Article

Citizen Science in the Promotion of Sustainability: The Importance of Smart Education for Smart Societies

Maria José Sá [1,*], Sandro Serpa [2] and Carlos Miguel Ferreira [3]

1 CIPES—Centre for Research in Higher Education Policies, 4450-227 Matosinhos, Portugal
2 Interdisciplinary Centre of Social Sciences—CICS.UAc/CICS.NOVA.UAc, Interdisciplinary Centre for Childhood and Adolescence—NICA—Uac, Department of Sociology, Faculty of Social and Human Sciences, University of the Azores, 9500-321 Ponta Delgada, Portugal; sandro.nf.serpa@uac.pt
3 Interdisciplinary Centre of Social Sciences—CICS.NOVA, Estoril Higher Institute for Tourism and Hotel Studies, 2769-510 Estoril, Portugal; carlos.ferreira@eshte.pt
* Correspondence: mjsa@cipes.up.pt

Abstract: Digital society is already a reality and is increasingly shaping many aspects of social, economic and political life, among other aspects. The concept of Society 5.0 is a proposed form of a possible political nature to fulfil this digital society through a super-smart society. Based on document analysis of articles and books on this topic, this conceptual paper aims to critically discuss some aspects of Society 5.0, such as the dimensions of digitalization and sustainability. It is concluded that Society 5.0 is not an inevitability, and that the transformations it entails, as well as its advantages, also have challenges and limitations that should be considered, such as the risk of reproducing old forms of micro, meso and macrosocial inequalities within each country and between countries and regions, and, at the same time, creating new forms of social, cultural, economic and political inequalities, among others. A critical spirit seems to be necessary in the follow-up of this Society 5.0 and for which citizen-science logic, in an interdisciplinary way, can potentially provide tools for previous and prospective analysis of its implementation. We justify the need for smart education in these smart societies as a way of contributing to responding to the pressing problem of sustainability. It is smart education in and for a super smart society.

Keywords: society 5.0; digital society; smart education; super-smart society; sustainability; digitalization; citizen science

1. Introduction

The digital society is already upon us and increasingly shapes numerous aspects of social, economic and political life, among other dimensions. In this context, the digital presence was amplified with the COVID-19 pandemic, which was caused by the severe acute respiratory syndrome coronavirus type 2 (SARS-CoV-2) [1–5], albeit with inequalities between countries and regions, and social, cultural and even gender inequalities [6,7]. The concept of Society 5.0 is a proposed form of a political nature possible to achieve this digital society through a super-smart society [8].

On sustainability, a centrally guiding framework is the 17 Sustainable Development Goals (SDGs) proposed by the United Nations [9,10], which refer to a multidimensional concept based on economic and social growth that respects the environment. According to this concept, economic development fosters actions that are financially sustainable, and the use of natural resources is efficient, thus adding to the decrease in the environmental impacts of the manufacturing industry [11].

Education for sustainability is pivotal to meeting these Sustainable Development Goals [12] inasmuch as these sustainable development trends underlie UNESCO's four education principles [11] (p. 579):

- Education as a fundamental human right;

- Education as a public good;
- Education as a foundation for human fulfilment, peace, sustainable development, economic growth, decent work, gender equality and responsible global citizenship;
- Education as a contributor to reducing inequality and poverty.

However, Education for Sustainable Development (ESD) places some relevant challenges to traditional curricula and formal education, insofar as it calls for systemic and critical thinking and interdisciplinarity. Indeed, and according to Zeeshan et al. [10] (p. 1), "Conventional educational settings remain the Achilles heel of sustainable education".

This conceptual paper aims to critically discuss some aspects of Society 5.0, such as the dimensions of digitalization and sustainability. It is also intended to discuss the importance, in an interdisciplinary way, of applying the logic of citizen science to the understanding and overcoming of these challenges.

2. Materials and Methods

The methodological approach chosen for the production of this paper is qualitative, and the research technique used in the analysis of the data collected was content analysis. This technique allows compression of a high amount of words and text into fewer content categories based on explicit rules of coding [13–15]. Bardin [13] advocates that content analysis incorporates a set of communication analysis techniques that use systematic and objective procedures to describe the content of messages conveyed through diverse communication outlets. Thus, when used correctly, content analysis is a powerful technique that allows researchers to filter large volumes of data more easily and systematically [14,16]. It is a useful technique that makes it possible to unveil and describe the focus of individual, group, institutional or social attention, with the advantage of being discreet and useful when dealing with high volumes of data [17].

A critical decision when choosing content analysis is the selection of the unit of analysis. The literature refers to the unit of analysis regarding a wide range of objects of study, namely an individual, a program, an institution or a community, an interview, part of a text or even a sentence [18]. Within the scope of this study, we chose the document as the unit of analysis.

The authors performed a literature search, using, as search terms, Society 5.0, digital society, higher education, soft skills, digital, universities, and super-smart society mentioned either in the title or in the abstract. The search took place between 21 and 28 February 2022, and the databases searched were B-ON [19] and SCILIT [20]. This literature search resulted in 74 publications, described in Table 1.

Table 1. Document sources analyzed and their characterization.

Type of Document		Geographical Scope		Year of Publication			
Theoretical/ Conceptual	Empirical	International	National	2022	2021	2020	Prior to 2020
49	25	52	22	5	40	15	14
			Total: 74 publications				

Source: Authors' production.

As mentioned, the collected data were treated and analyzed through the content analysis technique [13] so as to meet the objectives drawn for this research in a comprehensive, rigorous and grounded way. According to the methodological approach adopted, a set of categories was built and coded a priori based on a critical review of the literature on the topic under analysis (citizen science, promotion of sustainability, smart education and smart societies). However, the categorization initially created was not a closed system; data analysis allowed the establishment of emerging categories, i.e., categories that were, based on their relevance to the study, incorporated into the categorical system as the data analysis progressed. Thus, the following categories emerged from the analysis of the documents:

Society 5.0; digitainability; digitalization and sustainability; Society 5.0 and citizen science; and smart education. Each of the categories is analyzed in detail in the sections that follow.

3. Society 5.0

We live in an increasingly digital society, with many challenges emerging from this [1,21,22].

Society 5.0 embodies the transformations brought about by this digital society. It is a recent concept with an essentially political origin. This concept emerged in Japan as a super-smart society, and its purpose, articulating the virtual with the real world, is human and social development in fostering quality of life and economic growth with cohesion and social justice while respecting sustainability [1,8,21–29].

Society 5.0 is the most recent stage of human development. Before it, very briefly, Society 1.0 was characterized by groups of humans who hunted to survive and lived in a totally balanced way with nature; Society 2.0 began when groups started to develop agriculture, social organization and the formation of nations; Society 3.0 corresponds to the Industrial Revolution, with the emergence of industrialization and mass production; Society 4.0 introduced the concept of an information society through global connection and worldwide information networks. It led to a digital transformation of the information society, allowing the emergence of Society 5.0, which is, thus, the continuation and corollary of Society 4.0, but characterized by being human-centered. The big difference between these two societies is that, while Society 4.0 focuses on the reduction of costs and effective production techniques in industry, Society 5.0 focuses on society as a whole and is a human-centered society [28,30,31].

The world we live in is in permanent change, and the technological development we have been witnessing over the last decades is fast, constant and with profound influences on the lives of citizens. In this dynamic scenario, Society 5.0 has, as one of its main purposes, to place the individual as the epicenter of the choices that are made at various levels (e.g., social-, cultural- or economic-level decisions, among several others). Thus, the increase of social sustainability must take into account the establishment and development of a more inclusive society, in which digitalization should be put at the service of humanity [32] with a logic according to which no individual is left behind [21].

The core concept of the Society 5.0 model is the large-scale collection and garnering of real-time data from all sectors of society, and its fundamental purpose is to make the most of the technological transformation for the benefit of all its citizens, namely in problem-solving processes [21]. In this way, and according to this model, the individual is placed at the center of the various choices, from social to economic and cultural. Consequently, this model of society aims to build a more inclusive society in which digitalization is placed at the service of the individual to achieve so-called social sustainability. In this sense, technological innovation can and should be used to improve the functioning of societies in their various fields [32].

Having originated, as already mentioned, in Japan, Society 5.0 has been expanding on a planetary scale in the building of digital societies [24,26], having at its base a rather interesting paradox, which involves the establishment of a society in which the epicenter is the human being, implying their interaction with the most-diverse forms of artificial intelligence at the service of human beings, namely social robots and entities equipped with artificial intelligence, which are no longer passive agents that only execute the instructions they receive from humans but, rather, entities with learning, decision-making and autonomy abilities [23].

