

Article

The Learning of E-Sustainability Competences: A Comparative Study between Future Early Childhood and Primary School Teachers

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Abstract: Digital technologies play a key role in the fulfilment of the 2030 Agenda. However, their contribution to this goal depends on the digital culture of society. In this context, future teachers' knowledge of e-sustainability is of paramount importance, as the responsible and sustainable behaviour of future generations largely depends on their skills in this area. Therefore, this study aimed to identify the existence of possible differences in digital competences in sustainability among trainee teachers. The study involved the participation of 348 students in the 2nd year of their Bachelor's Degrees in Early Childhood and Primary Education at the University of Alicante (Alicante, Spain), who filled out a questionnaire on this topic. The SPSS v. 25 statistical programme, with which a comparative analysis was carried out, was used to process the data. On the basis of the results, the students of the Bachelor's Degree in Early Childhood Education generally presented a higher level of e-sustainable competences, especially with regard to general competences and the economic dimension of digital sustainability. Despite this, and given the small size of the differences, we conclude that there is a need to design didactic proposals to favour the acquisition of these competences among future teachers at both stages.

Keywords: digital competences; sustainability; initial teacher training; early childhood education; primary education



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1. Introduction

The inequalities and imbalances that have affected the planet over the last few decades have created an urgent need for effective measures to combat their devastating effects [1]. As a result, and in an attempt to achieve well-being and prosperity for the whole of humanity, in 2015 the United Nations (UN) proposed the 2030 Agenda, a roadmap for progress towards a fairer and equal world [2]. With this framework for action and the 17 Sustainable Development Goals (SDGs) that comprise it, most of the world's countries committed, among other aspects, to eradicate extreme poverty (SDG 1), achieve quality education (SDG 4), and eliminate all forms of discrimination (SDG 5) by 2030. However, more than five years after this declaration, it must be acknowledged that progress in this direction has been rather timid and scarce and that, therefore, this ambitious horizon seems increasingly distant and diffuse [3].

Faced with this situation, and given the threat that COVID-19 has posed to the achievement of the 2030 Agenda [4,5], the UN has recently urged the international community as a whole to accelerate its efforts to put an end to the major problems affecting humanity [6]. Thus, 2020 marked the start of the 'Decade of Action', an opportunity *in extremis* to address the major challenges facing our society and to promote equity, justice and prosperity. Undoubtedly, in this race, Education for Sustainable Development (ESD) becomes one of the most effective means to promote the acquisition of attitudes, behaviours, and values that are respectful and environmentally friendly [7–10]. In fact, as evidenced by the recent study

by Sánchez-Carracedo et al. [11], its implementation with Educational Science students is especially beneficial to increase their capacity for critical thinking, sustainable use of resources, participation in social transformation processes, and ethical principles. This learning is also greatly enriched when active methodologies are used in the process [12–15].

In this context, Information and Communication Technologies (ICTs) represent a particularly significant tool to favour socioeconomic progress, but also to contribute to the learning of sustainability [16,17]. In fact, several literature reviews in recent years have echoed its extraordinary potential in this field [18–20]. Thus, its remarkable value has been shown, among other aspects, to promote the development of environmental awareness [21] or to undertake actions to mitigate climate change [22]. It is no less true, however, that its excessive and disproportionate use can be harmful to the economic, social, and environmental balance of the planet. First of all, the manufacturing processes associated with ICT often lead to serious problems of pollution and the depletion of natural resources, as well as new forms of slavery [23,24]. Moreover, the impact of the digital divide is particularly damaging for the most vulnerable groups, who experience serious difficulties in accessing the possibilities offered by technological devices [25–28]. Hence, digital competences training in sustainability has become a key element for the achievement of the 2030 Agenda [29]. According to Sánchez et al. [30], this type of skill is specifically related to four domains (Figure 1): (1) the critical contextualisation of knowledge and its link to social, economic, and environmental problems; (2) the sustainable use of technological resources and the prevention of their negative social, environmental and economic effects; (3) participation in collaborative processes that favour digital sustainability; and (4) the use of ethical principles related to personal and professional behaviour.

