminary interviews with four academic staff members. They were: (1) Demographic information; (2) Sources that facilitate candidates' learning about sustainability; (3)

Perceptions about the concept of ESD; (4) Perceptions about the digital transformation in education quality.

Seven experts evaluated the questionnaire to determine its validity: two experts in scientific and environmental education, three experts in curriculum and teaching methods, and two were management experts. The evaluation was based on clarity, relevance to the objectives of the study, and accuracy of classification. Based on their comments, some items were deleted or reworded; some others were combined with still other items. The final version contained 31 statements through which teachers' perceptions towards ESD were solicited: Concept of ESD (13 elements); Digital Transformation on Education Quality (18 items).

A small group of candidates (30) undertook a pilot test to ensure the correctness of its content and to identify any anomalies. The Cronbach's alpha reliability coefficient was used to check the internal consistency of the questionnaire. The reliability scores for each domain ranged from 0.79 to 0.84, with a dependability value of 0.82 for the questionnaire; hence, no major changes were needed.

Apart from reliability testing, other measures for the validity of the instrument included seven experts in curriculum design, educational management, and sustainability education through expert judgment on content validity and clarity, relevance, and representativeness of items. The mean content validity ratio (CVR) was 0.82; much higher than the minimum value of 0.78 suggested by Lawshe (1975). Construct validity was also confirmed with exploratory factor analysis (EFA) of the pilot sample ($n = 30$), using principal component extraction and varimax rotation. Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy was 0.86, and Bartlett's test of sphericity was significant ($\chi^2 = 1423.54$, $p < 0.001$), suggesting factorability of the correlation matrix. The two explanatory factors that were the dominant and aligned with the theoretical dimensions were (a) ESD perceptions and (b) Digital Transformation in education perceptions, explaining 64.7% of the variance. The results affirm that the instrument is satisfactory in content and construct validity.

Teachers were given access to the questionnaire on Google Docs, and they were asked to score each item on a 5-point Likert scale. To answer the third research question, participants were also asked for details on their gender, area of expertise, type of school, age group they teach, and years of experience.

Data Analysis

SPSS, or the Statistical Package for Social Sciences, was used to collect and analyze the data. The first two questions were answered using descriptive analysis, while the third was answered using the MANOVA test. The Results Section provides details on the statistical analysis.

Before conducting the MANOVA, the assumptions underlying multivariate analysis were verified to validate subsequent inferences. Normal distribution of the data was confirmed via the Shapiro–Wilk test and visual inspection of Q–Q plots, and no major deviations from normality were detected ($p > 0.05$). Homogeneity of the variance-covariance matrices was checked with Box's M test, which was not significant ($p = 0.137$),

confirming equality of covariance matrices between groups. Levene’s test for error variances equality of each dependent measure also indicated non-significant results ($p > .05$), confirming homogeneity of variances. Multicollinearity was confirmed by the use of correlation matrices and tolerance levels, with all coefficients being below 0.80, showing good independence between the dependent variables (Field, 2018). All the assumptions were hence sufficiently met to enable a valid interpretation of the MANOVA output.

Results and Discussion

The Resources Teachers Used to Learn About ESD for the First Time

When the Jordanian educators were asked if they were familiar with the concept of sustainable development, 91.77% said ‘Yes’, 2.53 % said ‘No’, and 6.29 % were ‘Not sure’. Then, we asked those who answered ‘Yes’ to identify the sources they used for the first time they found the term “sustainable development”. The results of their responses are summarized in Table 2.