This Society 5.0, as a "system of systems" of interconnected elements linked to each other, with the mobilization of information and big data, and to and from the Internet in a digital way [25], has five principles to include all individuals, presented in Table 2.

Table 2. Society 5.0 principles.

Inclusivity
Sustainability
Human-centered approach
Innovative thinking
Improved governance

Source: Adapted from Mavrodieva and Shaw [33] (p. 11).

To achieve the intended goals and to ensure that this type of society is not controlled by large companies, it is critical to foster the effective participation of all [23,25,33]. This raises deeply complex challenges, not only in technical terms—of digitization—but also in terms of use by ordinary citizens [23,34], which implies "digitability", which the next section addresses.

4. Digitainability

Following Colás-Bravo, Conde-Jiménez and Reyes-de-Cózar [35], sustainability regards those actions that aim at enhancing contemporary societies' well-being in economic, social and educational terms while safeguarding future generations' living standards. Table 3 depicts the four sustainability areas that educational sustainability should cover.

Table 3. Sustainability areas of educational sustainability.

Environmental sustainability	Preservation of ecosystems and their conservation for future generations.
Economic sustainability	Promotion of economic growth that generates equitable wealth for all without damaging the environment.
Social sustainability	Assurance of social well-being; inclusion and equity; inequality reduction; inclusive education; gender equity; education and literacy for all; active and accountable citizenship; fostering of peace, justice, respect, diversity, social and cultural inclusion.
Educational sustainability	The articulation between gender equity, inclusion and lifelong learning in education.

Source: Based on Colás-Bravo et al. [35].

The 2030 17 SDGs (Figure 1) seek to achieve the development sustainability process by articulating human/social, economic and environmental development [36,37], respecting the past, present and future in harmony between society and nature [12].

Digitalization and digital transformation are pivotal for the 2030 Agenda goals to be attained and, thus, also for the accomplishment of most SDGs [3].

Digital transformation may be defined, according to Jummai [38], as all the changes that take place at all levels of any organization—regardless of its type—in terms of its culture and ways of functioning, through the adoption of digital technologies, processes and competences that foster the organization's development and enhancement.

The Internet plays a pivotal role in these changes, not only at the organizational level but also in terms of individuals' daily life. It allows people to interact with each other, to be permanently connected with the world, to know what is happening at the global level in real-time—in sum, to be socially linked to everything and everyone that surrounds them [11].

Figure 1. UN Sustainable Development Goals. Source: Zeeshan et al. [10] (p. 6).

However, even with all the technological advances the world has experience over the last decades, there are still distinct levels of digital access and use, which the International Communications Union calls (i) the digital access gap, regarding those who are able to and those who are not able to utilize ICT (Information and Communication Technologies); (ii) the digital gap of use, which regards the competences and abilities to use ICT; and (iii) the quality-of-use gap, concerning the different ways in which different people use ICT [39].

Regarding the last dimension (the quality-of-use gap), it has to do with digital literacy, defined as

[. . .] the individual's ability to identify in a digital environment and encompass basic knowledge, skills, and abilities related to digital hygiene, digital ethics, communication, technical and consumer security, the Internet of Things, XR, basics of data processing and analysis, as well as basic computer and Internet skills in the modern digital environment. [36] (p. 4)

In addition, the ability of individuals to show that they master the digital—that is, that they have digital literacy, both as consumers and as producers of digital artefacts—is critical for sustainable development [40]. This focus on the digital has produced a new term, "digitainability", which brings together "digitization" and "sustainability" and reflects the links between sustainability and digitalization [3].

Education is one of the most relevant arenas for digitalization, and it depends on digital processes for its advancement. One of these advancements is digital doubles, which consist of a digital model of an object (e.g., a part of the educational process) that "[. . .] repeats what is implemented by its existing prototype and also allows one to study the functioning of the latter" [12] (p. 6). Education has already started to and will experience major shifts as early as this century, namely in terms of the traditional teaching and learning processes and methods. Computerization, digitalization and the transition to sustainable development (SD) are at the heart of these shifts, the main purpose of which is to ensure that the way in which the contemporary generation is developed does not hamper the wellbeing of future generations [12]. The training of digital competences within the sustainability paradigm entails four fundamental dimensions: (i) the contextualization of knowledge, which regards the teaching of critical thinking skills that allow students to learn to reflect on the social, cultural and disciplinary conditions in which knowledge is produced; (ii) the sustainable use of technological resources, which implies the use of technologies in an eco-responsible way; (iii) collaborative processes that favor digital sustainability; and (iv) the respect for ethical principles [41,42] (Figure 2).
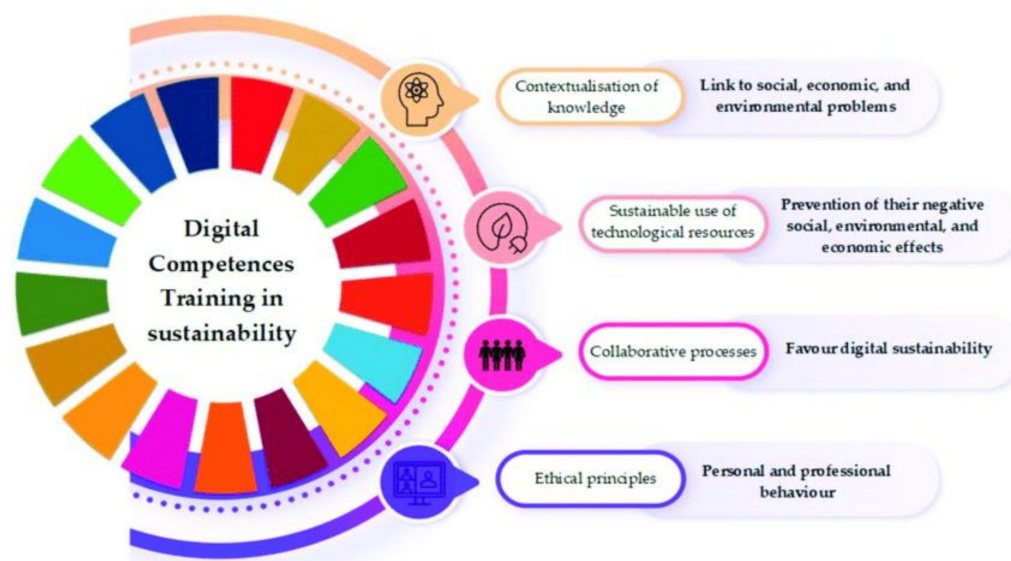
Figure 2. Areas of training in digital competences in sustainability. Source: Urrea-Solano et al. [41].

Thus, one of the main purposes and goals of sustainable digital education is to prepare today's individuals to commit themselves to be part of a responsible and sustainable social transformation and, in this way, to pave the way of sustainability for future generations [3,43,44].

These concerns underlying sustainable digital education are, naturally, in line with SGDs and, particularly, SDG#4 (quality education) [3], which occurs both inside and outside the educational system [35].

5. Digitalization and Sustainability

Currently, sustainability, in its multiple dimensions—social, economic and ecological, among others—is paramount. We are also living in unsustainability, having exceeded the limits of reasonability to have a successful future [45,46], with digitalization having the potential to create new consumption patterns [21].

This digitalization and the presence of the Internet entail profound changes in society. The developments brought about by digital transformation involve changes in terms of the quality of technologies, but also—and as a consequence—important changes at the level of social configurations. According to Meshcheryakova and Rogotneva [47] (p. 175), these changes and their direction are defined by four innovative technologies: "cloud computing, big data, artificial intelligence and the Internet of Things".

Digital literacy, as "access, consumption and production of digital forms" [1] (p. 4), in an intentional way is critical in this process of reducing the digital divide due to several cultural, economic and social factors of this (new) reality that shapes Society 5.0, as it is pivotal for the critical and conscious participation of the actors in the promotion of sustainable development [1].

As a way to ensure the attainment of a set of social priorities on a global scale, the United Nations (UN) approved, through its 2030 Agenda, a set of 17 Sustainable Development Goals (SDGs), whose fundamental goals are to protect the planet, eradicate poverty and to ensure the well-being of populations [48]. Table 4 presents the 17 SDGs defined by the UN.

