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Review

Sustainability and Digital Teaching Competence in Higher Education

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Abstract: This article examines the research that explores the relationship between sustainability and digital teaching competence in the university environment, through a qualitative systematic review, which covers 2011 to 2021. It is intended to identify how sustainability is applied in higher education through teaching experiences linked to the use of ICT, where the digital teaching competence is specified and put into practice. In other words, it is about responding to the following questions: What digital skills are being applied to develop educational sustainability in higher education? In which aspects of educational and pedagogical sustainability are they projected? As a work methodology, the PRISMA protocol is applied as the technique of systematic review, using the Scopus and WOS databases as sources of information. Subsequently, a qualitative analysis of the selected articles is carried out using the ATLAS.ti scientific software, using the DigCompEdu model as the basis for the analysis of the information. The results shed light on the panorama of research on digital competence and sustainability and the evolution of scientific production over ten years, as well as the methodology applied in these studies. The DigCompEdu model is found to be useful for registering the modalities of teaching competencies put into practice, manifesting a primacy of pedagogical digital competences over those of professional development and student empowerment. Sustainability development areas are also identified, linked to teaching digital competence, such as inclusion, educational quality or lifelong learning.

Keywords: teacher digital competence; sustainability; educational quality; inclusion; lifelong learning; higher education; teachers; teaching; systematic review

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1. Introduction

University systems have extended the use of ICT in teaching, relying on the implementation of digital platforms, with greater or lesser versatility, in recent years. However, it was in 2020 when, as a result of the COVID-19 pandemic, universities required the use of digital resources in whole. This forced situation required a significant effort from teachers to respond to training demands, which, in a large majority of cases, implied the use of active and participatory didactic methodologies, using technological means and platforms for learning, leading them to put into practice or develop their digital competence. These experiences provided a multitude of digital resources, knowledge and skills that represent a significant amount for the sustainability of university systems. Technology has been shown to make university systems more sustainable, as they provide inclusion and attention to diversity, among other aspects related to sustainability. However, there is a lack of systematization, based on empirical evidence, of the relationships established between digital competence and sustainability in the university system.

In addition, sustainability, from an educational point of view, requires conceptual clarification as well as greater specificity both from a theoretical and pragmatic point of view. For example, from a pedagogical point of view, sustainability is associated both with specific environmental education programs, as well as with very varied teaching practices, such as the creation of resources, pedagogical methods for inclusion, improvement of educational quality, etc.

This is the purpose that guides this contribution, to identify how sustainability is applied in higher education through teaching experiences linked to the use of ICT, where the digital competence of teachers is specified and put into practice. In other words, it is about investigating what digital competences are being applied to develop educational sustainability in higher education and in which aspects of educational and pedagogical sustainability they are projected.

More specifically, it is about responding to the following questions: How are the concepts of quality, inclusion and lifelong learning projected in educational practice, which are sustainable educational objectives set in university education? What digital competences are associated with sustainable goals in the university environment? What dimensions and indicators are relevant for the exploration of these practices? This systematic review aims to shed light in this regard.

With this purpose, it is proposed to analyze the scientific production of articles published by the double-blind system on the digital competences of teachers and sustainability in higher education, during the period from 2011 to 2021 in the Scopus and WOS databases. It is intended to identify studies that interrelate these two fields of research, as well as thematic areas in which this interrelation is projected. This contribution tries to discover the concept or conceptions of digital competences that are handled in the university environment, as well as the aspects of sustainability that are involved. This study also aims to discover the connection of two research spaces that, over a long period of time, were studied independently, thus filling a gap in the scientific production that interrelates sustainability and digital competences in the university environment.

At a methodological level, its approach is complex, due to the diversification and breadth of projections in which sustainability at the educational level is manifested. There is an added difficulty to this, which is the diversity of spaces in which digital skills are expressed. Thus, given that in this contribution two lines of research are connected—digital teaching competences and sustainability—we understand that it is necessary to present the conceptual frameworks of both fields since they constitute the bases on which to base the empirical analysis.

2. Digital Teaching Competences. The DigCompEdu Model

Digital teaching competences are a field of analysis and study relevant to both scientific, political and social levels. In the last decade, there has been a paradigmatic change in the concept of teaching digital competence [1]. It has gone from a technical conception [2,3], as a technological domain, to emphasize its transformative and activating value in the development of students' digital skills [4–7]. This new conception understands that teaching digital competence must be oriented toward fostering and stimulating the student's agency in the construction of digital citizenship [8]. This domain of competence is manifested both in the responsible use of ICT in problem solving, and in the use of a critical and reflective thinking and attitude toward them. In short, digital teaching competencies are aimed at training citizens to make conscious, active and participatory use in e-society through ICT. From this conception, digital competences become empowering, transformative and expansive skills for a sustainable society, from a cultural, economic, environmental and social perspective [1,8]. Therefore, digital skills are emerging as key tools to achieve the objectives of sustainable development, promoting educational quality, inclusion and the active participation of citizens in social and economic spheres.

The DigCompEdu model (European Framework for the Digital Competence of Educators) [9] is an international benchmark since it was built based on existing knowledge from reviews and syntheses of the literature, in addition to the contributions of international experts. This model provides a systematization that is very useful in educational research by specifying the manifestations of digital competences in educational contexts and practices. Specifically, allusions are made to three areas of teaching action: professional development, pedagogical action and learning achievements. In our case, it will serve as a reference for the content analysis of the scientific production identified in this systematic review

This model, therefore, provides the key dimensions with which to carry out the analysis of the scientific production identified in the systematic review developed in this work. One of the objectives of this narrative review is to identify in what dimensions digital competence is manifested in the university environment linked to sustainable development. This analysis will make it possible to offer an X-ray of the state of development of the digital competence of teachers in higher education linked to sustainability and, therefore, help to achieve the goal that university students acquire the digital skills necessary for their full social integration and professional development for a sustainable future.

