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Teachers' Experience and Perceptions of Sustainable Digitalization in School Education: An Existential Phenomenological Study of Teachers in Romania, Greece, Cyprus, Iceland, and The Netherlands

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Abstract: The purpose of this paper is to explore teachers' awareness, experiences, and perceptions regarding the environmental impact of digitalization in school education across five European countries. Using an existential phenomenological approach, the study uncovers the lived experiences of 29 teachers, who participated in group semi-structured interviews. The findings highlight that teachers share a strong awareness of contemporary environmental challenges, such as climate change and pollution, and that environmental education is integrated into most school curricula, especially topics like recycling, composting, and pollution. Teachers express a genuine concern for educating students about global warming and its consequences, recognizing that today's students will shape the future. Despite acknowledging the benefits of technology in education, teachers are not fully informed about the environmental impact of digitalization. The paper reveals teachers' concerns about the energy consumption, carbon emissions, and electronic waste associated with digital technologies. Teachers propose strategies to address the environmental impact of digitalization, including prolonging device lifespans, responsible e-waste recycling, and promoting energy-efficient practices. They emphasize the need for proper teacher training in incorporating digitalization's environmental impact into the curriculum. The study underscores the importance of engaging students through research activities, discussions, multimedia resources, and hands-on experiences to raise awareness about digitalization's ecological footprint. Implications of a more informed and proactive approach to addressing the ecological footprint of digital technologies in school education are discussed.

Keywords: sustainable digital transformation; digital competencies; school education; phenomenological study; Europe; teachers' experiences



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1. Introduction

In an era marked by rapid technological advancements and growing environmental concerns, the intersection of digitalization and sustainability has emerged as a pivotal focal point in several sectors [1,2], including the realm of education. Educational institutions worldwide are grappling with the challenge of integrating digital technologies into their curricula while simultaneously addressing the imperative of fostering environmental consciousness [3]. Sustainable educational institutions, characterized by a commitment to fostering environmental stewardship, have a vital role in shaping the future. The integration of digital tools within these institutions is undeniable, offering diverse opportunities for interactive learning, efficient resource management, and global connectivity with the labor market [4,5]. However, as the digital landscape expands, so too do its environmental

ramifications, necessitating a holistic examination of the implications of digitalization on ecological well-being.

This interconnection between technological innovation and ecological responsibility presents an opportunity to examine how educators navigate the complexities of sustainable digitalization within the context of school education, since there is lack of in-depth exploration into how teachers from diverse cultural and educational contexts perceive and navigate the complex relationship between digitalization and sustainability in school education [6,7]. While there has been growing awareness of the environmental impact of digital technologies and a parallel emphasis on incorporating sustainability education, there remains limited qualitative insight into teachers' personal experiences, challenges, and strategies in integrating these two critical aspects. In this context, the main research question of the study is the following:

- What are the teachers' lived experiences and perceptions of sustainable digitalization in school education in Romania, Greece, Cyprus, Iceland, and the Netherlands?

The sub-questions are the following:

- How do teachers conceptualize the role of environmental awareness in the education of students?
- What are the challenges that teachers encounter as they navigate the integration of digital technologies and sustainability principles within their classroom practices?
- How can the environmental impact of digitalization at school be addressed?

The cross-cultural comparison across countries such as Romania, Greece, Cyprus, Iceland, and the Netherlands provides an opportunity to examine how these distinct educational landscapes intersect with the global discourse on sustainable digitalization. Each of these countries possesses unique socio-cultural, economic, and educational backgrounds that could influence teachers' perspectives and practices. By addressing this gap, the study not only sheds light on the nuances of teachers' experiences but also contributes to the broader discussion on the evolving role of education in a rapidly changing world. The exploration of existential challenges faced by teachers, the strategies they employ, and the conceptualizations they hold can provide valuable insights for education policymakers, curriculum developers, and teacher training programs. This, in turn, can inform the development of effective strategies for integrating sustainable digitalization principles into school education while nurturing environmentally conscious future citizens. This research was funded by the European Union, grant number 2022-1-IS01-KA220-SCH-000086751.

2. Synthesis of Previous Studies on Sustainable Digital Transformation and Its Perception by the Education Community

The paradigm of remote work and study, ostensibly a sustainable choice with its reduction of travel and paper usage, takes on a more intricate guise as the surge in technology usage amplifies our digital carbon footprint, consequently triggering substantial environmental implications. While digital technologies offer innovative and environmentally friendly solutions—embracing renewable energy and propelling smart cities and sustainable urbanization—there are some challenges that pose potential hindrances to achieving sustainability goals. This dichotomy underscores the urgent need for critical assessment and mitigation of these challenges [8]. The act of working and studying online, facilitated by digital devices and cloud platforms, inadvertently consumes electricity, contributing to the expansion of our digital carbon footprint [9]. Delving into the domain of cloud usage reveals an electricity-intensive operation; data centers account for a staggering 1% of global energy demand, surpassing the energy consumption of entire nations [10]. A marked trend towards cloud-based data storage further underscores this trajectory, as the anticipated global data storage is projected to exceed 200 zettabytes by 2025 [11]. These data encompass a gamut of repositories: private and public IT infrastructures, utility infrastructures, cloud data centers, personal computing devices like PCs, laptops, tablets, smartphones, and Internet-of-Things (IoT) devices [11]. However, this cloud usage carries a consequential

impact on energy consumption, as studies predict that the internet network will consume 20% of global energy by 2030 [12].