Achieving these SDGs—which have been adopted by 193 countries, came into force in January 2016 and aim to stimulate economic growth, ensure social inclusion and protect the environment—means achieving the outcomes shown in Figure 3.

Albeit the implementation of this Society 5.0 model brings a wide range of advantages, it also has several drawbacks, which Table 5 accounts for.

Table 4. The 17 Sustainable Development Goals.

No poverty (SDG1)	Goal: Remove extreme poverty.
Zero hunger (SDG2)	Goal: Guarantee that all people have access to safe, nutritious and adequate food.
Good health and well-being (SDG3)	Goal: Supply people with basic health needs.
Quality education (SDG4)	Goal: Encourage equal, life-long and accessible education for all.
Gender equality (SDG5)	Goal: Provide gender equality in communities.
Clean water and sanitation (SDG6)	Goal: Take new measures so as to supply people with fresh and drinkable water.
Affordable and clean energy (SDG7)	Goal: Support energy production from resources that do not cause an increase in CO_2 emissions.
Decent work and economic growth (SDG8)	Goal: Ensure economic development and employing people in decent work.
Industry, innovation and infrastructure (SDG9)	Goal: Increase human welfare by creating innovations; and produce eligible products in accordance with human needs.
Reduced inequalities (SDG10)	Goal: Reduce inequalities among countries and within countries.
Sustainable cities and communities (SDG 11)	Goal: Reduce the life in slums; increase transportation facilities; arrange sewage and other infrastructure affecting human health; and plan decent sustainable cities.
Responsible consumption and production (SDG12)	Goal: Use food, water, houseware, electronic devices, energy and all fossil fuels economically and cyclically; and respect the future.
Climate action (SDG13)	Goal: Reduce the use of fossil fuels and the consumption of fossil-fuel dependent energy; take measures against natural disasters resulting from climate change; and develop counter measures.
Life under water (SDG14)	Goal: Ensure effective use of oceans, seas and those resources; create a healthy structure; and use resources sustainably.
Life on land (SDG15)	Goal: Protect ecosystems and species on earth and their sustainable use.
Peace, justice, and strong institutions (SDG16)	Goal: Form a more judicious and peaceful environment.
Partnerships for the goals (SDG17)	Goal: Help develop the whole world by enabling effective cooperation and communication among countries.

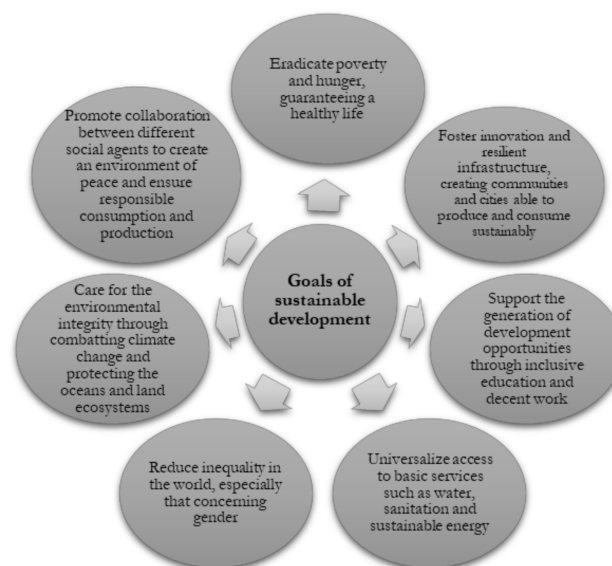Source: Adapted from Zengin et al. [28] (pp. 5 and 6).

Figure 3. Goals of sustainable development. Source: Adapted from Mensah [48] (p. 11).

Table 5. Some disadvantages of implementing Society 5.0.

1	Society 5.0 implementation is the technological leap from 4G to 5G. This process is complex and requires significant improvements to avoid computer scientist attacks.
2	The digital evolution proposed in Society 5.0 is closely linked with IoT technologies; there is an exponential increase in the volume of important data of companies and human beings that can be affected by hackers.
3	Cobot (collaborative robot) implementation in industrial processes leads to a decrease in the number of workers and an increase in the salaries of specialized staff.
4	Technology must be changed and hardware becomes obsolete, generating environmental pollution over time.

Source: Adapted from Narvaez Rojas et al. [25] (p. 12).

Even with the existence of some disadvantages, the implementation of the Society 5.0 model is envisaged as an important step towards improving people's living conditions and achieving sustainable development.

Hence, alongside all the advantages of developing Society 5.0 also come shortcomings, and this concept has raised serious reservations about the democracy upon which it is supposed to be based by some of its critics. McMillan Cottom [49] (p. 443), for example, states that

> [...] To both expand and exclude, the platform-mediated era of capitalism that grew from Internet technologies specializes in predatory inclusion [which regards] including marginalized consumer-citizens into ostensibly democratizing mobility schemes on extractive terms.

McLaren [24] (pp. 567, 582 and 595) also offers a very pertinent critical position on Society 5.0 and casts doubt on the true intentions and consequences for individuals and societies of implementing the Society 5.0 model, arguing that

> While Society 5.0 seeks its solutions through further abstracting humanity from the natural world it is destroying, locking us in a deterministic bubble, Ecological Civilization seeks to re-embed us in nature, repair our dysfunctional relationships with it and promote freedom through transcendence to higher levels of development. [...] Society 5.0 is a surveillance society, one with a scale of projected electronic monitoring of human behaviour never before seen in our history. [...] Society 5.0, therefore, like surveillance capitalism more generally, is designed to stunt human development creating a population of compliant, comfortable idiots.

In turn, Žižek, Mulej and Potočnik [50] (p. 11) speak of Society 6.0, proposing a "Sustainable Socially Responsible Society 6.0", while upgrading Society 5.0 by the application of a Sustainable Socially Responsible Society 6.0 model, materializing a "Well-being Society 6.0". Figure 4 graphically presents what Žižek et al. [50] consider to be the 10 basic dimensions of well-being in a welfare society.

The overall well-being of citizens thus involves synergy—in the sense of a collective and simultaneous effort—between the various types of well-being: material, social and environmental [50]. The authors argue that this Society 6.0 must obey a set of postulates that should be put into practice by all organizations, whatever their type (Table 6).

Table 6. Basic postulates of modern humanity.

The responsibility of everyone for the influences on society, i.e., people and nature.
Interdependence between individuals.
Integrity/holism and interdisciplinary cooperation.

Source: Adapted from Žižek et al. [50] (pp. 15 and 16).

Figure 4. Dimensions of well-being in a "well-being" society. Source: Adapted from Žižek et al. [50] (p. 11).

The authors put forth what they call the output of Well-being Society 6.0, which encompasses three core dimensions: (1) Sustainable social responsibility, in personal, corporate and societal terms; (2) SSR behavior, requiring personally accountable citizens; and (3) Sustainable leadership leaders [50] (p. 16).

Moreover, building a sustainable global society and finding solutions to its crises and challenges requires, more than resorting to technological solutions, changing and correcting individual behaviors, defining public policies that shape the sustainable society, and a combined, global effort to address the complexity inherent in the social relationships and structures that shape history [51].

6. Society 5.0 and Citizen Science

For Society 5.0 to become a reality on a global scale, it is critical that societies promote social dialogue, explore technologies and foster the participation of all at all levels. Society 5.0 has as one of its central assumptions, as already mentioned, the active participation of all in social issues, i.e., it must ensure that all citizens have access to the same opportunities in the logic of full participation mediated by innovative technologies. This is the basis for sustainable development [29].

To fulfill this purpose, citizen science (CS) seems to be entirely relevant. However, this is a concept with several blurred meanings [52,53]. According to Skarzauskiene and Mačiulienė [54], citizen science has a deep connection with transdisciplinary research. This stance towards research entails, on the one hand, various fields of knowledge working together and, on the other hand, close cooperation in addressing, analyzing and searching for solutions to scientific and social problems. Citizen science is, therefore, pivotal in building more sustainable and inclusive societies with the aim of developing solutions for social issues.

In this sense, CS contributes to making scientific results clear to all, building citizens' trust in science and increasing collective awareness of socio–political problems, thus forming the basis for change [54].

According to Göbel et al. [53], there are several stakeholders involved and contributing to this CS fostering process, as presented in Figure 5.

Figure 5. Groups of stakeholders involved in the Citizen-Science process. Source: Adapted from Göbel et al. [53] (p. 335).

Well-being Society 6.0 promotes the interrelationships between all social actors as a way to prepare them for the social and economic consequences of the digitalization of societies.