3. Educational Sustainability

Sustainability, in general terms, must be understood as all actions and activities that result in raising the levels of well-being of today's human societies with respect to the economic, social and educational areas, without compromising the living conditions of future generations. However, the breadth and diversification of areas in which sustainability is projected generates great complexity when it comes to specifying its manifestations in specific areas of its application in university education and, in turn, associates them with concretions of the digital teaching competences.

Based on the above, we understand as a preliminary task the identification of the expressions of sustainability in the educational field. The programs and lines of action in sustainability, which, at the same time, are linked to educational tasks, cover four areas: environmental, economic, social and educational [10]:

1 Environmental sustainability: refers to the need to preserve ecosystems and conserve them for future generations. At an educational level, it is addressed through programs aimed at raising awareness and acting on the part of students for responsible behavior toward the environment.
2 Economic sustainability: it is understood as an inclusive economic growth that respects the environment. In other words, it is about promoting economic growth that generates equitable wealth for all, without damaging the environment. Currently, this plot acquires special prominence in the prevalence of sustainability in all sectors of investment and creation of start-ups. Sustainable entrepreneurship, as well as the creation of resources based on nature, guide the actions of national and regional policies.
3 Social sustainability: implies guaranteeing social well-being, inclusion and equity. It is projected toward the achievement of the reduction of inequalities, inclusive education, gender equity, quality education, universal literacy, responsible and active citizenship, the promotion of peace, justice, respect and value of diversity, as well as social and cultural inclusion. It also includes access to decent employment and entrepreneurship. All these far-reaching goals are sustained and anchored in education.
4 Educational sustainability: is articulated around gender equity, educational inclusion and lifelong learning. These ideas are the starting point and key reference for this study.

The sustainable development objectives set and assumed by international organizations, such as the OECD, UNESCO, OEI, etc., constitute a general framework of reference that must be projected and take shape in concrete practices and contexts of educational action. However, there is a great gap in studies that allow identifying and evaluating the degree of scope, development and evolution of sustainability objectives in specific contexts of educational practice. To this is added the scarce development of methodological tools that allow the analysis and systematization of experiences in favor of sustainability. That is, there are still missing answers to questions such as the following: What experienced educational practices can be considered of quality under the parameters of the sustainability paradigm? How can we collect and systematize these contributions? What methodological tools can be used to know the manifestation of sustainable objectives in pedagogical work?

Therefore, it is necessary to know more precisely, and in a systematic way, which sustainability objectives are addressed in the teaching practice and in which educational spaces they are developed. Along these lines, we contemplate the scientific challenge of carrying out a systematic review about this article: digital teaching competences and sustainability. However, this proposal entails addressing and solving methodological challenges. One of them is to specify the concepts that are part of the sustainable educational objectives, such as guaranteeing an inclusive, equitable and quality education, as well as promoting lifelong learning opportunities for all (SDG 4).

Initially, a review was made of the quality concepts provided by international organizations, in order to identify dimensions on which to base the documentary analysis. However, it was concluded that there is no universally agreed definition of educational quality, in addition to being an ambiguous term. To this is added the difficulty of being a concept that is in constant evolution and frequently associated with other terms that are equally of an open nature as can be seen in the definition that is expressed in the 2030 educational goals: educational quality is that which entails inclusive and equitable education and lifelong learning for all [11]. These circumstances lead us to give up operating with a previous conceptualization and to use, at a methodological level, an inductive procedure, based on the evidence detected in the bibliographic search. It is about identifying, through analysis of production, how educational quality manifests itself at the university teaching level in relation to teaching digital skills.

Inclusion was the second term to be revised for the same purpose. We found that this term is associated with equity. Both equity and inclusion mean ensuring that all students achieve at least a basic minimum level of skills. Equitable education systems are fair and inclusive and help their students reach their learning potential, without erecting formal or informal barriers, or lowering expectations [12]. For UNESCO, inclusive education is a process that involves the care of all students (children, ethnic minorities, affected by diseases, learning disabilities, etc.) [13]. The report by [14], based on the postulates of UNESCO, specifies the scope of inclusive education in ensuring and guaranteeing the right of every child to access, presence, participation and success in their local school, as well as providing excellent educational experiences and results for all childhood and youth. However, how are these ideologies expressed in university educational praxis? Additionally, what role is given to digital skills in the inclusion of university students? These questions, among others, guide this contribution.

The third concept is lifelong learning, which at the same time is closely linked to the terms of quality and inclusion [15]. It is a very broad concept, which implies a permanence in time (it covers a lifetime). It occurs both inside and outside the educational system, is aimed at all ages and can be carried out through different teaching modalities: face-to-face, blended and e-learning. In addition, linked to sustainability, it can include any type of knowledge and is a concept that breaks down the barriers defined by the traditional idea of formal learning.

In summary, the three conceptual referents explained will serve as a guide for the empirical analysis. It is, therefore, to answer the following questions mentioned above in the introduction: How are the concepts of quality, inclusion and lifelong learning,

which are sustainable educational objectives set in university education, projected in educational practice? What digital skills are associated with sustainable goals in the university environment? What dimensions and indicators are relevant for the exploration of these practices? This systematic review aims to shed light in this regard.

Therefore, the purpose of this contribution is to identify and systematize the knowledge and scientific findings about this article: teaching digital competence and sustainability. It investigates the teaching digital competencies implicit in university education, as well as the aspects in which sustainability linked to these competencies materializes, exploring which aspects are prioritized and which areas are less represented.

Although, as was explained, there are numerous contributions related to sustainability training, there is a lack of studies that allow a panoramic vision of the state of the convergence of these two areas traditionally studied independently, as well as having methodological tools that allow study educational praxis at an empirical level on expressions of sustainability and digital competence.