Beyond energy consumption, the manufacturing process of digital devices compounds our digital carbon footprint, involving mineral extraction, transportation, and device disposal [9]. In light of these implications, Obringer et al. [13] advocate for a conscious awareness of the digital carbon footprint among internet users, urging them to embrace small behavioral changes. In tandem, businesses across sectors must contribute to diminishing digital carbon emissions. Jackson and Hodgkinson [14] propose sustainable digital strategies that emphasize data reuse, suggesting a shift from businesses' current data consumption to a more circular approach. As large-scale research projects align with the ethos of sustainability, Aujoux et al. [15] implore scientists to scrutinize and minimize the carbon footprint engendered by digital technologies, simulations, data analysis, storage, and communication. While glimpses of progress emerge from the business and research sectors [14–16], it remains evident that engagement in mitigating the digital carbon footprint is still in its nascent stage.

However, a pertinent query arises—does society, including the educational community, possess a grasp of the strategies to alleviate its digital carbon footprint and safeguard the environment? Gnanasekaran et al.'s [17] research indicates a lack of awareness among young individuals regarding the environmental impact of digital applications and services. This ignorance could be attributed to the paucity of public information and social awareness concerning the digital carbon footprint's repercussions [17]. Moreover, a dearth of understanding regarding technological processes impedes the recognition of digital devices' environmental impact [18]. As the present study's literature review reveals, a considerable gap persists in awareness within the educational community—both teachers and students—regarding the concept of the digital carbon footprint.

Yet, despite the research void, educational researchers demonstrate an interest in comprehending students' and teachers' acumen concerning environmental challenges and carbon footprint. Recent studies [19–21] have endeavored to gauge students' familiarity with prevailing and impending environmental issues. Kolenatý et al. [19] explored students' climate literacy, discerning their propensity to engage in climate-protective behaviors. Similarly, Lehnert et al. [21] scrutinized students' beliefs about actions that deter global warming. When it comes to educators, research has spotlighted teachers' self-efficacy and teaching practices related to education for sustainable development (ESD) [20]. Evidently, knowledge serves as an instrumental precursor to instigating climate action. Thus, an increased focus on research and teacher training is imperative to cultivate awareness within the educational community about the carbon footprint and environmental challenges. As it stands, the intricacies of digitalization's environmental repercussions remain concealed to both educational stakeholders and the wider populace.

Finally, it is imperative to consider the role of digital leadership within this context. Digital leadership refers to the ability of individuals, organizations, and institutions to effectively navigate the digital landscape while upholding ethical, sustainable, and responsible practices [22]. This approach can empower educational institutions to harness the potential of digital technologies while mitigating their environmental impact. By fostering a culture of digital responsibility, schools and universities can impart essential knowledge and skills to students, enabling them to make informed choices that reduce their digital carbon footprint [23].

3. Methodology

3.1. Rationale for the Selected Methodological Design

The existential phenomenological approach posits a perspective that seeks to comprehend and acknowledge human experiences from the vantage point of the individual undergoing those experiences [24]. In order to accomplish this, proponents of existential phenomenological psychology contend that a distinct method is imperative within the realm of social sciences. This approach aims to unearth the fundamental essence of the subject under scrutiny, avoiding the development of abstract theories centered around the

same phenomenon [25]. It is important, therefore, to underscore that this methodology pivots from presenting abstract conjectures about a subject's experience to charting a trajectory that originates from a concrete depiction of that experience, as perceived through the lens of a co-researcher [26]. This shift directs the researcher's focus towards interpreting the experience rather than formulating distant, detached statements that fail to grasp the intricacies of the subject's consciousness [24]. In the former scenario, the researcher assesses the incident subsequent to assimilating the co-researcher's explication, thereby facilitating a deeper comprehension of its underlying significance.

3.2. Concerns Theory

The Concerns Theory, a well-known framework in professional development for teachers [27], has significantly influenced this research. This theory has been widely studied in various countries, including the United States, Australia, England, Belgium, and the Netherlands [28]. Teachers' needs, concerns, and emotions significantly affect the whole education process [29]. Concerns, in this context, refer to the emotional questions that arise when faced with new situations or changes. These concerns can signal uncertainty and resistance to changes. This theory distinguishes three types of concerns: self-concern, task concern, and impact concern. Self-concern revolves around personal worries about change. Task concern focuses on worries about the processes and demands involved in implementing change. Impact concern relates to colleagues and students impacted by the change. Ignoring these concerns can hinder the implementation process [30] of sustainable digitalization. Using this theory, we categorized the concerns of the participants and the solutions they anticipated for their concerns related to sustainable digitalization at schools.