The participation and active involvement of all stakeholders in digital CS involves the assumption of several roles, namely those of data provider, collaborator, co-creator, ideator and disruptor [55], in the exercise of citizenship. Table 7 details the meaning and scope of each of these roles.

Table 7. Some disadvantages of implementing Society 5.0.

Data provider	Collecting data on predefined issues
Collaborator	Collaborating with authorities to monitor issues predefined by authorities
Co-creator	Co-creating solutions to address issues of shared concern
Ideator	Ideating civic actions
Disruptor	Disrupting established processes by passive non-participation or negative participation

Source: Adapted from Palacin et al. [55] (p. 2).

Based on these participatory dynamics and the assumption that CS development inevitably involves the input of all citizens, Fan and Chen [52] categorize CS uses into four modes or types, which are not static or mutually exclusive, although they have significant differences between them (Figure 6).
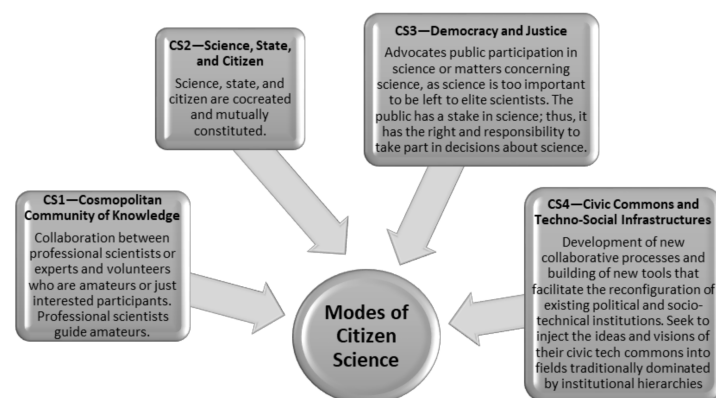

Figure 6. Modes of Citizen Science. Source: Adapted from Fan and Chen [52] (pp. 183–190).

CS turns scientific research into a participatory and shared process by involving citizens in its different stages. These dynamics of participation thus add to the democratization of science itself by actively inviting the contributions of nonprofessional scientists, but without

abdicating the scientific rules and structures. Following Wagenknecht et al. [56] (p. 3), "The integration of diverse actors, knowledge bases and objectives in citizen science makes it necessary for its research processes to be open, transparent and comprehensible for all".

McMillan Cottom [49] calls this involvement of citizens in the processes of science production predatory inclusion, meaning it is the involvement of marginalized individuals in democratizing mobility processes, such as ethnic minority citizens, for example.

CS, as a "co-design process", entails flexibility, engagement, reflexivity, collaboration, participation, motivation of the various actors, time control, negotiation, relevance, permanent dialogue, inclusiveness, transparency, articulation of diverse perspectives and interests, heterogeneity, selection of stakeholders, the abolition of traditional hierarchical structures and, thus, functioning as a legitimizing factor in the research process and product [56,57].

For this participatory process to be successful and truly inclusive of all, a balance between the interests, goals and constraints of researchers and those of a heterogeneous group of stakeholders and citizens in general needs to be found. Indeed, "This diversity is essential to ensure legitimacy, relevance, transparency, and credibility, yet it introduces greater complexity to the practicalities of the process" [57] (p. 8).

CS has numerous advantages and benefits, both for science itself (by answering research questions, increasing knowledge, management and awareness, and introducing new epistemologies), for citizens (by increasing their awareness, knowledge and skills) and for policymakers (as it can influence policy and management actions). Table 8 presents the main advantages.

Table 8. Example of values of Citizen Science.

Provides raw data
Expands total knowledge
Validates models and data
Answers research questions
Increases project scope and intensity
Economic incentives
Introduces new methodologies and philosophies
Increases stewardships and awareness
Influences conservation actions
Increases knowledge and skills
Increases advocacy efforts
Influences policy and management
Connects people, governments and the environment

Source: Adapted from MacPhail and Colla [58] (p. 3).

While CS has important advantages and benefits, it also faces numerous challenges and difficulties, particularly in terms of participants' and researchers' issues, defining the research design, and collecting and using the data collected [58]. Figure 7 details some of these challenges.

Figure 7. Examples of challenges of Citizen Science. Source: Adapted from MacPhail and Colla [58] (p. 7).

Digitality is a factor that can enhance the CS process [57]. However, critical literacy [59], digital literacy [60] and sustainability literacy [54] are crucial for its success [56] inasmuch as they promote sustainability through a necessarily interdisciplinary science literacy. This is not inevitable and, at the same time, raises profound challenges—some of which are discussed in this conceptual paper—such as going against established ideas about what and how education should be carried out on the part of many stakeholders (educational policymakers and educational actors), as well as overcoming digital divides, and the nonreproduction of preexisting inequalities and the establishment of new inequalities, in an ever-dynamic process.

7. Smart Education

For education for sustainable development (ESD) to fulfil its purpose of enabling individuals to attain the knowledge, skills, attitudes and values to shape a sustainable future, it must go beyond the traditional education offered in the 20th century. New educational approaches require students to develop competences that were not present or valued in the curricula of traditional education in the last century and that promote digitainability, seen as citizens' ability to use digital technologies, both in their roles as consumers and as producers of goods and/or services. Among these competences are communication, critical thinking, problem-solving, creativity and innovation, just to name a few [61]. However, student development in these competences also requires preparing both teachers and students for a rapidly evolving world and new challenges, and aligns formal with informal education [62].

Indeed, individuals are constantly subject to informal education and learning [12], and new (digital) technologies mediate all this learning more than ever before, with individuals actively participating in and building their learning and knowledge in the logic of co-creation and communities of practice [11]. This scenario brings yet another challenge, with the increasing availability of new media calling for the need for individuals to develop their digital literacy (i.e., the ability to continually search and critically assess information and to interact with others in a virtual environment), which is now central in the learning process that takes place more and more outside the walls of the traditional classroom [4,62]. This new educational landscape is taking place right at the preschool education level [63], in what Prensky [64] calls the afterschool space. Thus, it is paramount that educational policymakers and educational actors at large understand how learning takes place outside of the school, namely through online tools, so that fundamental ESD values and competences, such as "[. . .] ethical online

communities and the development of respectful, tolerant global digital citizens" [62] (p. 23) can take place [65].

In this new and fast-changing educational and social environment, educational processes that foster EDS need to use new educational instruments and pedagogical practices that enable students to attain core soft competences such as being able to cope with uncertainty and to adapt, be creative, communicate effectively, respect others and their standpoints, be self-confident, have emotional intelligence, be accountable and know how to think systemically [66], which is not always an easy or straightforward process.

One such tool is the DigCompEdu (European Framework for the Digital Competence of Educators) model, which specifies how digital competences should manifest in educational contexts and practices [35]. This model provides a framework for e-competences needed in a society in which technology is central to the life of its citizens and that should be a reference for teachers and educators in general to prepare students to thrive in this society. According to Redecker [67], the digital competences these professionals should develop fall within six specific working areas, depicted in Table 9.

Table 9. Skills and digital competences of teachers.

Professional engagement	Ability to use digital technologies to communicate, cooperate with colleagues and develop in personal terms.
Digital resources	Ability to identify, create and share digital resources.
Teaching and learning	Ability to use digital technologies in the teaching and learning process.
Assessment	Ability to reinforce students' assessments through digital technologies.
Learners' empowerment	Ability to use digital technologies for the learners' inclusion and active involvement.
Enable learners' digital competence	Ability to enable the learners' creative and responsible use of digital technologies to communicate, create content and develop solutions for problems.

Source: Adapted from Redecker [67].

Given the new and ever-changing educational scenario presented above, educational institutions in general, and particularly higher education institutions (HEIs), are faced with the challenge of developing an approach that incorporates research, teaching, knowledge transfer and operations always based on ESD. This approach entails a transformation, not only of the governance of HEIs, but also of the processes, the members' understanding of teaching and learning [68,69], and even, in the long run, likely the institutional culture.

In this new educational setting, new technologies are a strong source of support for the development of learning that promotes collaborative and group-work learning, as well as mobile and ubiquitous learning [12]. Smart classrooms promote and enhance individual active learning with the use of interactive resources that new technologies offer. Hence, smart education is built on an educational system centered on internet-based interaction between the educational actors and between them and the environment, developing an educational process that allows students to attain and/or to improve the transversal competences needed for them to succeed as students and future professionals [12].