4. Methodology

The general objective of this contribution is to discover the digital teaching competences that are being applied to practices related to sustainability in higher education. This general objective is specified in the following specific objectives:

1 Systematize scientific production regarding sustainability and digital teaching competence at the university level.
2 Trace the evolution of this scientific production in the last decade, identifying its main characteristics.
3 Explore those dimensions of digital teaching competence proposed by the DigCompEdu framework [16] linked to sustainability that emerge from the texts analyzed in the systematic review.
4 Identify dimensions, based on university educational praxis, that specify the concepts of educational sustainability, developing a categorization system for the analysis of scientific production on this topic.
5 Explore the types of educational praxis, found in the literature, associated with digital skills and sustainability in the university context.

The scientific methodology followed is carried out in three stages. In a first phase, the PRISMA protocol is applied to the systematic review of the literature. Subsequently, a qualitative analysis of the documents obtained is carried out, in order to identify the dimensions and categories implicit in the concepts of sustainability and digital skills. For the analysis of digital teaching competence, and in accordance with [16], a directed content analysis is applied, using the DigCompEdu framework model [9]. In the case of dimensions related to sustainability, an inductive analysis is carried out [16], from which categories emerge that make explicit and specify the educational projections of sustainability. The qualitative analysis is carried out using the scientific software ATLAS.ti. Each of these procedures is detailed below.

4.1. PRISMA Protocol

In this study, a systematic review of the existing scientific literature on digital teaching competence and sustainability in higher education is developed. For the correct performance of this review and to guarantee its validity and rigor, a decision was made to follow the recommendations and indications of the PRISMA statement [17–19]. The process followed to carry out the review is shown below, explaining the different phases of the protocol.

Initial Search

The initial search began in January 2021 using the combination of terms 'digital teaching competence' and 'sustainability' in the WOS and Scopus databases. In a second phase, the search was extended using the Boolean operators AND and OR in combination with the descriptors 'Sustainable Development', 'Sustainable practice', 'Sustainable education'.

'ICT' and 'Higher Education'. These searches showed an extensive number of scientific productions, many of them of being of little use for the purpose of this study. However, thanks to this initial phase, it was possible to obtain a global vision of the topic studied and, therefore, the relevance of carrying out a systematic review of the literature. In view of the results obtained, it was decided to select Scopus as the only relevant database for the study, due to the low number of results from the WOS database, most of which are also indexed in Scopus.

Systematic search

The final systematic search was carried out in February 2021 using the Scopus database, using a search interval of 10 years (from 2011 to 2021, both inclusive).

The best combination of terms used was the following: (digital AND teaching AND competence OR (ICT AND uses AND teaching)) AND (sustainable AND development OR sustainability OR sustainable AND practice OR sustainable AND education). Finally, 4739 results were obtained. The inclusion and exclusion criteria used for filtering results following the PICOS format are shown below (Table 1).

Table 1. Inclusion and exclusion criteria according to the PICOS structure.

	Inclusion Criteria	Exclusion Criteria
Participant	teachers and students	others
Intervention	any	none
Context *	Higher Education published between 2011–2021 open access social sciences articles and published	other non-university levels not published between 2011–2021 not open access not social sciences not articles not published
Outcomes	linked to sustainability and digital competence at the same time	others
Study Design	any	none

* The Comparator section of the usual PICOS format was modified by Context, following [20]. Source: Authors.

After identifying the 4115 results found in Scopus, the screening phase began based on the inclusion and exclusion criteria mentioned above. According to these criteria, n = 3328 results were discarded for the following reasons: n = 2627 for not being publications in Open Access, n = 475 for not belonging to the area of Social Sciences, n = 201, for not being articles and n = 25 for not yet being in the final publication state. After this screening phase, 787 articles were obtained. Subsequently, and after reading the title and abstract, n = 755 were eliminated because they are articles that were not relevant to our object of study, n = 657 because they are not about higher education, and n = 98 because they do not specifically address sustainability. This left a total of n = 32 records selected to evaluate their eligibility. Finally, after reading the full text of the selected articles, n = 13 were discarded because they are not framed within the concept of digital teaching competence used in this study or do not meet some of the previous criteria not detected in the previous filtering phases. Thus, n = 19 records were included for the systematic review. It should be clarified that no new results were added after conducting a manual search in additional sources since no relevant results were found for our study. The synthesis of the process can be seen in Figure 1.