Table 2
The Sources Teachers Used to First Learn About the Concept of ESD (Sample size: N = 232)

Source	n (%)
Social Media and Online Communities	120 (21.1%)
Teacher Training Programs	128 (22.5%)
Colleagues and Professional Networks	47 (8.3%)
During University Studies	81 (14.3%)
School Leadership and Administration	40 (7%)
Textbooks and Teaching Materials	64 (11.3%)
Media and News Outlets	24 (4.2%)
Academic Journals and Publications	8 (1.4%)
Educational Conferences	16 (2.8%)
Community and Parental Involvement	24 (4.2%)
Others (Environmental Clubs, Student-Led Initiatives, Government and NGO Initiatives, Online Platforms and Webinars etc.)	16 (2.8%)

Table 2 shows that 22.5% of teachers first learned about ESD through teacher training programs. These programs are critical for improving instructors’ ability to incorporate sustainable development concepts into their instruction. Research reveals gaps in teachers’ understanding of sustainability, emphasizing the importance of comprehensive training (Soto-Solier et al., 2023). Furthermore, continual professional development is essential for developing sustainability-related competencies among educators and students.

The next largest source is social media and online communities (21.1%), followed by academic research (14.3%). University education plays a key role in preparing students with knowledge and skills related to sustainability. The integration of sustainability into curricula motivates achievement and enhances teamwork (Bonilla et al., 2024), besides the development of a sustainable viewpoint among future professionals, particularly computer-related ones (Moreira et al., 2024).

Academic journals and publications are among the least used resources by instructors (1.4%). According to research, teachers frequently prefer other sources due to journals’ complexity, limited access, and low practical value (Parry & Metzger, 2023). Institutional hurdles, time constraints, and the necessity for practice-oriented resources further limit their use (Fiel’ardh et al., 2023).

Teachers’ Perceptions of the Concept of ESD

Mean values and standard deviations were computed for each domain and each item within the domain to determine how teachers perceived ESD (Table 3).

a) Perceptions About the Concept of ESD

To explore teachers’ perceptions of the concept of ESD, their responses were taken to 13 items that included concepts of sustainability in different contexts; for every item, the means and standard deviations were computed.

Table 3
Means and the Standard Deviations of Teachers’ Perceptions of the Concept of the ESD Domain

Item	Mean	Standard deviation
To prepare students to tackle global issues, I think it is essential to include sustainability concepts in the classroom.	4.14	0.975
To successfully include Education for Sustainable Development (ESD) into their teaching techniques, educators should undergo specialized training.	4.34	0.884
ESD encourages pupils to develop higher-order thinking abilities, including critical and problem-solving thinking.	4.38	0.763
Global citizenship and environmental sustainability should be covered in high-quality education.	4.28	0.785
Schools and local communities should work together to address sustainability issues and encourage sustainable behaviors.	4.48	0.727
Students need to be actively engaged in sustainable practices within the school to develop a sense of responsibility towards the environment.	4.66	0.544

See next page for continuation of table

Continuation of Table 3

Item	Mean	Standard deviation
Students' comprehension of sustainability principles and their capacity to apply them in practical situations should be evaluated through assessments.	4.14	1.108
Preparing students to help achieve the Sustainable Development Goals (SDGs) is a key component of quality education.	4.45	0.771
Students' understanding of global issues and their obligations as global citizens is improved through ESD.	4.38	0.763
Educational institutions should be evaluated based on their commitment to sustainability in both curriculum and operations.	4.31	0.794
Educational institutions should include sustainable measures like recycling and energy conservation in their everyday operations.	4.48	0.858
To solve sustainability issues, I am in favor of promoting cooperation amongst many academic fields (such as science, social studies, and the arts).	4.62	0.717
Practical application of sustainability concepts in real-world circumstances should be stressed in university courses.	4.59	0.559

Table 3 displays the highest mean score for Item 6, "Students need to be actively engaged in sustainable practices within the school...". Such interaction promotes environmental stewardship through awareness and commitment (O'Grady, 2025). Lack of sufficient support and finances, as well as student participation, hinders the effective implementation (Khadim et al., 2022).