The International Association of Smart Learning Environments (IASLE) defines smart education as a novel field combined with, for instance, smart technology, smart teaching and learning processes, smart education, smart classrooms, smart HEIs and smart society [70]. This smart education based on new technologies allows more efficient and easy knowledge and competences transfer to learners, while promoting active learning and broad communication between all educational actors, which enables the sharing of knowledge without the traditional time–space constraints [71].

According to Nezhyva [72], smart education follows a set of basic principles, detailed in Table 10.

Table 10. Basic principles of smart education.

Using up-to-date curriculum information for learning objectives	This entails the speed and volume of information flow. Moreover, professional activity is growing rapidly. Teaching materials should be complemented with real-time information on practical problem-solving in the context of real-life situations.
Organization of independent cognitive, research and project activities for students	This is paramount for developing in students the competences needed for searching for practical problems, independent information and research.
Implementation of the educational process in a distributed-learning environment	The learning environment is not limited to the HEI, whether in face-to-face and/or distance-learning systems. The learning process must be continuous and embrace training in professional environments using professional tools.
Flexible educational trajectories and individualized learning	Education is aimed not only at students but also for professionals who want to enhance their knowledge through continuing training. The HEI should provide educational services to meet the needs of those who wish to attain new knowledge or to develop their existing knowledge.
Student interaction with the professional community	The professional environment is essential in the educational process. Using ICT throughout the training process enables participants to better adapt to professional environments where ICT is central. According to student needs and capabilities, the HEI's task is to provide this sort of educational services.
Multifaceted educational activities	Depending on the institution's capacity, health, laboratories and overall conditions, these activities are excellent opportunities for those who wish to study in any training program.

Source: Based on Nezhyva [72] (p. 68).

The existence of Society 5.0, as a form of smart society based on digitalization, informs the potential for the implementation of smart education. In sum, for smart education to be adequately implemented, it needs to (i) ensure the existence of an up-to-date syllabus; (ii) foster students' autonomy; (iii) provide adequate learning environments; (iv) allow flexible and individualized educational trajectories for students; (v) promote broad communication between all actors involved in the teaching–learning process; and (vi) provide students with a wide variety of educational activities, both in terms of formal and informal learning, with the mobilization of this new technology and the shifts in the teaching processes.

In line with what Nezhyva [72] argues smart education should entail, Demir [73] (p. 3) defines this new educational approach as the "[. . .] effective and coherent use of information and communication technologies to reach a learning outcome using a suitable pedagogical approach". The authors stress that smart education goes beyond the use of new technologies and involves the adoption of new teaching and learning approaches, with students being autonomous, collaborative and experts in information and communication technologies, and teachers becoming facilitators.

Demir [73] argues that education is, currently, permeated both by new technologies and new ways of thinking and provides a comprehensive list of the main information technologies that enable smart education (Table 11).

Moreover, the author developed a Smart Education Framework, composed of several layers (Figure 8). The core layer regards the new or improved learning/teaching approaches (e.g., personalized learning and flipped learning). The second layer regards essential/transforming technologies that are critical for smart education. The third layer of the framework concerns enriching technologies, whose use in smart education enhances the educational process. Finally, the fourth layer regards supporting technologies, which are general-purpose technologies.

Table 11. Use of information technologies in smart education.

Learning management systems	Software applications or systems developed to create, communicate, manage and deliver educational programs.
Smart classrooms	Physical educational environments that use ICT. They may use ambient intelligence technology.
Virtual classrooms	Educational environments where the teaching and learning process occurs virtually.
Cloud computing technology	On-demand access to shared computing resources. The technology underlying this process is cloud computing technology.
Extended reality (XR)	All real and virtual combined environments, including augmented reality (AR), virtual reality (VR) and mixed reality (MR).
Virtual environments	Computer-generated environments that replace real environments with virtual ones.
Augmented reality	Technology that deals with enhancing the user's sense of the physical world with computer-generated sensory data in real-time.
Web 2.0+	Technologies that follow Web 1.0. These web technologies offer interactive, semantic and intelligent web services.
Social networks	Online platforms where users having profiles may interact.
Educational resources	Any type of learning and teaching material. They may be open to the public (open educational resources) or private to specific institutions.
Academic and corporate tubes	Online video-sharing platforms for educational purposes.
E-books and interactive books	Digital books enhanced with user-interaction ability.
Mobile technology	The information and communication technology that enables portable mobile devices.
Serious games	Computer games used for instructional purposes.
Learning and academic analytics	Learning analytics regards the collection and analysis of data about learning activities. Academic analytics uses business intelligence tools and strategies to support educational decision-making.
Educational data mining	Concerns analyzing data obtained from educational environments to understand patterns of learner behavior and improve educational settings.
Educational robots	Robots used in educational and training processes.
Gesture-based computing	Technology aimed at understanding human gestures.
Ambient intelligence	Emerging paradigm that brings intelligence into our lives with the help of intelligent interfaces and smart environments.

Source: Adapted from Demir [73] (p. 6).

This is not, naturally, a static model and may be adapted or customized to specific situations, topics or subjects. Furthermore, as new technologies emerge constantly, the ones presented in the framework are likely to change on a virtually daily basis.

For smart education to be able to fully develop, a (smart) educational environment is paramount. Moreover, such an education approach entails smart actors, namely educators and students, and smart educational intermediators [74]. The role of smart educators, as facilitators of the teaching and learning process, is to (i) organize and promote smart educational activities; (ii) design and convey adequate educational content; (iii) foster an appropriate educational environment; and (iv) regulate the smart educational process. This process needs, more than smart educators, smart learners who understand and embrace the process [74]. Indeed, in a smart education environment, learners have intelligent thought and are efficient in acting and solving problems in a student-centered, personalized, interactive and collaborative educational process [10,75].
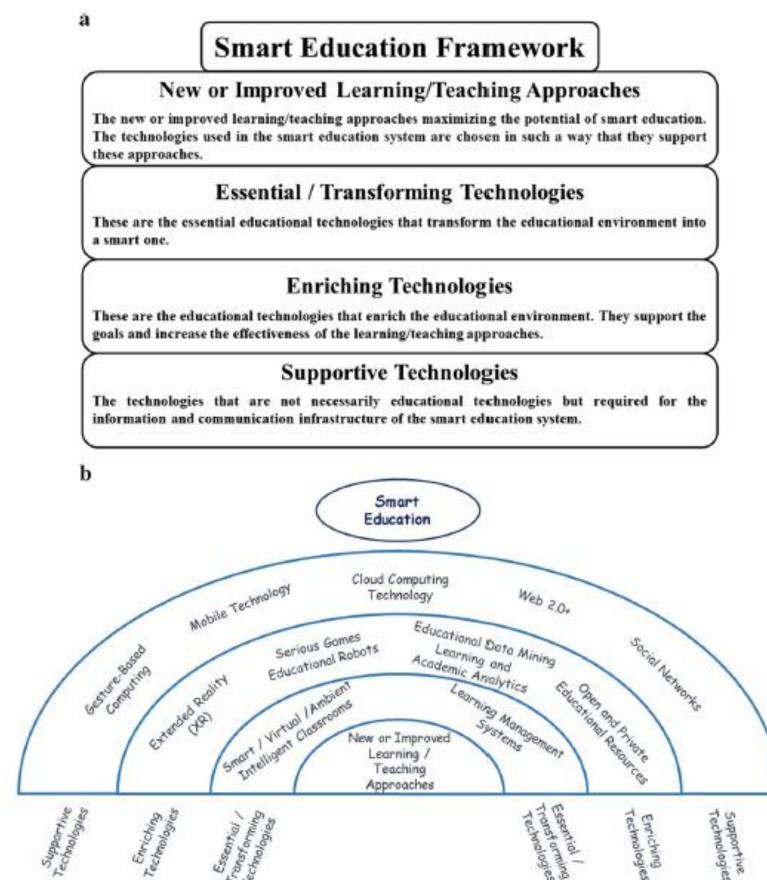
Figure 8. (**a**) Smart education framework layers; (**b**) Smart education technologies. Source: Demir [73] (p. 9).

Zeeshan et al. [10] put forth a set of goals that smart schools pursue and that bring them advantages when compared with traditional schools (Table 12).

Table 12. Some of the key purposes of a smart school.