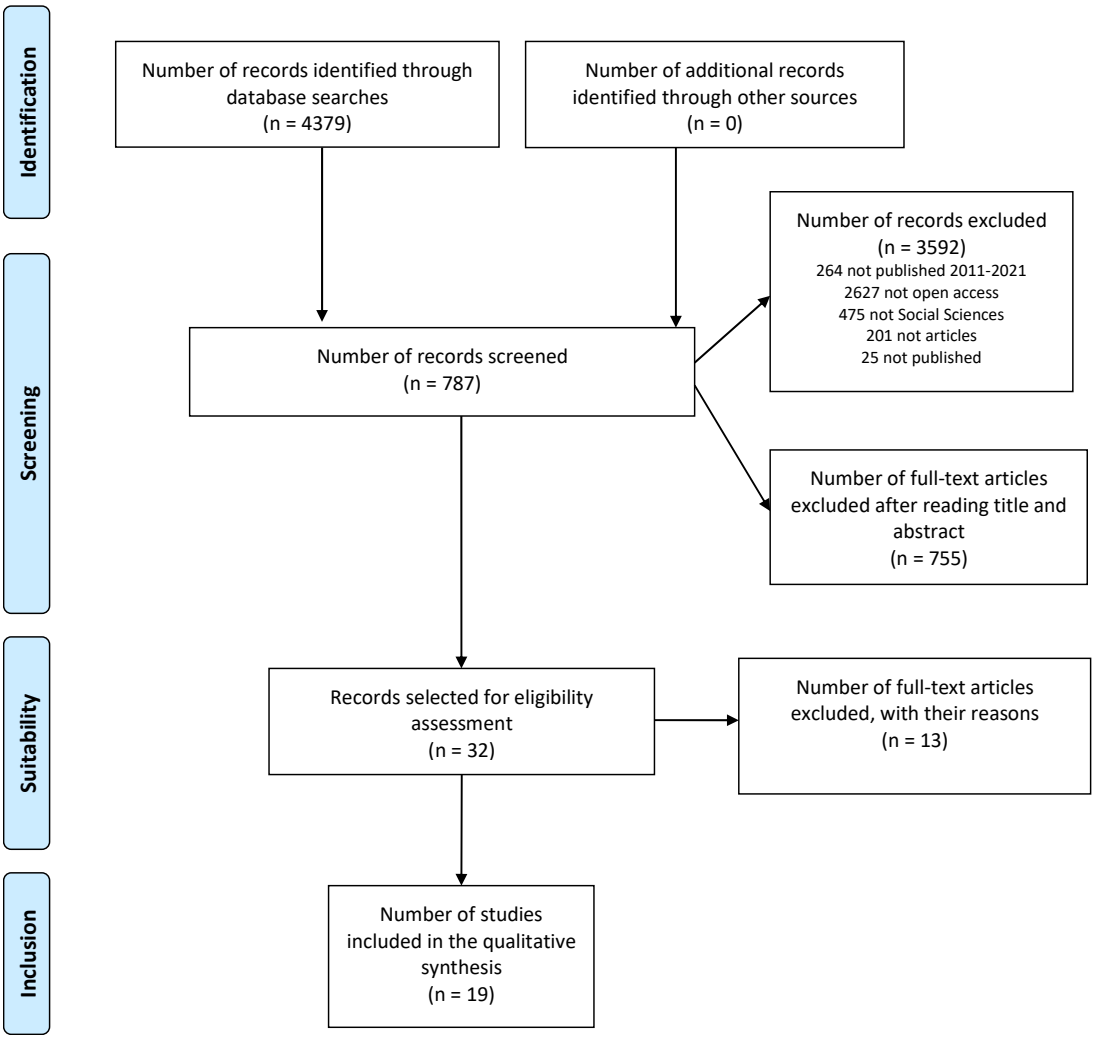

Figure 1. Planning, identification and eligibility process workflow. Source: Authors.

4.2. Analysis of Documentary Information

Information analysis is carried out by combining two methodological procedures: directed content analysis is applied to digital skills and inductive analysis focused on sustainability. In the first case, it starts from a system of previous categories and in the second, it is extracted from the information.

4.2.1. Analysis of Directed Content Applied to the Concept of Digital Competences

This type of analysis allows us to know how the digital teaching competence is expressed in the reviewed studies, using a previous taxonomy based on the DigCompEdu model [16], previously referenced. This model consists of three large dimensions, which in turn include their corresponding categories. These are made explicit in the following:

1 Professional competences:

- Professional commitment (Code: Engage). This area refers to digital skills and abilities to improve organizational communication between different educational agents, establish networks for professional collaboration, make use of reflective practice and serve for continuous professional training.

2 Pedagogical Competence: This dimension is specified, in turn, in 4 categories:

- Digital resources (Code: Resources): This refers to the skills to select appropriate resources for teaching, create and/or modify existing digital resources to respond

to learning objectives, as well as knowing how to manage, protect, share and understand the use of open educational resources.

- Teaching and learning/digital pedagogy (Code: Pedagogy): This refers to the use of digital resources and tools for their integration in teaching and for innovation. It consists of designing educational proposals that guide students, while promoting interaction, collaborative and self-directed learning.
- Evaluation and feedback (Code: Assessment): It is the use of digital tools for innovation and evaluation improvement. It is linked to evaluation strategies through ICT, understood in the sense of a tool to improve learning.
- Empower (Code: Empower): This category relates to teacher practices to ensure that all students have access to all kinds of digital resources for solving tasks. In this sense, the teacher uses the potential of ICT to personalize differentiated learning itineraries and achieve the active participation of students, fostering an active and creative commitment of these.

3 Student competences:

- Facilitate students' digital competence (Code: Facilitate): It is linked to teaching practices that promote the development of students' digital competence. It is specified in posing challenges based on real problems that involve the use of technologies to provide answers to them.

4.2.2. Analysis of Focused and Inductive Content Used in the Concept of Sustainability

This analysis is intended to bring to light the concepts of educational sustainability linked to digital teaching competence, based on the university educational praxis. The result of this process is to obtain a category system, with an empirical base, that can be used in future studies, to know how sustainability is projected and interpreted in educational actions. Theoretically, it starts from the concepts associated with sustainability in the educational field: educational quality, inclusion and learning throughout life. These general concepts serve as a focus for exploring categories linked to them.

5. Results and Discussion

5.1. Scientific Production on Digital Teaching Competence and Sustainability in Higher Education in the Decade 2011–2021

Table A1, which can be consulted in Appendix A, shows the synthesis of analyzed articles organized by their main characteristics—author, year, sample and research method—as well as the codes assigned to each study that are used throughout this work. In Appendix B, all the bibliographic references of the articles reviewed according to APA can be consulted.

This identification allows us to discover that the scientific production on these two concepts was practically nil during the decade studied and had a significant increase in 2020, finding 14 of the 19 articles included for analysis, as can be seen in Figure 2.