The lowest mean was for Item 1 "To prepare students to tackle global issues..." ($M = 4.14$, $SD = 0.975$), indicating slightly less agreement. Some teachers feel that sustainability education takes time from key courses and lowers achievement (Parry & Metzger, 2023). Students also struggle with complicated concepts, which makes learning challenging (Kowasch & Lippe, 2019). Rigid curricula, testing requirements, and restricted training are barriers (Parry & Metzger, 2023).

Many studies underline the vital role of incorporating sustainability in confronting global issues and training students to deal with challenges. Teachers also appreciate its role in facilitating understanding (Abo-Khalil, 2024Pegalajar-Palomino et al., 2021). The study found that it inculcates environmental consciousness while enhancing problem-solving abilities. The disagreements highlight the high value placed on sustainability, in contrast to the ease of accessing it. Effective incorporation will need curriculum changes, training for instructors, and the development of easier teaching methods. A balanced approach can support sustainability while ensuring core subject learning.

b) Perceptions About the Digital Transformation in ESD

The responses of teachers to eighteen items involving concepts of sustainability in different contexts provided insight into their perception of digital transformation in ESD. The means and standard deviations for each item were calculated.

Table 4

Teachers' Perspectives on Digital Transformation in ESD

Item	Mean	Standard deviation
1. I am aware of the idea of transforming education using digital means to achieve sustainability.	3.83	1.179
2. Digital tools and technologies improve teaching ESD concepts.	4.17	0.835
3. Students' participation in ESD-related activities is facilitated by digital transformation.	4.17	0.914
4. Digital transformation is essential for preparing students to address environmental challenges.	4.10	1.031
5. I'm comfortable incorporating ESD into my lessons using digital resources.	4.03	0.930
6. My school offers sufficient training in the use of digital technologies in ESD.	2.97	1.302
7. Digital resources increase students' access to ESD content.	4.14	1.076
8. I believe digital transformation is crucial to reaching ESD goals.	4.21	0.998
9. Digital tools assist me in evaluating students' comprehension of ESD concepts.	3.93	1.050
10. I find it difficult to include digital tools in my ESD lessons.	3.45	1.194
11. The digital transformation promotes student cooperation in ESD.	3.97	0.892
12. In my opinion, digital tools can effectively address the global sustainability challenges.	3.83	1.119
13. The facilities in my school are enough to facilitate digital ESD projects.	3.52	1.306
14. I think the emphasis is too much on the use of digital technologies in teaching ESD.	3.10	1.426
15. Digital tools help me relate ESD concepts to real-world issues.	4.14	0.821
16. It is easier to work on ESD projects with other teachers because of digital tools.	4.07	0.946
17. I have concerns about how using digital tools in ESD may impact ethics.	3.90	0.925
18. With digital transformation, I've gotten better at effectively teaching ESD.	4.03	0.966

Table 4 shows that Item 6 has the lowest mean score – “My school provides adequate training for using digital tools in ESD”. The responses vary widely, with most of them disagreeing. Mixed research results have emerged regarding training of digital tools in

ESD (Napal et al., 2020), while others highlight challenges due to insufficient training, lack of support, and constrained resources (Khadim et al., 2022; Pegalajar-Palomino et al., 2021). Meanwhile, Item 2, “Digital tools and technologies improve the teaching of ESD concepts”, and Item 3, “Students’ participation in ESD-related activities is facilitated by digital transformation”, both recorded higher mean scores. There was strong agreement among participants.

The poll results align with studies that highlight the positive effects of digital tools on ESD instruction and student engagement (Lucas & Vicente, 2023; Napal et al., 2020). However, factors such as inadequate training and institutional support may render them ineffective; hence, there is a need for improved teacher training (Khadim et al., 2022). Overall, the mean scores generally hovered at a moderate to high level of agreement, with most responses clustered around a mean value of 4.00. Particularly Item 8, which asked whether “I believe digital transformation is crucial to reaching ESD goals”, recorded the highest mean score, thus indicating strong consensus on the importance of digital transformation for ESD goals.

c) The Effect of the Five Study Variables on Teachers’ Perceptions

To answer this question, ESD and digital transformation teachers’ perspectives were identified in terms of gender, specialization, type of school, age group taught, and years of experience using means as shown in Table 5. Later, MANOVA was used to find any significant differences among the independent variables.