Attain digital literacy and ICT-literate future professionals.
Achieve an interactive, collaborative learning experience and higher-quality education.
Achieve inclusive education by providing virtual education to remote areas without having to build physical school infrastructures.
Equip teachers with up-to-date teaching tools and applications to ease their work and enhance the quality of their work.
Attain sustainable resource management in quality education.
Achieve SDGs by supporting and building sustainable communities.

Source: Based on Zeeshan et al. [10] (p. 4).

It is, thus, critical that smart schools invest in teacher training, digital infrastructures, curricular change, improved teaching and learning methods, interactive and collaborative technologies, and learning environments that foster this new way of teaching and learning [10]. Moreover, according to Nezhyva [72], smart education aims, first and foremost, to develop in students the skills they will need in the future to be successful professionals that know their way in a digital society. To attain this objective, smart education needs to create learning environments that promote the students' continuous learning and development of competences, both in formal and informal learning processes.

However, the implementation of smart education faces some challenges, namely concerning the role of the teacher in the 21st century educational process [11,12,72], as well

as the need for mindset shifts both in educational institutions and in their students [5,38,76]. Furthermore, the existing inequality in accessing education via digitalization aggravates the gaps in accessing information and knowledge. These gaps concern both the access to digital equipment and tools and the opportunities to develop the necessary competences to navigate in the digital environment [39]. One example of this digital divide is the lack of digital skills that many teachers still reveal, which is overcome by increased teacher training in this dimension, thus fostering sustainable educational development [77]. Thus, teacher training in both digital technologies and sustainability are paramount to empower teachers and provide them with the knowledge and tools that allow them to fully take on their role as vehicles of social change in sustainable development [5,10,72,74,78].

In sum, for education to become sustainable, all institutional actors (academics, students and non-academic staff) need to attain and/or develop digital competences, namely through the adaptation of training programs for the emerging educational digital needs [79].

Nusantoro, Sunarya, Santoso and Maulana [80] refer to the concept of a smart university as one whose processes are designed to meet the needs of the institution, and they make a distinction between a smart university and a smart city, detailed in Table 13.

Table 13. The six smart points of a smart university in terms of management procedures.

Smart people	The involvement of HEI users is much needed in the teaching and learning process and at certain events.
Smart management	Allows students and HEI staff to participate in joint decision-making.
Smart atmosphere	Environmental sector with smart solutions to sustainably manage available resources.
Smart entrepreneurship	Creates productivity and innovation to be implemented in HEIs.
Smart activity	All activities can be monitored for various life factors, namely concerning health, behavior and safety.
Smart movement	Discusses the best solutions for the implementation of systems in HEIs, e.g., environmentally friendly and efficient transportation.

Source: Based on Nusantoro et al. [80].

Considering the six smart points above, the authors sustain, thus, that smart cities and smart universities share many similarities in terms of management procedures, while having, naturally, particularities that are characteristic of educational institutions.

In their systematic literature review on the current state of smart education, Martín, Alario-Hoyos and Kloos [81] conclude that, while there is a wide array of publications on this topic, must of them use a theoretical perspective to address it. The authors identify some challenges facing smart education that need a more in-depth analysis, depicted in Table 14.

Table 14. Challenges of Smart Education in need of further research.

Connectivity	Tests performed in several smart education settings in terms of the speed of their communications revealed a high decrease in performance as more devices connect, which is a difficulty, as the trend is increasing numbers of students per classroom. This may be solved by the definition of a specific protocol for mixed communications, which could allow quicker response and/or the introduction of more elements into the systems.
Security	Smart education environments frequently collect personal data of students and teaching and non-teaching staff. Hence, further research should be developed concerning the ethical aspects of data collection, namely privacy and secure data management.

Table 14. *Cont.*

Prediction systems	Another pertinent research line regards the prediction of events before they take place, such as student dropout, to allow corrective measures and/or increase resources to improve teacher and student performance.
Data visualization	Further research is needed in terms of how to deal with the large amount of data generated in smart education environments, display them correctly and make this data easier to understand for institutional actors.

Source: Based on Martín et al. [81].

Once again, the issue of teacher training is pivotal in that it provides them with skills so that they are able to fully play their role as facilitators and co-creators of knowledge in a smart education system, namely through the use of innovative teaching practices [74].

Interaction is a core element in smart education and smart learning environments. According to Nezhyva [72], interaction in these educational environments takes on the following forms:

- Student–learning material. The student interacts with the learning materials;
- Student–teacher. Teachers help, stimulate and motivate students in understanding and mastering the learning contents they interact with.
- Student–student. Enables the development of communication competences. Communication occurs through a diversity of channels, such as e-mail or web-conferences, for example [72].

Guo et al. [74] argue that, through smart education, there are increased learning opportunities to achieve excellent education, lifelong learning and sustainable development, specifically covering the implementation of SDG 4 (Equal, life-long and accessible education for all).

Moreover, this comprehensive and all-encompassing smart education is a powerful tool in preparing future professionals inasmuch that, according to Zeeshan et al. [10], smart education must consider sustainable development in its economic, social and environmental aspects. According to the authors, it is critical to adopt a technology-based education system that intimately contributes to sustainability in terms of equity, equality, justice and quality. This is one of the basic principles of an education that, in addition to being intelligent and sustainable, adequately prepares and qualifies future professionals.

Nezhyva [72] sustains that the use of smart technologies in the teaching and learning process will foster the transition from the traditional education process, based on knowledge reproduction, to an entirely and novel form of teaching and learning through the use of innovative methodologies and the development in students of critical technological knowledge and transversal competences that they will have to mobilize in their future profession careers [72].

8. Conclusions

The main purpose of this paper was to critically discuss some aspects of Society 5.0, such as the dimensions of digitalization and sustainability.

The document analysis carried out allows for the conclusion that Society 5.0 is not an inevitability, and that the transformations it implies, alongside the advantages, also have challenges and limitations that should be considered due to the risk of reproducing old forms of micro, meso and macrosocial inequalities within each country and between countries and regions and, at the same time, creating new forms of social, cultural, economic and political inequalities, among others. A critical spirit seems to be necessary for monitoring this Society 5.0 and for which CS, in an interdisciplinary way, can potentially provide tools for prior and prospective analysis of its implementation in a scientifically informed society.

In summary, science and technology produce more robust and sustainable knowledge if they weigh their instrumental knowledge with other types of knowledge, such as, for example, critical political ecology, which promotes "[. . .] the social construction of all

knowledge, supposedly neutral explanations of ecological reality and multiple discourses of sustainable development" [82] (p. 137).

This results in the importance of smart education, with its multidimensional interdisciplinarity [65,72], in promoting a learning process that is simultaneously efficient and effective. Furthermore, an increase in cooperation—both professional on the part of academics and in research on this pressing topic, mainly in the search for a more proactive attitude [65] in the creation of a Sustainable Digital Society—will result in smart education and a smart society.

This conceptual paper, which aims to critically discuss some aspects of the importance of the relationship between citizen science and smart education in promoting sustainability in increasingly digital societies through the promotion of smart education, resulted in the perception that the relationship between these concepts is still very tenuous and has yet to be explored by science. As a consequence, several suggestions for future research result directly from this analysis. Among these, we highlight (i) the need to study the role of interdisciplinarity in implementing the logic of citizen science in this process of developing smart education; and (ii) the importance of studying the emergence of new inequalities, as well as the possible reproduction of old inequalities that perpetuate the social reproduction cycle when social production is intended in inclusive societies. Action research, in its various modalities, may be a desirable instrument in the development and assessment of projects for the implementation of smart education for sustainability in scientifically informed sustainable digital societies.