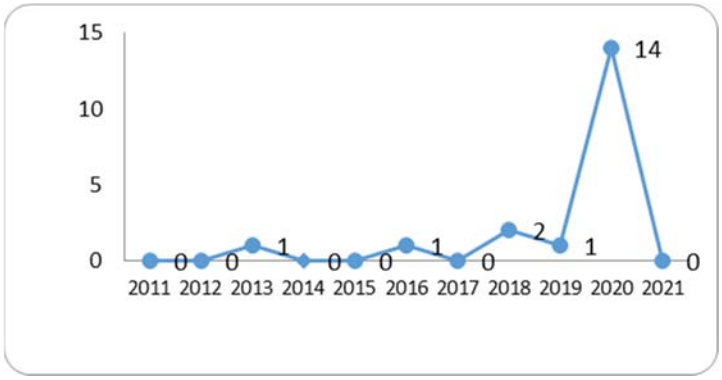

Figure 2. Frequency of publication of studies per year. Source: Authors.

Regarding the nature of the type of study (Figure 3), the majority are quantitative (42.1%), followed by mixed methodology studies (26.3%), review studies (21%) and, lastly, those studies of a qualitative nature (10.53%).

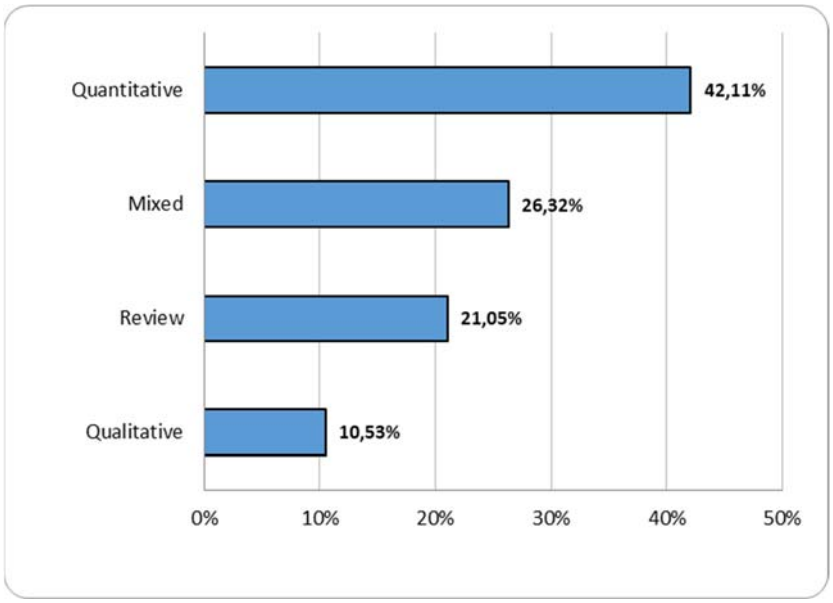

Figure 3. Percentage of studies by methodology. Source: Authors.

5.2. Digital Teaching Competence Linked to Sustainability in the University Environment

The qualitative analysis of the selected studies provides a mapping of the nodes and main focuses around which the research on digital competences in the university environment in relation to sustainability revolves.

One of the most notable results is that the topics addressed in this review refer to the digital teaching competencies proposed by the DigCompEdu model. As can be seen in Table 2, all the studies can be classified in the dimensions and categories proposed by this model. This leads us to consider that this taxonomy is validated at the empirical level and can serve as a reference in subsequent studies.

Table 2. Percentage of appearance of the dimensions of the DigCompEdu model contemplated in the directed qualitative analysis.

Teaching Digital Competence (DigCompEdu)					
Educators' Professional Competences	Educator's Pedagogic Competences				Learners' Competences
Engage	Resources	Pedagogy	Assessment	Empower	Facilitate
13.4%	28.4%	20.9%	6%	13.4%	17.9%
	68.7%				

Source: Authors.

The results obtained, as can be seen in Table 2, indicate a focus of the digital competences of higher education teachers around pedagogical competences (68.7%), compared to those of facilitator of students' digital competence. (17.9%) or their own professional competences (13.4%).

Specifically, within the pedagogical digital competences, the area where the greatest results are found (28.4%) is that linked to the selection, organization and creation of digital resources. In second place is the area of digital pedagogy (20.9%), highlighting skills related to the use of digital tools to improve and innovate through aspects, such as instruction, collaboration, interaction or self-directed learning. In third place (13.4%), the area linked to the teaching capacity of empowering students takes on importance,

highlighting competencies that promote accessibility and inclusion, personalization, as well as the active participation of students. Finally, it is the area of evaluation (6%) that counts the fewest contributions.

Second, in terms of percentage, is the field of development of digital teaching competence linked to the ability to facilitate the development of this in students, with an occurrence of 17.9% in the studies analyzed. In this, competences related to media and information literacy, communication, content creation, responsible use of digital tools or problem solving stand out.

In last place, with an appearance percentage of 13.4% in the studies analyzed in the systematic review, the development of the professional digital competence of teachers is located, encompassing aspects such as professional collaboration, reflective practice, organizational communication or the teacher's own training.

In short, the taxonomy derived from the DigCompEdu model allows the analysis of scientific production and sheds light on aspects that are developed in the university environment. In this sense, we can conclude that digital competence is developing according to established theoretical models.

5.3. The Projections of Sustainability in Education Contemplated in University Studies in Relation to Digital Teaching Skills

The results obtained from the inductive analysis applied to the concept of educational sustainability yield the data shown in Table 3. This shows us the categories that emerge derived from sustainability: educational quality, inclusion, responsible action, universal literacy and sustainability as a purpose.

Table 3. Percentage of appearance of sustainability projections derived from inductive analysis.

Sustainability	Percentage %
Educational quality	25.4%
Inclusion	14.9%
Responsible actions	19.4%
Universal literacy	10.4%
Sustainability as a purpose	29.9%
%	100%

Source: Authors.