Figure 1
Means and Standard Deviations of Sustainable Development Dimensions by the Five Demographic Variables

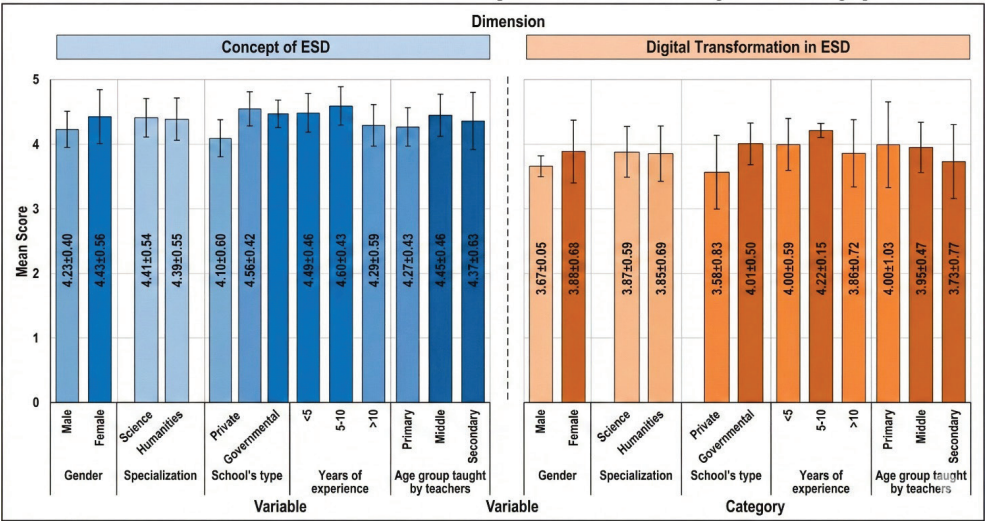


Figure 1 shows the observable differences in the mean responses of participants across the domains of the study, by gender, specialization, type of school, age group

taught, and teaching experience. A variance analysis was used to determine the statistical significance of these differences, as shown in Table 5.

Table 5

Results of the MANOVA Test

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Gender Wilks' Lambda=0.882 Sig= 0.00	Concept of ESD	.237	1	0.237	1.929	0.166
	Digital Transformation in ESD	3.468	1	3.468	25.818	0.000
The subject being studied Wilks' Lambda=0.831 Sig=0.00	Concept of ESD	2.237	1	2.237	18.231	0.000
	Digital Transformation in ESD	5.814	1	5.814	43.281	0.000
Teaching experience Wilks' Lambda=0.843 Sig=0.00	Concept of ESD	3.489	2	1.745	14.217	0.000
	Digital Transformation in ESD	3.518	2	1.759	13.094	0.000
Age group taught by teachers Wilks' Lambda=0.940 Sig=0.01	Concept of ESD	0.112	2	0.056	0.455	0.635
	Digital Transformation in ESD	1.171	2	0.586	4.360	0.014
School type Wilks' Lambda=0.704 Sig=0.00	Concept of ESD	10.849	1	10.849	88.404	0.000
	Digital Transformation in ESD	5.452	1	5.452	40.592	0.000

Note: Type III Sum of Squares is the variance attributable to each independent variable, controlling for all other variables. df is degrees of freedom, Mean Square is the estimate of variance, F is the test statistic used in MANOVA, and Sig. is the significance level (p-value).

Table 5 shows that while the (F) values for gender and age group taught are not statistically significant in the ESD domain, they are significant for Digital Transformation in ESD. There are statistically significant differences ($\alpha < 0.05$) across subjects studied, teaching experience, and school types.