3.3. Research Phases

This existential phenomenological research methodology comprises a structured sequence of steps, each contributing to a comprehensive and nuanced understanding of the phenomenon under investigation (teachers' experience and perceptions of sustainable digitalization in school education). This method goes beyond mere data collection and analysis, delving into the depths of human experience to uncover profound insights. For the common understanding of the term sustainable digitalization, the researchers used the approach of D'Auria et al. [31], who approached it as the process of integrating digital technologies in a way that promotes long-term sustainability and addresses environmental, social, and economic challenges. The same definition was introduced in the data collection process with the participants. The main phases of the research are the following:

- The selection of phenomenon of interest. Our literature review and experience demonstrated that the teachers' experience and perceptions of sustainable digitalization in school education hold significance in all countries of our study.
- Bracketing interviews. The journey begins with five bracketing interviews, one in each country. This is a pivotal step that entails exploring the researchers' own preconceptions, biases, and assumptions about the phenomenon. This introspective exercise ensured that the researchers approach the study with a clear and open mindset, enabling an unfiltered understanding of the subjects' experiences.
- Identification of participants. The participants, often referred to as co-researchers, are carefully chosen based on their lived experiences relevant to the selected phenomenon. Their perspectives serve as valuable insights into the essence of the phenomenon.
- Phenomenological group interviews. Central to this approach is the conduct of in-depth phenomenological interviews with the selected participants. These group interviews provide a platform for participants to articulate their experiences, emotions, thoughts, and reflections related to the phenomenon. The researchers' role is that of an empathetic listener, allowing the co-researchers' narrative to unfold organically.
- Interpretation of collected data. The gathered data, often comprising rich narratives and detailed accounts, are subjected to rigorous analysis. The researchers seek patterns, themes, and underlying meanings that illuminate the core essence of the phenomenon.

This interpretative process involves moving beyond the surface to discern the profound implications of the experiences shared.

- Seeking feedback from the participants. In a collaborative spirit, the researchers seek feedback from the participants. This step is instrumental in ensuring the accuracy and fidelity of the interpretations. Participants' perspectives on the researcher's analysis contribute to a more holistic and authentic representation of their experiences.
- Dissemination of results. The final step involves sharing the results of the study with the broader academic and professional communities, allowing for the integration of the findings into the wider body of knowledge, contributing to the advancement of understanding in the field.

3.4. Sample

The study encompassed a cohort of 29 teachers from private and public schools across Romania (5), the Netherlands (8), Greece (8), Iceland (5), and Cyprus (3). This diverse group of educators contributed their insights to the research endeavor. All of these participants were natives of their country of residence, and they were interviewed in their local language. In order to preserve their anonymity, pseudonyms were employed to protect their identities.

These educators, with diverse professional backgrounds encompassing fields such as science, languages, and special education were all employed as educators in private and public schools within their home countries. We applied a convenience purposive sampling method. Specifically, the involvement of the educators in the research was entirely voluntary and driven by personal motivation. Upon receiving an invitation from the consortium, which was extended to teachers across their professional networks, they enthusiastically embraced the opportunity to participate. Notably, within this cohort, half of the participants undertook the education of elementary school students aged between 6 and 12 years, while the remaining educators guided secondary school students aged 13 to 18, showcasing the study's scope across distinct educational levels.

Central to their participation was the pivotal step of providing written consent, underscoring their voluntary commitment to the research endeavor. The consent form, which was signed by the participants, can be found in Appendix A.

3.5. Data Collection

The study engaged the 29 participants in comprehensive group interviews. This methodological choice facilitated a profound exploration of the subject matter through semi-structured, open-ended inquiries. This approach, as endorsed by Connaway et al. [32], strategically guided the interview process, permitting participants to offer detailed narratives of their experiences while accommodating the inherent fluidity of personal reflections. The interview guide was crafted with a focus on aligning with the research questions while promoting participant engagement. The project coordinator, the University of Iceland, led the design of the focus group guide with a first version of questions, and the guide was finalized during a design session that took place in March 2023 in Iceland, in the context of the authors' transnational project meeting. This strategic design enabled all researchers integrate their input, and a consensus was achieved for the final version that was used with the participants.

To ensure the guide's appropriateness and effectiveness, it was subjected to a validation process. A panel of 3 experts in research methods from Iceland, Greece, and the Netherlands reviewed the interview guide. Their feedback was invaluable in refining the wording of questions and prompts to enhance clarity and coherence. This validation step aimed to enhance the guide's comprehensibility and its potential to elicit rich insights from the participants. In addition, the guide was tested with two teachers who are part of the research team, who confirmed that it allowed them to express their experiences authentically while providing the necessary structure to guide the interview process. Specifically, the focus groups were designed to encapsulate a vivid and intricate portrayal of the participants' encounters with sustainable digitalization and the role of education. The primary

objective was to unearth the intricate nuances of their lived experiences and extract the profound essence of how they have experienced this topic in their professional lives. Each focus group started with an overarching query, encouraging participants to delineate their connection with the realm of education. As the dialogue unfolded, the participants were prompted to delve into specific facets of their school experiences, enabling a more nuanced exploration. To provide a structural overview of the focus group structure, Appendix B delineates the focus group guide, encompassing the array of questions posed and the corresponding prompts designed to further enrich the discussion.