Sustainability as a purpose is the dimension that accumulates the highest percentage with a total of 29.9%. Educational quality is in second place with 25.4%. In third place, with 19.4%, the category of carrying out responsible actions or sustainable awareness arises. The reference to inclusion obtains a percentage of 14.9%. Universal literacy is the one with the lowest percentage of all, with 10.4%.

In summary, this analysis allows us to identify the expressions of sustainability framed in the field of teaching digital competence in the university context, as well as to observe the areas that are best represented and those that need a greater presence. The taxonomy that emerges from this study can be a useful tool for observing the evolution of sustainability in educational systems and levels.

5.4. The Convergences between Educational Sustainability and Digital Competences in University Studies

Once the information is collected through the corresponding taxonomies on digital teaching competences and educational sustainability, the next step is to explore the interconnection between both taxonomies. That is, to explore how the results obtained on digital teaching competence converge with the categories found in educational sustainability. This exploratory procedure illuminates more precisely the interconnection between these two scientific domains.

The convergence of educational sustainability and digital competences is represented in Table 4. In the cells, the codes used are those assigned to the studies referenced in Appendix A.

Table 4. Studies and dimensions of digital competence based on DigCompEdu and sustainability.

		Teaching Digital Competence (DigCompEdu)						
		Educators' Professional Competences	Educator's Pedagogic Competences				Learners' Competences	
		Engage	Resources	Pedagogy	Assessment	Empower	Facilitate	Frequency/%
Sustainability	Educational Quality	A3, A11	A2, A3, A11, A15	A1, A2, A3, A11	A1, A2, A11	A15,	A2, A3, A11	17 /25.4%
	Inclusion		A10, A19	A4, A10		A1, A2, A4, A16	A1, A19	10 /14.9%
	Responsible Action	A8, A9	A10, A13, A17, A19	A5, A13, A17		A19	A4, A9, A19	13 /19.4%
	Universal Literacy		A6, A10, A19	A6		A19	A6, A19	7 /10.4%
	Sustainability as a purpose	A7, A8, A12, A14, A16	A10, A12, A14, A16, A18, A19	A5, A7, A14, A18	A12	A16, A19	A18, A19	20 /29.9%
	Frequency/ %	9 /13.4%	19 /28.4%	14 /20.9%	4 /6%	9 /13.4%	12 /17.9%	67 /100%

A study may appear in more than one category. Source: Authors.

As can be seen, all the categories of both concepts—digital teaching competence and educational sustainability—are represented in these studies. As for sustainability as a purpose, it is the dimension that accumulates the most frequency of appearance, with a total of 29.9%. For the most part, teaching digital competence is linked to proposing solutions in a specific area of sustainability or to the Sustainable Development Goals (SDGs) themselves, for example, studies such as A14, which highlight the need to use digital teaching competence to take advantage of human capital and, therefore, the creation of sustainable societies, or A5, which points out the importance of generating good teaching practices based on ICT for achieve the SDGs (#4: Quality Education).

In second place, educational quality is the next dimension with the highest frequency of appearance with 25.4%. In this dimension, digital competence linked to sustainability is related to educational variables, such as performance improvement, time management, teamwork, improvement in student involvement and improvement in learning (A2, A15). Similarly, other studies focus on the fact that it is necessary for teachers and students to have a good development of digital competence in order to have the ability to create meaningful learning experiences and obtain good use of them (A11). Furthermore, it involves collaboration and mediation processes, where the teacher's role becomes that of a guide or facilitator, allowing the use of digital tools for innovation and creativity in university teaching to promote more social and participatory teaching formulas (A1). A quality education is linked, therefore, with an optimal use of all the resources that are put at its disposal and, therefore, contributes to generating a sustainable educational system. This conception of sustainability, understood as the improvement and use of digital educational resources, available for university training, is evident in studies such as A3, which raises the interdependence between ICT and pedagogy.

In third place, with a 19.4% frequency of appearance, there is an application of the teaching digital competence to the service of carrying out responsible actions. In this sense, the need to develop an ethical and moral position from a sustainable perspective for the application of digital technologies arises (A8). Similarly, although the use of digital technologies brings innumerable benefits, it also carries risks for people (A9). Therefore, the teacher, making use of their digital competence, has the challenge of minimizing risks through the development of activities with a view to raising awareness of sustainability (A17) and fostering a responsible attitude toward the use of ICT (A13).

Inclusion is placed in fourth place, according to the results obtained, obtaining a frequency of appearance of 14.9%. This dimension places the teaching digital competence at the service of inclusive social and cultural practices. In this sense, there are studies that

show how online learning favors lifelong learning (throughout life) (A16), thus promoting the use of digital resources to achieve inclusion, as well as the elimination of barriers to democratization and knowledge acquisition (A19). Other studies point to a formative inclusion, betting on the interactive dynamization of the human factor and the technological factor in a balanced way (A4), where the teacher has the responsibility of making accessible and personalized designs to include all their students (A1, A2).

In last place and with an occurrence of 10.4% is universal literacy. In this case, it is convenient to clarify the difficulty of discriminating specific studies that address the principle of universal literacy linked to technologies since it is understood that all the previous categories that link digital competence and sustainability are a way to achieve it. However, it was decided to maintain this category to address those studies that specifically point to the digital divide as a problem to be solved in order to achieve more sustainable societies. In this sense, some studies highlight how digital competence is related to financial factors or the standard of living of students (A6). Nevertheless, other authors consider that the expansion of ICTs and global interconnection have great potential to accelerate human progress, reduce the digital divide and develop knowledge societies (A10). Therefore, the teacher, through their digital competence, has the potential to apply educational resources that favor the democratization of knowledge in vulnerable areas and offer tools that respond to problems related to SDG (A19).