To complement statistical significance testing, effect sizes were computed to find the magnitude of differences between groups. Partial eta squared (η^2) for each independent variable in the MANOVA was computed. On Cohen's (1988) scale (0.01 = small, 0.06 = medium, 0.14 = large), the results were medium to large effects for *school* type ($\eta^2 = 0.18$) and *teaching* experience ($\eta^2 = 0.12$). Smaller effects were for subject specialization ($\eta^2 =$

0.08) and gender ($\eta^2 = 0.05$). These findings suggest that the actual effect of institutional context and years of teaching experience on teachers' perceptions of ESD and digital transformation is large and deserves pedagogical attention more than statistical significance. To identify the direction of these variations in teachers' opinions of ESD and digital transformation based on experience and age group taught, a Schaffer post-hoc test was used, and the findings are displayed in Tables 6–8.

Table 6
Post-hoc Test for the Variable of Teaching Experience in the Field of ESD

ESD	Less than 5	5–10	More than 10
Less than 5	-	- 0.10	0.20*
5–10	0.10	-	0.30*
More than 10	-0.20*	-0.30*	-

**The mean difference is significant at the 0.05 level.*

Table 6 reveals that in the Concept of ESD, teachers with less than 5 years of experience scored highest, followed by those with 5–10 years, and those with more than 10 years scored lowest.

This is consistent with previous findings, demonstrating that newer graduates understand modern pedagogies and sustainability concepts better (Daramola, 2024; Waltner et al., 2020), most likely due to revised training and curricula.

The study found that those teachers who considered themselves experts with more than ten years of experience had less understanding of ESD, thus questioning the conception related to expertise. Either resistance to new approaches or lack of proper training in ESD could be the reason (Álvarez-Vanegas et al., 2024; Parry & Metzger, 2023). Old methodologies inhibit adaptation to sustainability education.

Table 7
Post-hoc Test for the Variable of Teaching Experience in the Field of Digital Transformation in ESD

Digital Transformation in ESD	Less than 5	5–10	More than 10
Less than 5	-	- 0.22*	0.32*
5–10	0.22*	-	0.54*
More than 10	-0.32*	-0.54*	-

**The mean difference is significant at the 0.05 level.*

Table 7 demonstrates that educators with <5 years of experience had the highest digital capabilities in ESD, whereas those with 5–10 years surpassed both junior and senior colleagues, indicating optimal digital adaptation at mid-career. This is consistent

with previous research demonstrating early-career teachers’ digital proficiency as a result of recent training (Howard & Mozejko, 2015; Tondeur et al., 2017). Other studies show results opposed to the above, proving that veteran teachers become highly digitally skilled with proper training. Saud (2024) found evidence of their effective integration of digital technologies, thus debunking the belief that new entrants were inherently more competent. This highlights the necessity for continuous training involving all educators and institutional support.

Table 8
Post-hoc Test for the Variable of Age Group Taught by Teachers Teaching the Field of Digital Transformation in ESD

Digital Transformation in ESD	Primary	Middle	Secondary
Primary	-	0.04	0.27*
Middle	-0.04	-	0.22*
Secondary	-0.27*	-0.22*	-

**The mean difference is significant at the 0.05 level.*

Table 8 shows that primary teachers are more competent than secondary teachers in digital ESD, with middle-level instructors also scoring higher (Lenziardi et al., 2025; Tondeur et al., 2017). Secondary teachers face more issues of integration, and performance can reach a similar level, if well prepared and supported, as indicated by Saud (2024) and Scherer et al. (2019). Females scored higher in digital ESD than males. Government schools scored higher than private schools in both digital ESD and ESD principles, while science teachers scored better in these subjects. Each finding shall be supported by recent studies.

Gender Differences in Favor of Females

Females showed stronger digital ESD skills than males. This aligns with previous findings on their adaptability to integrate technology (Avsec & Ferk Savec, 2021). Research shows the enhancement of women’s teamwork abilities through digital ESD (Scherer et al., 2019), hence making them better sustainability educators.