3.6. Data Analysis

The analysis of the gathered data was undertaken collaboratively by the research team associated with the Eco-Digital project. This interdisciplinary team comprised researchers specializing in education sciences and teacher education, under the guidance of the lead author. The process of interpreting the data commenced with the reading of the transcriptions from the focus groups. During this reading, pauses were taken whenever the researchers sensed that specific segments stood out, necessitating contemplation and discussion. In a spirit of mutual understanding, team members elucidated the rationale behind their perception of particular transcribed sections, articulating how these instances augmented their grasp of the encountered experiences. This iterative procedure of uncovering the significance underlying the shared content during the focus group sessions resonates with Gadamer's notion of the "fusion of horizons" [33]. Subsequently, the progression entailed formulating a thematic depiction of the emerged experience that surfaced during the group interviews. In this context, the concept of a theme aligns with the definition of recurring descriptive patterns signifying crucial dimensions in participants' accounts [34]. These themes predominantly emerged as expressions within the words of a participant, encapsulating the essence of particular facets of the collective experience across all participants in the study [35]. Following the identification of themes within each distinct focus group, the research team engaged in a collaborative effort to identify overarching themes spanning all the focus groups. These global themes ultimately encapsulated the essence of the teachers' collective experience.

Upon the completion of data interpretation for Greece and the Netherlands, a preliminary comparison of thematic structures was undertaken. The research team juxtaposed global and ground themes alongside associated quotations, aiming to discern variances and commonalities. Upon concluding the interpretation of Icelandic data, this process was replicated, culminating in the comparison of global and ground themes, along with the connotations of supporting quotations across all three studies. This methodical approach was subsequently mirrored in the analysis of data from Romania and Cyprus. To enhance the credibility of the findings and ascertain whether the distilled thematic structure authentically reflected teachers' experiences, feedback on the findings was sought from the participating teachers [25]. Their feedback led to the final version of the results. This iterative process of interpretation, comparison, and validation collectively contributes to a comprehensive understanding of teachers' perceptions and experiences within the framework of sustainable digitalization in school education [36]. At the end of this process, the following themes were identified:

- (1) Teachers' awareness of environmental issues and environmental education at school.
- (2) The environmental impact of digitalization.

These first two themes are linked to the first sub-question of this study.

- (3) Challenges while integrating the topic of sustainable digitalization in their practice.

This third theme is linked to the second sub-question of this study.

- (4) Suggestions on addressing the environmental impact of digitalization at school.

This fourth theme is linked to the third sub-question of this study.

4. Results

4.1. Teachers' Awareness of Environmental Issues and Environmental Education at School

Across all focus groups, the participants demonstrated a baseline familiarity with significant contemporary environmental challenges. These encompassed climate change, pollution, global warming, environmental degradation, and resource depletion. Notably, each participant exhibited a genuine concern regarding the detrimental impacts of human activities on the environment.

"It's remarkable how knowledge and awareness are increasing about environmental issues. We're all on the same page when it comes to recognizing the impact of human activities on the environment." (EN)—self-concern

"In this room, we may have different academic backgrounds and different teaching approaches, but when it comes to these environmental problems, we're all pretty much speaking the same language." (BN)—self-concern

"It's amazing to observe our sensitivity on climate change; this is a real concern that we're all conscious of." (JN)—self-concern

The concept of global warming was universally understood as a rise in temperature, carrying potential consequences for the environment. Additionally, global warming was linked to elevated atmospheric and oceanic temperatures, resulting in excessive warming and a range of associated effects.

"It's not just about temperature—it's a red flag for the environment, a rise that triggers a cascade of impacts." (JN)—self-concern

"Global warming phenomenon is more than just a rise in temperature; it's a serious signal of the environment's distress, with far-reaching effects in the sea, the air and the land... everywhere" (MN)—self-concern

Within the majority of school curricula, environmental education assumed a central role. Students engaged in projects that covered recycling, composting, and pollution. These projects facilitated an exploration of the natural environment and its phenomena, fostering an understanding of the influence of human intervention on ecological systems.

"Environmental education is at the heart of our curriculum. We've seen students enthusiastically take on projects that involve recycling, which have ongoing success and they offer students hands-on experience that helps them realize the impact of human actions on the environment." (AP)—impact concern

"Environmental education is evident across all subjects. From science to social studies, I introduce projects that examine the effects of human intervention on the natural world." (KK)—self-concern

Another prevailing sentiment among educators was the significance of equipping students with knowledge about global warming, empowering them to reflect on and possibly take action in response to this issue. The imperative to educate students about the environmental ramifications of digitalization was underscored.

"We accept digitalization as an inherent and valuable resource for placing everything at our fingertips, yet we often neglect considerations of energy consumption and associated factors." (PA)—task concern

"This comes with costs in terms of money, electricity, and energy." (EK)—task concern

Moreover, teachers recognized the urgency of informing students about the environmental consequences of digitalization, given their extensive use of digital devices and the potential repercussions if they remain uninformed about the adverse environmental impacts. This awareness equips them to potentially curtail or alleviate environmental harm, a vital consideration for their own lives and those of subsequent generations.