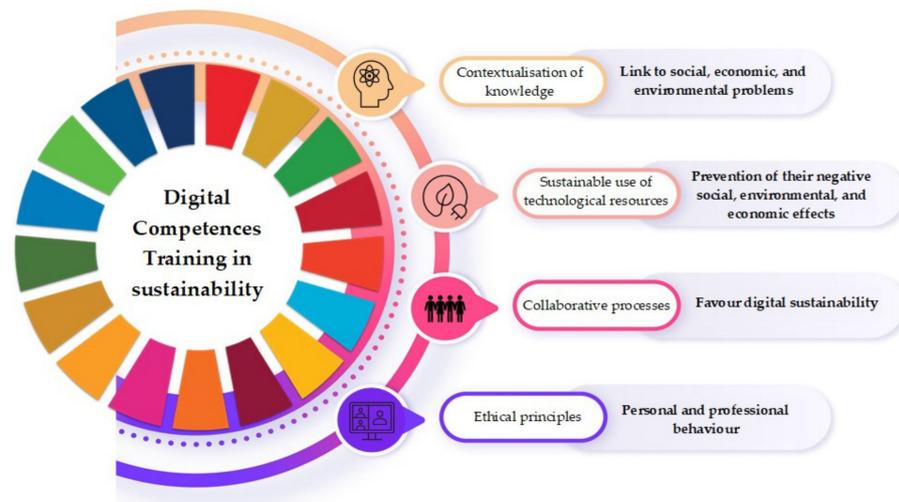


Figure 1. Areas of training in digital competencies in sustainability. Based on Sánchez et al. [30].

With regard to future teachers, these competences acquire even more relevance, since the behaviour of future generations is largely mediated by teacher training in this area [31,32]. In fact, Dziminska et al. [33] and Zamora-Polo and Sánchez-Martín [34] underline the important role that Higher Education institutions have to play in this field. Despite this, several studies emphasise the weak integration of sustainability in university curricula [11,35,36]. For example, in the analysis carried out by Muñoz-Rodríguez et al. [37] of students of Education Sciences in Spain, it was possible to verify the deficiencies in the curricular treatment of sustainability. Even the students themselves recognise their lack of knowledge and admit that they do not feel qualified to incorporate this approach in their future professional performance [38,39].

This shortage of training seems to be most pronounced in relation to the acquisition and development of digital competences. In fact, several studies highlight the limited training of future teachers in this area [40–43]. According to Gewerc and Montero [44], the

profile of use is rather of an instrumental and informational nature, without reaching the skills necessary for the production of authentic knowledge. This low level of proficiency has been observed especially in future teachers of Early Childhood and Primary Education who, in both cases, seem to have a low level of digital competences [45]. However, the most worrying aspect is that this lack of technological skills remains virtually unchanged throughout their initial training. That is, both at the beginning and at the end of their undergraduate studies, their knowledge of digital content creation and problem-solving is very limited [46]. This situation is also particularly evident with regard to the use of emerging technologies [47].

On the other hand, if a comparative perspective is adopted and the degree of digital proficiency among future Early Childhood and Primary School teachers is analysed, it seems to be the latter who define themselves as more competent in ICT [48]. At the same time, it is also this group who show a higher level of awareness and individual responsibility for sustainability. As research by Estrada-Vidal et al. [49] has shown, trainee teachers at this stage understand that individuals, as integral members of institutions, should be the architects of transformation and social change, while their Early Childhood counterparts prefer effort and collective work. Despite this, and as Marcos-Merino et al. [50] rightly point out, it is necessary to optimise training in sustainability for Primary Education students, as their knowledge of the economic and environmental dimensions of sustainability is very limited.

Some of the strategies that are currently implemented for this purpose undoubtedly make use of the potential of digital tools. Thus, for example, the use of the e-portfolio is a particularly useful resource for learning about sustainability, as it promotes participation, awareness, and critical reflection [51]. Other experiences are based, instead, on the possibilities offered by emerging technologies, such as robotics. In fact, holistic training in this type of methodology helps future teachers to acquire the skills necessary for the design of interdisciplinary sustainability projects, while improving their digital competences [52].

Within this framework of considerations, and considering the close relationship between knowledge, attitudes and sustainable behaviours [50], this study aimed to identify possible differences in the learning of e-sustainability competences among future Early Childhood and Primary School teachers. The recognition of such discrepancies allows the design of didactic proposals that are better adjusted and more in line with the real needs of trainee teachers. Moreover, the identification of these divergences will contribute to the sustainability of the curricula of future teachers and, therefore, to the strengthening of the role that Higher Education institutions must play in this area.