School Type Differences in Favor of Governmental Schools

Governmental schools performed better than private schools in digital ESD practice and understanding, likely because they had more institutional support. Jordan’s Education Reform Program (2017–2022) improved its blended learning infrastructure, and research (European Commission, 2020) shows increased access to finance and training, facilitating more integrated ESD programs.

Subject Differences in Favor of Science

The study identified science subjects to possess greater levels of Digital Transformation for ESD and conceptual knowledge of ESD in comparison with other subjects. This corresponds with evidence that science education lends itself to easy connection with principles of sustainability and digital media. Tourón et al. (2018) posit that the deployment of digital technology by science educators to illustrate environmental problems in real life makes the application of ESD principles tangible to students. Moreover, Rogers et al. (2015) established that scientific curriculum frequently utilizes multidisciplinary approaches, such that digital tools and ESD can be incorporated into them. The incorporation of both science education and ESD is highly probable to be the cause of the reported improved competency in science subjects.

Conclusion

The study has discovered that it is within science subjects that Digital Transformation for ESD is more explicit and where a better conceptual understanding of ESD can be achieved than in other subjects. This supports the results that show that sustainability and digital technology concepts connect very smoothly to science education.

The study has found that teacher education programs are the main source through which teachers first encounter ESD, highlighting the role of systematic professional development in competency formation among teaching staff. Social media, online forums, and university research are also relevant, with minimal emphasis on academic journals and publications. This indicates a necessity for wider university research dissemination on ESD to provide educators with easier access to evidence-based approaches. The teachers strongly believe that students should be involved in sustainable practices within schools. This reflects and underscores their awareness of the need for active student participation with ESD. Few strongly agree on inculcating the principles of sustainability in addressing global issues inside classrooms, indicating a lack of conception of the bigger picture concerning ESD. Most respondents view institutional capacity building as unsatisfactory to very slightly satisfactory towards using digital tools for enhancing teachers' methods and students' engagement towards achieving ESD, thus highlighting an urgent necessity for more professional development regarding digital tools and technology aimed at facilitating implementations of ESD.

The demographic analysis has indicated significant differences in the teachers' judgments by specialty, years of experience, school type, and gender. Better performances are recorded among science teachers and government school teachers in both ESD and digital transformation, while the judgment of less experienced teachers overtakes their more experienced counterparts with enthusiasm and adaptability. Another interesting finding is that women top the performance list in digital transformation for ESD. This potentially indicates a difference between genders concerning the application of technology and training.

The results bear implications for policymakers, educational leaders, and teacher education institutions. To support ESD and digital transformation in Jordanian schools,

targeted interventions must address the gaps that were found by enhancing teacher training programs mainly on the use of digital literacy and ESD implementation, providing equal access to resources for all types and specializations of schools, and inculcating continuous professional development as a culture among teachers. Besides, an attempt should also be made at narrowing down the gap between academic research work and classroom practice so that teachers get equipped with recent evidence-based solutions towards sustainable development.

This research provides actionable suggestions for enhancing the quality and efficiency of sustainable education practice in Jordan. By addressing the problems identified and leveraging the opportunities, Jordan can move towards fulfilling the SDGs and developing a generation of environmentally aware and digitally capable learners. This research contributes to the growing knowledge base on ESD and digital change in education by providing practical ways to improve the quality of sustainable educational practices.

Based on the findings of this study, we can recommend the following: First, educational institutions should offer ongoing professional development programs that are specifically focused on integrating ESD and digital technologies into teaching practices. Second, policymakers should promote equal access to digital infrastructure and education resources across different kinds of schools. Third, teacher education programs must integrate sustainability competencies and digital pedagogy as a core element of pre-service training. In conclusion, future research is encouraged to explore the long-term effects of digital transformation on sustainable educational practices using mixed-method or longitudinal approaches.

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