“We understand the urgency of educating our students about the environmental effects of digitalization and it’s our responsibility to make them aware of the consequences of using devices for so many hours. Without proper information, there will be negative impact for the planet and their lives” (RW)—task concern

“Students use technology very much, but they don’t know all the implications of such use. By informing them about the environmental implications of their digital habits, we will help them to make conscious choices” (HR)—impact concern

In this context, it is essential for students to grasp that a substantial portion of digital waste results from needless emails, unused files, and applications—all of which contribute to pollution. Individually, an email or a photograph may not significantly pollute, but the cumulative effect of these actions undertaken daily collectively leaves an indelible mark on the environment. While most educators acknowledged the significance of addressing environmental concerns, they acknowledged the challenges posed by time constraints and the pressure to adhere to a standardized curriculum, which often hindered the seamless integration of environmental subjects into their teaching practices.

“We’re often grappling with a packed curriculum and pressure to meet certain standards. Integrating environmental subjects becomes a challenge” (BM)—task concern

“...finding the space to work into environmental topics can be difficult” (VG)—task concern

4.2. The Environmental Impact of Digitalization

Most teachers, in all focus groups, admit that they are not familiar with the environmental impact of digitalization. Some mainly because they do not think about it on a day-to-day basis. Few of them only recently (with their involvement in the Eco-Digital project) became aware of the fact that the production and use of digital devices can negatively affect the environment. Still, most of the teachers are concerned about the extraction and production of raw materials required for manufacturing digital devices.

“I care about the broader impact of the technology my students are using in my class” (NC)—impact concern

“The awareness about the environmental toll of producing raw materials for digital devices is a conversation that keeps coming up at school meetings” (CM)—self-concern

The production of smartphones, laptops, and other electronic gadgets relies heavily on mining activities to obtain minerals such as lithium and cobalt [36]. These minerals are essential components of batteries and electronic circuits. Mining can lead to deforestation and water pollution—by causing significant harm to ecosystems and biodiversity [37]. All the teachers recognized that the increasing reliance on digital devices, such as computers, tablets, and smartphones, contributes to electronic waste, energy consumption, and carbon emissions during the production and disposal processes. Teachers expressed concern about the ecological footprint associated with the manufacturing, usage, and disposal of digital technologies.

“It’s important to make students aware of the digital footprints they leave online and help them find ways to reduce them” (HO)—impact concern

“We need to teach our students to make wiser and environmental-friendly use of their devices, especially tablets and mobile phones” (RW)—task concern

“It is good for the environment and sustainability if you use technology right. By using our phones or computers we can minimize printing of papers and by holding meetings online we reduce unnecessary travel” (RW)—task concern

“We use a lot less paper after email came along, but I’ve realized that by keeping my data on my computer (emails and such) I’m using an incredible amount of electricity” (JN)—task concern

4.3. Challenges while Integrating the Topic of Sustainable Digitalization in Teaching Practice

The majority of the participating teachers reported that, when tackling the subject of environmental issues and sustainability within the classroom, students face specific challenges, primarily centered around comprehending and appreciating the gravity of these concerns and their significance.

“More than half of my students might not fully grasp the seriousness of these matters, which can impede meaningful discussions” (OM)—impact concern

“While they are all familiar with the terms sustainability or global warming or pollution, etc. I don’t see—in practice—an understanding of how their daily activities contribute to such topics” (TC)—impact concern

In certain cases, students have exhibited resistance, particularly concerning the negative impacts of digitalization due to its association with modernization.

“Sometimes when I advocate for less use of digital devices, I see my students reacting that I don’t follow the current trends in society” (MM)—task concern

Some teachers highlighted that this resistance from the students comes from the fact that sustainability and digitalization are intangible concepts. This makes it difficult for the teachers to demonstrate the immediate consequences, as they cannot directly show or experience the consequences of the extensive use of digital devices.

“I struggle to show my students the direct impact of their actions and when I use terms like global warming or pollution, it is very difficult for my students to associate them with their use of phones and tablets” (CM)—task concern

Lack of (suitable) training was raised as one of the most important challenges for the participating teachers. In Greece, Cyprus, and Romania, some teachers mentioned that they have very limited options in following cost-free training programs on these topics. In the Netherlands, on the other hand, some teachers highlighted that while there are trainings available, they are not easily applicable in their practice because they are either too theoretical or they require additional time and resources, which are not available.