6. Conclusions

The results obtained provide empirical knowledge on scientific production in digital skills and sustainability in the last ten years. The recorded data indicate that it is still very scarce, with a rebound in the last two years. These records can be interpreted due to a very recent interest in this subject, but this may be the beginning of a robust line of research in the near future.

Another finding is the identification of the research methodologies applied in these studies. Quantitative studies predominate (42.1%), followed by mixed methodology studies (26.3%), review studies (21%) and, lastly, those studies of a qualitative nature (10.53%). These data attest to the applied methodological variability, being an indicator of the breadth of methodological perspectives with which the research is currently carried out.

The content analysis of a qualitative nature applied sheds light on the interrelation between two research topics addressed, to date, independently. One of the interesting findings, from our point of view, is the verification of the usefulness and relevance of the DigCompEdu model for the analysis of scientific production on digital competences. This taxonomy confirmed its empirical value and makes it possible to investigate and delve into the manifestation of digital teaching competencies in university education. In this sense, it is found that higher education teachers fundamentally develop digital skills with a pedagogical orientation (68.7%), compared to other options, such as facilitating students' digital competence (17.9%) or their own professional skills (13.4%). Additionally, this model is valid to specify the specific aspects in which the pedagogical competences are manifested. Our analysis detects that (28.4%) of pedagogical competences are linked to the selection, organization and creation of digital resources, and 20.9% are related to the use of digital tools to improve and innovate teaching. There is also evidence of categories related to the training of students for active participation, inclusion and personalization (13.4%). Finally, teaching digital skills are also projected in the area of evaluation (6%). Therefore, we can conclude that the DigCompEdu model is useful and valid for making an analysis of scientific production, allowing a systematization of the findings. These, in turn, are important indicators to understand the evolution of the applications of teaching digital skills in university education. In this sense, this work provides an overview of the subject from 2011 to the present. Subsequent review studies will indicate their evolution and direction. At the present time, we can conclude that the focus is on a didactic instrumental use, but the opening toward broader uses is observed, which implies a more evolved concretion of university learning.

This study also detects areas of educational sustainability that are associated with the classic concept of sustainability, such as quality and inclusion. However, inductive analysis has allowed us to extract other dimensions that may be useful to monitor sustainable practices in the university environment, such as universal literacy, responsible action and sustainability as a purpose.

In summary, the main contributions of this study are specified in being able to know the state of research on teaching digital competence in the university environment linked to sustainability, carried out at an international level and with quality criteria, as well as being able to know the trajectory and evolution of these studies in recent years. The qualitative inquiry, based on the analysis of inductive content, has made it possible to determine the nature of the digital competences that are manifested in university practice, as well as the suitability of the DigCompEdu model for its investigation. Similarly, another relevant contribution is how these are related to sustainability through areas such as educational quality and inclusion.

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Conflicts of Interest: This article is submitted for the Special Issue "Digital Teaching Competences for Sustainable Development", of which two authors of this work are invited editors: Pilar Colás-Bravo and Jesús Conde-Jiménez. Therefore, it is understood that the revision process has to go through other processes. The MDPI editor Cassie.Hu (cassie.hu@mdpi.com) is in charge of coordinating this special issue with us. We mentioned to her that we were going to send this article, which also has no cost since we are guest editors of it. We warn so that the appropriate measures are taken.

Appendix A

Table A1. Main characteristics of the publications included in the qualitative synthesis.

Study 1. Code: A1		
Author (Year)	**Sample**	**Method**
Barth and Burandt (2013)	Teachers and students	Qualitative (Case study)
Study 2. Code: A2		
Author (Year)	**Sample**	**Method**
Altomonte et al. (2016)	University staff and students	Quantitative (Survey)

Table A1. *Cont.*

Study 3. Code: A3		
Author (Year)	**Sample**	**Method**
Salmerón-Manzano and Manzano-Agugliaro (2018)	Not applicable	Bibliometric Analysis
Study 4. Code: A4		
Author (Year)	**Sample**	**Method**
Daniela et al. (2018)	PAS, Teachers and students	Quantitative (Survey)
Study 5. Code: A5		
Author (Year)	**Sample**	**Method**
Alonso-García et al. (2019)	Not applicable	Systematic review (Prisma-P)
Study 6. Code: A6		
Author (Year)	**Sample**	**Method**
Bucea-Manea-Ţoniş et al. (2020)	Students	Quantitative (Online Survey)
Study 7. Code: A7		
Author (Year)	**Sample**	**Method**
Mian et al. (2020)	University employees and students (or stakeholders)	Quantitative (Survey)
Study 8. Code: A8		
Author (Year)	**Sample**	**Method**
Mâță, Clipa and Tzafilkou (2020)	Teachers	Quantitative (Survey)
Study 9. Code: A9		
Author (Year)	**Sample**	**Method**
Gómez-Galán et al. (2020)	Students	Quantitative (Poll)
Study 10. Code: A10		
Author (Year)	**Sample**	**Method**
González-Zamar et al. (2020)	Not applicable	Bibliometric Analysis
Study 11. Code: A11		
Author (Year)	**Sample**	**Method**
Pilotti and Ghazo (2020)	Female Students	Mixed (Questions and task analysis)
Study 12. Code: A12		
Author (Year)	**Sample**	**Method**
Sá and Serpa (2020)	Not applicable	Qualitative (Content Analysis)
Study 13. Code: A13		
Author (Year)	**Sample**	**Method**
Abad-Segura et al. (2020)	Not applicable	Bibliometric Analysis
Study 14. Code: A14		
Author (Year)	**Sample**	**Method**
Orozco-Mesana, Martínez-Rubio and Gonzálvez-Pons (2020)	Teachers and students	Mixed (Survey and debate)

