Digitainability and Smart Education

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Smart education, with its multidimensional interdisciplinarity, allows the promotion of a learning process that is simultaneously efficient and effective, enhancing digitainability and, consequently, more proactive attitudes in shaping a Sustainable Digital Society.

digitainability digital competences digital society digital sustainability society sustainability development smart education sustainability

1. Introduction

Literacy plays a very relevant role in a digital society, in which the promotion of sustainability is unavoidable. However, this digitalization of the educational process poses several challenges: it requires both software and hardware conditions, as well as digital literacy as a result of a complex of literacies. It also implies that teachers and students change their standpoints and practices with the attainment of new teaching and learning competencies, such as smart education, in order to fight the digital divide and foster the widest possible social inclusion for the promotion of sustainable society – digitainability.

2. Digitainability

The digital, in the form of technologies, is already present in multiple dimensions of our daily life, with specificities that shape social relationships[1][2][3][4][5][6]. The digital is shaping, with increasing intensity and speed, social change, with profound consequences in terms of sustainability, with its advantages and limitations[7][8][9][10][11][12][13]. In this context, the ability to exhibit digital competences or digital literacy is critical.

On the concept of digital literacy[14][15][16], Martin[17] (p. 155) offers the following definition and explanation:

Digital Literacy is the awareness, attitude and ability of individuals to appropriately use digital tools and facilities to identify, access, manage, integrate, evaluate, analyze and synthesize digital resources, construct new knowledge, create media expressions, and communicate with others, in the context of specific life new knowledge, create media expressions, and communicate with others, in the context of specific life situations, in order to enable constructive social action; and to reflect upon this process.

It follows from this definition that digital literacy is crucial for the harmonious participation of individuals, empowering them in their life in society as consumers, but also as creators of digital technology in a conscious,

critical and intentional way, which is also vital for sustainability development[18][19][20][21][22].

On sustainability, a central guiding framework is the 17 Sustainable Development Goals (SDGs) proposed by the United Nations[23][24], which refer to a multidimensional concept based on economic and social growth that respects the environment. Education for sustainability is pivotal to meeting these SDGs[25].

In a summary, **Table 1** depicts the key competences for sustainability, according to the vision of UNESCO[26].

Table 1. Key competences for sustainability.

Systems thinking competence: the ability to recognize and understand relationships; to analyze complex systems; to think of how systems are embedded within different domains and different scales; and to deal with uncertainty.
Anticipatory competence: the ability to understand and evaluate multiple futures – possible, probable and desirable; to create one's own visions for the future; to apply the precautionary principle; to assess the consequences of actions; and to deal with risks and changes.
Normative competence: the ability to understand and reflect on the norms and values that underlie one's actions; and to negotiate sustainability values, principles, goals and targets, in a context of conflicts of interests and trade-offs, uncertain knowledge and contradictions.
Strategic competence: the ability to collectively develop and implement innovative actions that further sustainability at the local level and further afield.
Collaboration competence: the ability to learn from others; to understand and respect the needs, perspectives and actions of others (empathy); to understand, relate to and be sensitive to others (empathic leadership); to deal with conflicts in a group; and to facilitate collaborative and participatory problem-solving.
Critical thinking competence: the ability to question norms, practices and opinions; to reflect on own one's values, perceptions and actions; and to take a position in the sustainability discourse.
Self-awareness competence: the ability to reflect on one's own role in the local community and (global) society; to continually evaluate and further motivate one's actions; and to deal with one's feelings and desires.

> Integrated problem-solving competence: the overarching ability to apply different problem-solving frameworks to complex sustainability problems and develop viable, inclusive and equitable solution options that promote sustainable development, integrating the abovementioned competences.

Source: UNESCO[26] (p. 10).

It will be necessary to build a sustainable digital society in the development of digitainability (digitalization + sustainability)[27].

3. Smart Education Learning Processes

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. Educational processes are crucial in fostering digital sustainability in a digital society[19][28][29], with active learning[18][30][31].

In this process, learning development by all stakeholders is critical, with the acknowledgement that education is more than schooling[32], transcending the transmission-based school culture[33][34][35][36][37].