“There are very limited options available, actually none that I am aware of in this topic” (JN)—task concern

“I know only master degree programs on such topics but there are costly and time-consuming” (ST)—task concern

“Our school has a program about this topic, but we are an exception because our school focuses on environmental action. However, I am not familiar of any similar training offered to public school teachers in our country” (KC)—self-concern

“The trainings offered are very useful to acquire knowledge on the topic and reflect on it. Most of the time immediate application of the knowledge acquired is very challenging because either it requires additional resources” (JN)

Finally, the challenge for which there was consensus among all 29 participants was time. Eighteen teachers said that there is a lot of pressure to cover the curriculum within limited timeframes, and this hinders the thorough exploration of the multifaceted topic of sustainable digitalization. Twelve teachers highlighted that this lack of available time increases their stress levels when they are asked to introduce additional elements in their teaching practice. When the participants were asked to prioritize the above-mentioned challenges, they ranked “time” as the biggest challenge, followed by “lack of (suitable) training” and the “intangible nature of sustainable digitalization”. It is important to acknowledge that, while our study aimed to uncover similarities and dissimilarities among educators from different countries regarding their concerns about the environmental impact of digital technologies, certain limitations inherent to the study’s methodology and sample size must be considered. The qualitative approach we employed allowed us to delve deeply into the perceptions and insights of a diverse group of educators, providing rich and nuanced information that

might not have been accessible through quantitative means. However, due to the relatively small sample size, recruited via convenience sampling method, and the qualitative character of the analysis, it is important to exercise caution when making definitive comparisons between the countries represented in our study. This is why differences among countries were highlighted only when significant dissimilarities were identified.

4.4. Suggestions on Addressing the Environmental Impact of Digitalization at School

As teachers strive to equip their students with an understanding of their role as responsible global citizens, addressing the ecological footprint of digitalization was a crucial component during our focus groups. Teachers recommended several actions that can be employed to foster critical thinking, engagement, and action of students on this topic. The following suggestions were considered the most important by the participating teachers when they were asked to give their feedback on the data collection (phase 6 of the research process).

First, the need for well-organized awareness campaigns was mentioned. The teachers highlighted the importance of constantly reminding and visualizing the risks of not understanding the impact of unsustainable digitalization. They proposed the organization of events, posters, and talks throughout the school year. They also suggested the formal integration of environmental education into the curriculum, specifically addressing the ecological footprint of digital technologies, which is currently missing in most countries.

To counter the previously mentioned student resistance, the participating teachers mentioned that educational videos may serve as an effective approach. Through the utilization of multimedia resources, students can gain a deeper understanding of the environmental repercussions, enabling them to develop a more holistic perspective on the importance of sustainability and the requisite actions for safeguarding our planet's future. Teachers with more knowledge of educational technology proposed interactive simulations and online tools to visually illustrate the environmental consequences of digitalization, which were well received by all participants.

Furthermore, all participants positively evaluated the initiation or expansion of concrete activities within the school environment, such the addition of electronic waste recycling drives and educational excursions to technology recycling facilities. These activities may provide students with real-world experiences related to sustainable digital practices.

Finally, the participating teachers reflected on the pedagogical approaches that can be used to promote sustainable digitalization in school education. The implementation of project-based learning, where students research and propose solutions to mitigate the environmental impact of digitalization, was the most popular suggestion across focus groups. The teachers selected this approach most because it encourages critical thinking and problem-solving, while addressing real-world issues.

"It is an educational approach that links the classroom with real-world situations. The best way to help students understand the impact of unsustainable digitalization" (ST)—task concern

"Project-based learning can be introduced in different classes, from science to languages" and it is known by most teachers". (VT)—task concern

The second teaching and learning approach that was suggested by the teachers was collaborative learning, which is also linked to project-based learning (though projects can be individual sometimes). The implementation of collaborative assignments that encourage students to analyze a situation and present their findings related to the environmental effects of digitalization will enhance their understanding on the topic.

"Collaborative projects bring useful debates and when monitored by a knowledgeable teacher the results can be amazing" (HO)—task concern

"The students with more information and knowledge can influence their peers, sometimes more than their teacher to understand the implications of the topic in their lives" (RW)—task concern

A cross-disciplinary approach for both project-based and collaborative learning was proposed by Dutch teachers, involving students from different ages or classes working together, promoting a holistic understanding of the topic.

Some of the participants highlighted that they should encourage students to express their understanding of sustainable digitalization through artistic mediums such as visual arts, theater, and creative writing. While teachers from only one focus group thought of this suggestion, when it was presented to the participants in phase 6, it was very positively received.

The same applied to the suggestion of creating an environmental journal at the school or class level, where students can reflect about their digital habits, track their energy usage, and note observations about the impact of digitalization on their surroundings.

Finally, gamification and service learning were also popular suggestions among the participating teachers. The idea of designing games that immerse students in scenarios related to sustainable digital practices was very positively received, but the cost and time constraint aspects were also mentioned. As far as service learning was concerned, it was proposed by teachers who had experience with having their students working with local community organizations or businesses, while other participants did not have deep knowledge about this pedagogical approach.

Finally, it is important to mention that other pedagogical methods were mentioned, such as group work, problem-based learning, student-led debates, and student-led projects, which were perceived very similarly to the previously mentioned methods, so after phase 6 of the research they were included in these methods.