References

1. Sá, M.J.; Santos, A.I.; Serpa, S.; Miguel Ferreira, C. Digitainability—Digital competences post-COVID-19 for a sustainable society. *Sustainability* **2021**, *13*, 9564. [CrossRef]
2. Pu, R.; Tanamee, D.; Jiang, S. Digitalization and higher education for sustainable development in the context of the Covid-19 pandemic: A content analysis approach. *Probl. Perspect. Manag.* **2022**, *20*, 27–40. [CrossRef]
3. Arnold, M.G.; Vogel, A.; Ulber, M. Digitalizing higher education in light of sustainability and rebound effects—Surveys in times of the COVID-19 pandemic. *Sustainability* **2021**, *13*, 12912. [CrossRef]
4. Kohler, F.; Kuthe, A.; Rochholz, F.; Siegmund, A. Digital Education for Sustainable Development in non-formal education in Germany and COVID-19-induced changes. *Sustainability* **2022**, *14*, 2114. [CrossRef]
5. Betancourt-Odio, M.A.; Sartor-Harada, A.; Ulloa-Guerra, O.; Azevedo-Gomes, J. Self-perceptions on digital competences for m-learning and education sustainability: A study with teachers from different countries. *Sustainability* **2021**, *13*, 343. [CrossRef]
6. Maity, S.; Sahu, T.N.; Sen, N. COVID-19 and digital primary education: Impact and strategies for sustainable development. *J. Dev. Policy Pract.* **2021**, *7*, 10–30. [CrossRef]
7. Chiu, W.-K. Pedagogy of emerging technologies in chemical education during the era of digitalization and artificial intelligence: A systematic review. *Educ. Sci.* **2021**, *11*, 709. [CrossRef]
8. Ferreira, C.M.; Serpa, S. Society 5.0 and social development: Contributions to a discussion. *Manag. Organ. Stud.* **2018**, *5*, 26. [CrossRef]

9. Lampoltshammer, T.J.; Albrecht, V.; Raith, C. Teaching digital sustainability in higher education from a transdisciplinary perspective. *Sustainability* **2021**, *13*, 12039. [CrossRef]
10. Zeeshan, K.; Hämäläinen, T.; Neittaanmäki, P. Internet of Things for sustainable smart education: An overview. *Sustainability* **2022**, *14*, 4293. [CrossRef]
11. Gómez-Zermeño, M.G. Massive open online courses as a digital learning strategy of education for sustainable development. *J. Sustain. Dev. Energy Water Environ. Syst.* **2020**, *8*, 577–589. [CrossRef]
12. Ursul, A.D. Digitization and transition to sustainable development: The problem of their integration in the educational context. *Autom. Doc. Math. Linguist.* **2020**, *54*, 1–9. [CrossRef]
13. Bardin, L. *L'Analyse de Contenu [Content Analysis]*, 2nd ed.; PUF: Paris, France, 2013.
14. Mayring, P. *Qualitative Content Analysis: Theoretical Foundation, Basic Procedures and Software Solution*; GESIS: Klagenfurt, Austria, 2014.
15. Krippendorff, K. *Content Analysis: An Introduction to Its Methodology*, 4th ed.; Sage Publications: Thousand Oaks, CA, USA, 2018.
16. Quivy, R.; Campenhaudt, L.V. *Manual de Investigação em Ciências Sociais [Handbook of Research in Social Sciences]*, 4th ed.; Gradiva: Lisbon, Portugal, 2005.
17. Stemler, S. *An Introduction to Content Analysis*; ERIC Clearinghouse on Assessment and Evaluation: Washington, DC, USA, 2001.
18. Elo, S.; Kääriäinen, M.; Kanste, O.; Pölkki, T.; Utriainen, K.; Kyngäs, H. Qualitative content analysis: A focus on trustworthiness. *SAGE Open* **2014**, *4*, 1–10. [CrossRef]
19. B-ON. What is B-ON? Available online: https://www.b-on.pt/en/what-is-b-on/ (accessed on 28 February 2022).
20. SCILIT. Available online: https://www.scilit.net/ (accessed on 28 February 2022).
21. Bagaric, D.; Franca, V. What will the future bring? Work, digitalization and social protection under Society 5.0. *İnsan İnsan* **2021**, *8*, 45–55. [CrossRef]
22. Aquilani, B.; Piccarozzi, M.; Abbate, T.; Codini, A. The role of open innovation and value co-creation in the challenging transition from Industry 4.0 to Society 5.0: Toward a theoretical framework. *Sustainability* **2020**, *12*, 8943. [CrossRef]
23. Gladden, M.E. Who will be the members of Society 5.0? Towards an anthropology of technologically posthumanized future societies. *Soc. Sci.* **2019**, *8*, 148. [CrossRef]
24. McLaren, G. Why the Future Needs Ecological Civilization and Not Society 5.0. *Cosmos Hist.* **2021**, *17*, 567–598. Available online: https://www.cosmosandhistory.org/index.php/journal/article/view/952 (accessed on 15 December 2021).
25. Narvaez Rojas, C.; Alomia Peñafiel, G.A.; Loaiza Buitrago, D.F.; Tavera Romero, C.A. Society 5.0: A Japanese concept for a superintelligent society. *Sustainability* **2021**, *13*, 6567. [CrossRef]
26. Pituła, B. The teacher and the idea of Society 5.0—Initial diagnosis of the problem. *Pol. Polit. Sci. Yearb.* **2021**, *50*, 1–17. [CrossRef]
27. Amadasun, K.N.; Short, M.; Shankar-Priya, R.; Crosbie, T. Transitioning to Society 5.0 in Africa: Tools to support ICT infrastructure sharing. *Data* **2021**, *6*, 69. [CrossRef]
28. Zengin, Y.; Naktiyok, S.; Kaygın, E.; Kavak, O.; Topçuoğlu, E. An investigation upon Industry 4.0 and Society 5.0 within the context of Sustainable Development Goals. *Sustainability* **2021**, *13*, 2682. [CrossRef]
29. De Felice, F.; Travaglioni, M.; Petrillo, A. Innovation trajectories for a Society 5.0. *Data* **2021**, *6*, 115. [CrossRef]
30. Harayama, Y. Society 5.0: Aiming for a New Human-Centered Society. Hitachi Review Online. Available online: https://www.hitachi.com/rev/archive/2017/r2017_06/trends/index.html (accessed on 11 July 2022).
31. Roblek, V.; Meško, M.; Podbregar, I. Mapping of the emergence of Society 5.0: A bibliometric analysis. *Organizacija* **2021**, *54*, 293–305. [CrossRef]
32. Peluso, P. The effects of the Covid-19 pandemic on organized crime activities in the Society 5.0. *İnsan İnsan* **2021**, *8*, 85–95. [CrossRef]
33. Mavrodieva, A.V.; Shaw, R. Disaster and climate change issues in Japan's Society 5.0—A discussion. *Sustainability* **2020**, *12*, 1893. [CrossRef]
34. Sugiyama, M.; Deguchi, H.; Ema, A.; Kishimoto, A.; Mori, J.; Shiroyama, H.; Scholz, R. Unintended side effects of digital transition: Perspectives of Japanese experts. *Sustainability* **2017**, *9*, 2193. [CrossRef]
35. Colás-Bravo, P.; Conde-Jiménez, J.; Reyes-de-Cózar, S. Sustainability and digital teaching competence in higher education. *Sustainability* **2021**, *13*, 12354. [CrossRef]
36. Razinkina, E.; Zima, E.; Pankova, L. Formation of digital competencies in higher education as the basis for realization of sustainable development goals. *E3S Web Conf.* **2021**, *296*, 08012. [CrossRef]
37. Ayman, U.; Kaya, A.K.; Kuruç, Ü.K. The impact of digital communication and PR models on the sustainability of higher education during crises. *Sustainability* **2020**, *12*, 8295. [CrossRef]
38. Jummai, B.A. The need for digital transformation in the education sector in Nigeria. *Curr. J. Appl. Sci. Technol.* **2021**, *40*, 41–47. [CrossRef]
39. Ancheta-Arrabal, A.; Pulido-Montes, C.; Carvajal-Mardones, V. Gender digital divide and education in Latin America: A literature review. *Educ. Sci.* **2021**, *11*, 804. [CrossRef]
40. Anthonysamy, L.; Koo, A.C.; Hew, S.H. Self-regulated learning strategies in higher education: Fostering digital literacy for sustainable lifelong learning. *Educ. Inf. Technol.* **2020**, *25*, 2393–2414. [CrossRef]
41. Urrea-Solano, M.; Hernández-Amorós, M.J.; Merma-Molina, G.; Baena-Morales, S. The learning of e-sustainability competences: A comparative study between future early childhood and primary school teachers. *Educ. Sci.* **2021**, *11*, 644. [CrossRef]