At the pedagogical level, Daniela[38] considers that digitalization entails a profound transformation in the learning and teaching process and proposes a smart pedagogical process to operate in a technology-enhanced learning environment using digitalization capabilities. According to Daniela[38], some principles of smart pedagogy include: learning anywhere, anytime; a fascination with new technologies; the availability of technology and software; the existence of online opportunities for transforming teaching materials; the development of new teaching materials and the assessment of their impact on learning outcomes; the process of learning analytics, which requires constant monitoring of the learning process; and learning design, i.e., the way the learning process is designed to include learning via online materials.

Palanivel[39] (p. 7) comments that a smart classroom is the high-quality shape of a digital classroom and a digitalized learning and teaching process. The author continues, characterizing smart education as “[...] a set of technology-based solutions that leverage the Internet and other smart technologies combined with engineering excellence to enhance learning, affordable education and reachable to the target audience”. Communication between the institutional actors in such a learning environment is possible with the utilization of digital technologies and tools, such as smartphones, tablets and wireless Internet connections, among others. The whole process is, according to the authors, all about smart technology, given that “The components of a smart education include smart classroom, smart teaching, smart learning, smart learning environments and smart campus”[39] (p. 7), among other components.

The author offers a detailed scheme of the complex smart education architecture, which is composed of three layers: the smart learning application layer (which encompasses the smart classroom, smart analysis, smart management, smart monitoring and tracking, smart analytics and users such as domain experts and end-users); the smart computing layer, which includes all the technological tools); and the smart campus layer (which provides support to the learning and teaching process as well as research, enhances service quality and facilitates unified decision-making)[39].

A smart education involves ascribing a more central role to the students and their participation, in a process from "by one to many" into "by many to many"[40] (p. 11).

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[41]. 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[42].

According to Nezhyva[43], smart education follows a set of basic principles, detailed in **Table 2**.

Table 2. Basic principles of smart education

Using up-to-date curriculum information to learning objectives	The speed and volume of information that flows. Moreover, professional activity is growing rapidly. Teaching materials should be complemented with real-time information in practical problem-solving, in the context of real-life situations.
Organization of independent cognitive, research and project activities of students	This is paramount in developing in students the competences needed for searching 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 distance learning systems. The learning process must be continuous and embrace training in professional environments using professional tools.
Flexible educational trajectories, individualized learning	Education is aimed not only for 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 or 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 the students' 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 that wish to study in any training program.

Source: Based on Nezhyva[43] (p. 68).

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[44]. 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[44]. 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[24][45]. However, the implementation of smart education faces some challenges, namely concerning the role of the teacher in the 21st-century educational process [25][43][46], as well as the need for mindset shifts both in educational institutions and in their students[47][48][49].

Martín, Alario-Hoyos and Kloos[50] identify some challenges facing smart education that need a more in-depth analysis, depicted in **Table 3**.

Table 3. Challenges of Smart Education in need of further research.

Connectivity	The 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 the increasing number of students per classroom. This may be

	solved with the definition of a specific protocol for mixed communications, which could allow a quicker response and/or the introduction of more elements into the systems.
Security	Smart education environments frequently collect personal data of students, teaching and non-teaching staff. Hence, further research should be developed concerning the ethical aspects of data collection, namely privacy and secure data management.
Prediction systems	Another pertinent research line regards the prediction of events before they take place, such as student drop-out, to allow to take corrective measures and/or increase resources, aiming to improve teachers' and students' 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.[50].

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[44]. Interaction is a core element in smart education and smart learning environments.

According to Nezhyva[43], 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 content they interact with.
- Student–student. Enables the development of communication competences. Communication occurs through a diversity of channels, such as e-mail or webconferences, for example[43].

Guo et al.[44] 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).

4. Conclusions

The above results in the importance of smart education, with its multidimensional interdisciplinarity[43][51], 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[51] in creating a Sustainable Digital Society—will result in smart education and a smart society.

These requirements are not necessarily shared by all the actors involved in this process. It also implies that teachers and students change their standpoints and consequent practices of how to teach and learn, respectively, with the attainment of new teaching and learning competences. This may be, at least in the least developed regions, the most challenging component to achieve for the success of smart education in a digital society.

As a way of fighting this possible – and we would even say – probable alienation, it seems essential to us to disseminate knowledge through interdisciplinarity[52][53][54][55][56].

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.

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