5. Discussion

The findings of this study reveal a commendable baseline familiarity among teachers concerning contemporary environmental challenges. Climate change, pollution, global warming, environmental degradation, and resource depletion were collectively acknowledged as significant concerns. This shared self-concern demonstrates the increasing recognition of the detrimental impacts of human activities on the environment, which is in line with the corresponding literature [38]. Participants expressed (self-concern) a unified commitment to understanding and addressing these issues. The sentiment that environmental problems resonate universally [39] was another evident self-concern in the participants' comments, reflecting a unified stance transcending academic backgrounds and teaching approaches. The concept of global warming was widely understood as a phenomenon encompassing both temperature rise and its subsequent cascading effects across ecosystems (self-concern). The participants recognized the imperative to educate students about these environmental challenges, especially global warming, as a means of empowering them to make informed choices and potentially engage in mitigating actions (self-concern). Furthermore, environmental education emerged as a pivotal aspect of school curricula, with teachers reporting a prevalent inclusion of projects related to recycling, composting, and pollution in line with the corresponding literature (task concern) [40]. These initiatives facilitated students' engagement with the natural environment and its interplay with human actions, enhancing their comprehension of ecological systems and the impact of human intervention (impact concern).

Teachers' awareness of the environmental impact of digitalization varied, confirming the existing literature [41]. Some teachers, particularly those involved in the project, demonstrated heightened awareness of the negative consequences associated with the production and use of digital devices (impact concern). However, many teachers admitted a lack of familiarity with these issues, attributing it to infrequent contemplation of the topic (task concern). The participants collectively voiced concerns about the extraction and production of raw materials required for manufacturing digital devices, revealing an understanding of the ecological toll associated with these processes [42]. The study exposed teachers' concern about the ecological footprint stemming from the production, use, and disposal of digital devices. These observations indicate a growing awareness among educators regarding the

need to address the environmental impact of digitalization, albeit to varying degrees of depth [43].

To address the topic of sustainable digitalization in educational settings, teachers proposed a range of strategies (task concerns). They emphasized the need for well-organized awareness campaigns that continually remind students of the risks associated with unsustainable digital practices [44]. Teachers suggested integrating environmental education into the curriculum, specifically targeting the ecological footprint of digital technologies, to ensure comprehensive coverage of the topic [45].

To overcome student resistance, teachers identified the potential of educational videos as an effective teaching approach (task concern). The use of multimedia resources, such as videos and interactive simulations, could provide students with a deeper understanding of the environmental consequences of digitalization, fostering a holistic perspective on sustainability [46].

Teachers also recommended practical activities such as electronic waste recycling drives and technology recycling facility excursions to immerse students in real-world experiences related to sustainable digital practices (task concern).

Project-based learning emerged as a highly endorsed pedagogical approach among participants [47]. This approach encourages critical thinking and problem-solving while addressing real-world issues. Additionally, collaborative learning [48] and cross-disciplinary projects [49] were highlighted, emphasizing peer influence and holistic understanding (task concerns).

Other suggested methods included artistic expression, the creation of environmental journals, gamification, and service learning. These multifaceted approaches collectively underscore the diverse range of strategies teachers can employ to promote sustainable digitalization within their classrooms.

6. Conclusions, Limitations, and Implications of the Study

In conclusion, this study reflected on the intricate relationship between environmental awareness, digitalization, and education, offering valuable insights into the perceptions, challenges, and potential solutions faced by teachers in navigating this dynamic landscape. Through the exploration of the research questions, it became evident that teachers possess a foundational understanding of the environmental challenges at hand, recognizing the importance of integrating sustainability principles into education. The findings have unveiled the multifaceted challenges educators encounter when attempting to merge digital technologies and sustainability concepts within their classroom practices, including students' limited comprehension, resistance, and time constraints. The study's contribution lies not only in identifying these challenges but also in presenting an array of practical suggestions to address the environmental impact of digitalization in schools. As education plays a pivotal role in shaping the perspectives and actions of future generations, the insights from this study offer a stepping stone for educators, policymakers, and stakeholders to proactively promote environmental consciousness and sustainable practices among students, ultimately fostering a generation equipped to address the complex challenges of a digitalized world while safeguarding the well-being of the planet.

While this study provides valuable insights into the perceptions and experiences of teachers regarding the integration of sustainable digitalization in education, it is important to acknowledge some limitations that may influence the interpretation of the findings. The study was conducted with a sample size of 29 teachers from diverse European countries. Given that the teachers originate from diverse European countries, their priorities and approaches may vary accordingly. For instance, in Iceland, the melting of glaciers is a pressing concern, and people are witnessing the alarming disappearance of glaciers and experiencing unprecedented weather extremes. This reality cannot have the same impact on the teachers in Cyprus, for example. While efforts were made to include participants from varied educational backgrounds, contexts, and regions, the sample may not fully represent the broader spectrum of teachers' experiences and perspectives at the EU-level.

In addition, the study offers a “snapshot” of teachers’ perceptions and experiences at a specific point in time. A longitudinal approach could have provided a more comprehensive understanding of how attitudes and practices evolve over time. The research questions addressed in this study are specific to teachers’ perceptions and experiences. While these questions offer valuable insights, a broader exploration of other stakeholders’ viewpoints, such as parents, administrators, and policymakers, could provide a more comprehensive understanding of the topic.