42. Baena-Morales, S.; Martinez-Roig, R.; Hernádez-Amorós, M.J. Sustainability and educational technology—A description of the teaching self-concept. *Sustainability* **2020**, *12*, 10309. [CrossRef]
43. Santoveña-Casal, S.; Fernández Pérez, M.D. Sustainable distance education: Comparison of digital pedagogical models. *Sustainability* **2020**, *12*, 9067. [CrossRef]
44. Sousa, M.J.; Marôco, A.L.; Gonçalves, S.P.; Machado, A.B. Digital learning is an educational format towards sustainable education. *Sustainability* **2022**, *14*, 1140. [CrossRef]
45. Islam, M. Sustainability through the lens of environmental sociology: An introduction. *Sustainability* **2017**, *9*, 474. [CrossRef]
46. Longo, S.B.; Clark, B.; Shriver, T.; Clausen, R. Sustainability and environmental sociology: Putting the economy in its place and moving toward an integrative socio-ecology. *Sustainability* **2016**, *8*, 437. [CrossRef]
47. Meshcheryakova, N.N.; Rogotneva, E.N. Digital transformation and new methods of sociological research. *KnE Soc. Sci.* **2021**, *5*, 175–180. [CrossRef]
48. Mensah, J. Sustainable development: Meaning, history, principles, pillars, and implications for human action: Literature review. *Cogent Soc. Sci.* **2019**, *5*, 1–21. [CrossRef]
49. McMillan Cottom, T. Where platform capitalism and racial capitalism meet: The sociology of race and racism in the digital society. *Sociol. Race Ethn.* **2020**, *6*, 441–449. [CrossRef]
50. Žižek, S.Š.; Mulej, M.; Potočnik, A. The sustainable socially responsible society: Well-being Society 6.0. *Sustainability* **2021**, *13*, 9186. [CrossRef]
51. Longo, S.B.; Isgren, E.; Clark, B.; Jorgenson, A.K.; Jerneck, A.; Olsson, L.; Kelly, O.M.; Harnesk, D.; York, R. Sociology for sustainability science. *Discov. Sustain.* **2021**, *2*, 47. [CrossRef]
52. Fan, F.; Chen, S.-L. Citizen, science, and citizen science. *East Asian Sci. Technol. Soc. Int. J.* **2019**, *13*, 181–193. [CrossRef]
53. Göbel, C.; Ottolini, L.; Schulze, A. Science as a lever: The roles and power of civil society organisations in citizen science. In *The Science of Citizen Science*; Vohland, K., Land-Zandstra, A., Ceccaroni, L., Lemmens, R., Perelló, J., Ponti, M., Samson, R., Wagenknecht, K., Eds.; Springer: Cham, Switzerland, 2021; pp. 331–349.
54. Skarzauskiene, A.; Mačiulienė, M. Citizen science addressing challenges of sustainability. *Sustainability* **2021**, *13*, 13980. [CrossRef]
55. Palacin, V.; Ferrario, M.A.; Hsieh, G.; Knutas, A.; Wolff, A.; Porras, J. Human values and digital citizen science interactions. *Int. J. Hum. Comput. Stud.* **2021**, *149*, 102605. [CrossRef]
56. Wagenknecht, K.; Woods, T.; Nold, C.; Rüfenacht, S.; Voigt-Heucke, S.; Caplan, A.; Hecker, S.; Vohland, K. A question of dialogue? Reflections on how citizen science can enhance communication between science and society. *J. Sci. Commun.* **2021**, *20*, A13. [CrossRef]
57. Neset, T.-S.; Wilk, J.; Cruz, S.; Graça, M.; Rød, J.K.; Maarse, M.J.; Wallin, P.; Andersson, L. Co-designing a citizen science climate service. *Clim. Serv.* **2021**, *24*, 100273. [CrossRef]
58. MacPhail, V.J.; Colla, S.R. Power of the people: A review of citizen science programs for conservation. *Biol. Conserv.* **2020**, *249*, 108739. [CrossRef]
59. Serpa, S.; Santos, A.I. Critical literacy and literacies. *J. Educ. Teach. Soc. Stud.* **2020**, *2*, 18. [CrossRef]
60. Guitart Martín, A.; Palomo Zurdo, R.J. Digital inability and social sustainability in the face of the fourth industrial revolution: A proposal of new non-financial indicators. *Sustainability* **2021**, *13*, 13958. [CrossRef]
61. Sá, M.J.; Serpa, S. Transversal competences: Their importance and learning processes by higher education students. *Educ. Sci.* **2018**, *8*, 126. [CrossRef]
62. Howard, P. Digital citizenship in the afterschool space: Implications for Education for Sustainable Development. *J. Teach. Educ. Sustain.* **2015**, *17*, 23–34. [CrossRef]
63. Chen, J.; Yang, S.; Mei, B. Towards the sustainable development of digital educational games for primary school students in China. *Sustainability* **2021**, *13*, 7919. [CrossRef]
64. Prensky, M. *Teaching Digital Natives: Partnering for Real Change*; Corwin: Thousand Oaks, CA, USA, 2010.
65. Kyzovleva, N.; Samoilova, A. Relevant Legal Aspects of Sustainable Technologies of the Digital Economy in the Educational Organization. In Proceedings of the 2021 1st International Conference on Technology Enhanced Learning in Higher Education (TELE), Lipetsk, Russia, 24–25 June 2021.
66. López-Alcarria, A.; Olivares-Vicente, A.; Poza-Vilches, F. A systematic review of the use of agile methodologies in education to foster sustainability competencies. *Sustainability* **2019**, *11*, 2915. [CrossRef]
67. Redecker, C. *European Framework for the Digital Competence of Educators DigCompEdu*; Publications Office of the European Union: Luxembourg, 2017.
68. Bauer, M.; Rieckmann, M.; Niedlich, S.; Bormann, I. Sustainability governance at higher education institutions: Equipped to transform? *Front. Sustain.* **2021**, *2*, 640458. [CrossRef]
69. Singh, H.; Miah, S.J. Smart education literature: A theoretical analysis. *Educ. Inf. Technol.* **2020**, *25*, 3299–3328. [CrossRef]
70. Zavala-Yoé, R.; Iqbal, H.M.; Ramírez-Mendoza, R.A.; Parra-Saldívar, R. Smart educational tools and learning management systems: Supportive framework. *Int. J. Interact. Des. Manuf.* **2020**, *14*, 1179–1193.
71. Norbutaevich, J.T. Use of digital learning technologies in education on the example of smart education. *J. Edusci.* **2020**, *1*, 33–37. [CrossRef]
72. Nezhyva, O. The aspects of smart education in the world. *Khazar J. Humanit. Soc. Sci.* **2021**, *24*, 62–72. [CrossRef]
73. Demir, K.A. Smart education framework. *Smart Learn. Environ.* **2021**, *8*, 29. [CrossRef]

74. Guo, X.-R.; Li, X.; Guo, Y.-M. Mapping knowledge domain analysis in smart education research. *Sustainability* **2021**, *13*, 13234. [CrossRef]

75. Li, K.C.; Wong, B.T.-M. Research landscape of smart education: A bibliometric analysis. *Interact. Technol. Smart Educ.* **2021**, *19*, 3–19. [CrossRef]

76. Morato, J.; Sanchez-Cuadrado, S.; Iglesias, A.; Campillo, A.; Fernández-Panadero, C. Sustainable technologies for older adults. *Sustainability* **2021**, *13*, 8465. [CrossRef]

77. Sánchez-Prieto, J.; Trujillo-Torres, J.M.; Gómez-García, M.; Gómez-García, G. Incident factors in the sustainable development of digital teaching competence in dual vocational education and training teachers. *Eur. J. Investig. Health Psychol. Educ.* **2021**, *11*, 758–769. [CrossRef] [PubMed]

78. Chin, C.K.; Munip, H.; Miyadera, R.; Thoe, N.K.; Chng, Y.S.; Promsing, N. Promoting education for sustainable development in teacher education integrating blended learning and digital tools: An evaluation with exemplary cases. *EURASIA J. Math. Sci. Technol. Educ.* **2018**, *15*, em1653. [CrossRef]

79. Deev, M.; Gamidullaeva, L.; Finogeev, A.; Finogeev, A.; Vasin, S. The convergence model of education for sustainability in the transition to digital economy. *Sustainability* **2021**, *13*, 11441. [CrossRef]

80. Nusantoro, H.; Sunarya, P.A.; Santoso, N.P.L.; Maulana, S. Generation smart education learning process of blockchain-based in universities. *Blockchain Front. Technol.* **2021**, *1*, 21–34. [CrossRef]

81. Martín, A.; Alario-Hoyos, C.; Kloos, C. Smart Education: A Review and Future Research Directions. *Proceedings* **2019**, *31*, 57.

82. Huckle, J. Teacher education for sustainability in network society: Combining digital and sustainability literacies. *J. Teach. Educ. Sustain.* **2012**, *14*, 130–146. [CrossRef]