Table A1. *Cont.*

Study 15. Code: A15		
Author (Year)	**Sample**	**Method**
Martín-García, López-Martín and Arguedas-Sanz (2020)	Students	Quantitative (Poll)
Study 16. Code: A16		
Author (Year)	**Sample**	**Method**
Bertheussen (2020)	Students	Mixed (Survey and in-depth Interview)
Study 17. Code: A17		
Author (Year)	**Sample**	**Method**
Mahmud, Husnin and Soh (2020)	Students	Mixed (Survey, Focus Group and Written Reflections)
Study 18. Code: A18		
Author (Year)	**Sample**	**Method**
Castro and Zermeño (2020)	Students	Mixed (Case study)
Study 19. Code: A19		
Author (Year)	**Sample**	**Method**
Hosman, Zermeño and Alemán-de-la-Garza (2020)	Directors and teachers	Quantitative (Case Study)

The codes assigned in this table are used throughout this article to refer to the articles included in the systematic review with synthetic and generic value, to provide greater fluency and clarity to the text. Source: Authors.

Appendix B

Next, this appendix contains the references of the articles reviewed according to APA:

A1: Barth, M., and Burandt, S. (2013). Adding the "e-" to Learning for Sustainable Development: Challenges and Innovation. *Sustainability*, *5*(6), 2609–2622. https://doi.org/10.3390/su5062609

A2: Altomonte, S., Logan, B., Feisst, M., Rutherford, P., and Wilson, R. (2016). Interactive and situated learning in education for sustainability. *International Journal of Sustainability in Higher Education*, *17*(3), 417–443. https://doi.org/10.1108/IJSHE-01-2015-0003

A3: Salmerón-Manzano, E., and Manzano-Agugliaro, F. (2018). The higher education sustainability through virtual laboratories: The Spanish University as case of study. *Sustainability*, *10*(11). https://doi.org/10.3390/su10114040

A4: Daniela, L., Visvizi, A., Gutiérrez-Braojos, C., and Lytras, M. (2018). Sustainable higher education and Technology-Enhanced Learning (TEL). *Sustainability, 10*(11). https://doi.org/10.3390/su10113883

A5: Alonso-García, S., Aznar-Díaz, I., Cáceres-Reche, M., Trujillo-Torres, J., and Romero-Rodríguez, J. (2019). Systematic Review of Good Teaching Practices with ICT in Spanish Higher Education Trends and Challenges for Sustainability. *Sustainability*, *11*(24). https://doi.org/10.3390/su11247150

A6: Bucea-Manea-Ţoniş, R., Simion, V., Ilic, D., Braicu, C., and Manea, N. (2020). Sustainability in higher education: The relationship between work-life balance and XR e-learning facilities. *Sustainability, 12*(14). https://doi.org/10.3390/su12145872

A7: Mian, S., Salah, B., Ameen, W., Moiduddin, K., and Alkhalefah, H. (2020). Adapting universities for sustainability education in industry 4.0: Channel of challenges and opportunities. *Sustainability*, *12*(15). https://doi.org/10.3390/su12156100

A8: Mâţă, L., Clipa, O., and Tzafilkou, K. (2020). The development and validation of a scale to measure university teachers' attitude towards ethical use of information technology for a sustainable education. *Sustainability (Switzerland)*, *12*(15). https://doi.org/10.3390/SU12156268

A9: Gómez-Galán, J., Martínez-López, J. A., Lázaro-Pérez, C., and Sánchez-Serrano, J. (2020). Social networks consumption and addiction in college students during the COVID-19 pandemic: Educational approach to responsible use. *Sustainability*, *12*(18). https://doi.org/10.3390/su12187737

A10: González-Zamar, M., Abad-Segura, E., López-Meneses, E., and Gómez-Galán, J. (2020). Managing ICT for sustainable education: Research analysis in the context of higher education. *Sustainability*, *12*(19). https://doi.org/10.3390/su12198254

A11: Pilotti, M., and Ghazo, R. (2020). Sustainable education starts in the classroom. *Sustainability*, *12*(22), 1–13. https://doi.org/10.3390/su12229573

A12: Sá, M. J., and Serpa, S. (2020). The COVID-19 pandemic as an opportunity to foster the sustainable development of teaching in higher education. *Sustainability*, *12*(20), 1–16. https://doi.org/10.3390/su12208525

A13: Abad-Segura, E., González-Zamar, M.., Luque-de la Rosa, A., and Cevallos, M. (2020). Sustainability of educational technologies: An approach to augmented reality research. *Sustainability*, *12*(10). https://doi.org/10.3390/su12104091

A14: Orozco-Messana, J., Martínez-Rubio, J., and Gonzálvez-Pons, A. (2020). Sustainable higher education development through technology enhanced learning. *Sustainability*, *12*(9). https://doi.org/10.3390/SU12093600

A15: Martín-García, R., López-Martín, C., and Arguedas-Sanz, R. (2020). Collaborative learning communities for sustainable employment through visual tools. *Sustainability*, *12*(6). https://doi.org/10.3390/su12062569

A16: Bertheussen, B. A. (2020). Growth strategy of a rural business school: Sustainable implementation of online studies. *Sustainability*, *12*(13). https://doi.org/10.3390/su12135270

A17: Mahmud, S., Husnin, H., and Soh, T. (2020). Teaching presence in online gamified education for sustainability learning. *Sustainability*, *12*(9). https://doi.org/10.3390/su12093801

A18: Castro, M., and Zermeño, M. (2020). Challenge based learning: Innovative pedagogy for sustainability through e-learning in higher education. *Sustainability*, *12*(10). https://doi.org/10.3390/SU12104063

A19: Hosman, L., Zermeño, M., and de la Garza, L. (2020). SolarSPELL assessment: Impact of a solar-powered digital library as a teaching-learning resource on climate change. *Sustainability*, *12*(16). https://doi.org/10.3390/su12166636

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