The insights from this study hold several implications for educational practice, policy development, and future research. First, the findings highlighted the crucial role of educators in fostering environmental awareness and sustainable digital practices among students. By recognizing teachers’ baseline familiarity with environmental challenges and their genuine concern for imparting this knowledge, educational institutions can capitalize on these sentiments to develop comprehensive curricula that integrate sustainability principles into various subjects. Moreover, the challenges identified by teachers call for the development of innovative teaching methodologies and resources. Policymakers can address the lack of suitable training and time constraints by investing in professional development opportunities for teachers, equipping them with the necessary tools and strategies to effectively promote sustainable digitalization in school education. The study’s recommendations provide practical guidance for educators seeking to bridge the gap between technology, sustainability, and education. By implementing these approaches, schools can empower students to become critical thinkers, responsible consumers of digital technology, and advocates for environmentally conscious behaviors.

Future research studies could expand the scope of this research, including a more diverse range of participants, such as students, parents, administrators, and policymakers. Longitudinal studies tracking changes in teachers’ attitudes and practices over time could provide insights into the effectiveness of interventions and training programs. Delving into the impact of different teaching methodologies and pedagogical approaches on students’ understanding and behavior regarding sustainable digitalization appears as another promising direction. Comparative studies that assess the effectiveness of various educational interventions in promoting environmentally conscious technology use could guide the development of evidence-based strategies.

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Appendix A. Focus Group Consent Form

Appendix A.1. Context

You have been invited to participate in a focus group sponsored by the Erasmus + project “Eco-Digital” with reference number KA220-SCH-000086751. The EcoDigital project aims to motivate more and more people to realize the importance of the digital waste problem and to develop positive changes in young people’s behavior with the aim of conveying such behaviors in the wider society. More specifically, the project will carry out a survey to assess the level of awareness of the digital waste problem in school education and will develop a literature review on the seriousness of the problem, training resources for teachers and a variety of ready-made educational activities to be used in formal and informal education, as well as a collection of assessment tools and policy recommendations. Thus, the project funding will fill important gaps in school education regarding digital waste management where young people are actively contributing to due to the increased use of various entertainment platforms and social networks.

Appendix A.2. Purpose

The purpose of this focus group is to investigate your lived experiences and perceptions of sustainable digitalization in school education. Specifically, we are interested in:

- ✓ How do you conceptualize the role of environmental awareness in the education of students?
- ✓ The challenges you encounter as you navigate the integration of digital technologies and sustainability principles within your classroom practices.
- ✓ How the environmental impact of digitalization at school can be addressed.

Appendix A.3. Procedure

As part of this study, you will be placed in a group of 3–5 individuals. A moderator will ask you several questions while facilitating the discussion. This focus group will be audio-recorded, and a note-taker will be present. However, your responses will remain confidential, and no names will be included in the final report (you will be assigned a nickname instead). This discussion will take approximately 60 min. Please note that there are no right or wrong answers to focus group questions. We want to hear the many varying viewpoints and would like for everyone to contribute their thoughts. Out of respect, please refrain from interrupting others. However, feel free to be honest even when your responses counter those of other group members.

Appendix A.4. Confidentiality

Should you choose to participate, you will be asked to respect the privacy of other focus group members by not disclosing any content discussed during the focus group. As stated above, your responses will remain confidential, and no names will be included in any reports.

Appendix A.5. Contact

If you have any questions or concerns regarding this study, please contact:

xxxxx@xxxxx.org

I understand this information and agree to participate fully under the conditions stated above.

Signature:

Date:

Print name:

Appendix B. Focus Group Guide

- When you hear the term “global warming”, what comes to mind first? Can you provide an explanation of your understanding of this concept?

Prompt: Can you elaborate on any sources of information that have influenced your understanding of global warming?

- Have you ever engaged your students in activities related to the environmental impact of digitalization as part of your teaching?

Prompt: Could you share an example of such an activity and its outcomes? How did the students respond to it?

- In your opinion, is it important to educate students about the environmental impact of digitalization? Could you elaborate on your reasoning?

Prompt: Have you observed any changes in students' attitudes or behaviors after learning about this topic?

- How would you go about incorporating discussions on the environmental impact of digitalization within your teaching methods?

Prompt: Can you provide specific examples of how you might integrate this topic into different subjects or lessons?

- Have you encountered any challenges or resistance when addressing environmental issues or sustainability in the classroom? If yes, how do you handle such situations?

Prompt: Could you share an instance where a challenging situation arose and how you navigated it?

- What grade levels do you teach, and what methods do you use to convey information? Specifically, if you teach different levels, such as primary or secondary, do you utilize different strategies?

Prompt: Can you share an example of a teaching method or resource that you find particularly effective for each level?

- What steps do you believe you could take to reduce your own digital footprint?

Prompt: Could you offer an example of a change you've made or could make to minimize your digital impact?

- In your perspective, what are the top three major concerns related to global warming, and why do these concerns stand out to you?

Prompt: Can you delve deeper into why these specific concerns resonate with you personally?

- What negative impacts do you associate with digital transformation when considering its effects on the environment?

Prompt: Could you provide an example or scenario that highlights one of these negative impacts?

- From your viewpoint, what suggestions do you recommend for sustainable digitalization at school? Can you elaborate on your stance?

Prompt: Are there any specific examples/situations that influenced your answer?

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