2. Materials and Methods

The appropriateness of quantitative methodology for the study of teachers' professional development in terms of sustainability meant that the research was designed with a quantitative approach [53]. Specifically, a comparative analysis was carried out [54].

2.1. Sample

Of the 690 students of Bachelor's Degrees in Early Childhood Education (BDECE) and Primary Education (BDPE) at the Faculty of Education of the University of Alicante (UA) enrolled in the subject of Curriculum Development and Digital Classrooms (CDDC), 348 participated (50.43% of the total population). Of these, 66.6% belonged to the BDPE and 73.5% were women, which is consistent with the feminization of this area of knowledge [55]. At the time of the data collection, 46.4% were 20–25 years of age and 45.1% were under 20 years of age. Only a small group of participants were over 25 years of age (8.6%).

According to the curricula of both degrees, CDDC is a core subject of 6 ECTS (0.6 theoretical credits, 1.80 practical credits and 3.60 distance-base hours) that is taken in the second year. It seeks to provide future teachers of Early Childhood and Primary Education with the knowledge and skills necessary to facilitate the didactic integration of technology in the classroom. It consolidates and expands students' instrumental knowledge, encour-

ages their reflection on the educational integration of ICT, and promotes their continuing education in this area.

2.2. Instrument

An adaptation of the questionnaire by Sánchez et al. [56] was used to collect the data. The objective of this instrument was to assess digital competences in sustainability in ICT engineering degrees. As a result, and with the aim of adapting the questionnaire to the pedagogical field, 9 of the 34 items it contained were eliminated. Specifically, those items most closely related to the management of technological projects (items 10 and 21–28) were removed.

Thus, the final instrument consisted of 25 Likert-type items, whose scale ranged from 1 (“Strongly disagree”) to 5 (“Strongly agree”). Three closed questions were added to these to collect information on gender, age, and degree studied. The final version of the questionnaire was structured in five dimensions: (1) Sociodemographic information (three items); (2) general competences in e-sustainability (ten items); (3) digital competences in environmental sustainability (five items); (4) digital competences in social sustainability (four items) and (5) digital competences in economic sustainability (six items). The final instrument was validated by a team of judges, consisting of three female expert professors in educational research at the UA. They were invited to revise the questionnaire due to: (1) their extensive career and recognition in the field of quantitative analysis and teacher training; and (2) the ease of accessing them, given that they are researchers from the same center as the authors of the study. We created an online survey with the items of the instrument using Google Forms and sent it to the professors via email. The aim was for the professors to assess the relevance of the items for each of the dimensions and for the instrument as a whole. The following criteria were used as indicators: (1) not at all relevant (the item could be eliminated without affecting the measurement), (2) useful (the item had relevance, but was not essential) and (3) essential (the item should be included). In addition, they were given the option of making a qualitative assessment of the syntax and clarity of the wording of each item. Based on their expert judgment, some grammatical issues had to be modified. This, together with the high internal consistency score presented by the instrument through the calculation of Cronbach’s alpha ($\alpha = 0.91$), motivated its use in the study.

In order to facilitate its dissemination, the questionnaire was developed in a digital format using Google Forms. The choice of this application was justified by the multiple features it offers, such as automatic data storage, its free nature, and the unlimited number of responses it allows [57].

2.3. Procedure

In order to obtain the required authorisation, the female lecturer who coordinates the CDDC teaching in the Faculty of Education of the UA was contacted. Subsequently, six CDDC professors administered the questionnaire to their respective groups of students. This application was carried out through the virtual campus of the UA at the beginning of the unit. The participating students completed the instrument during normal class hours, individually and with the virtual presence of one of the members of the research group. The latter was responsible for informing them about the aim of the study and providing the necessary instructions for filling in the questionnaire. The response time was approximately 20 min. The procedure followed was the same for both sample groups (BDECE and BDPE).

With regard to the ethics of the research, the study complied with the basic principles of the Declaration of Helsinki. The voluntary nature of participation and the anonymity and confidentiality of the information provided were guaranteed at all times.

SPSS Statistics 25 software was used for data processing and analysis, through which a comparative study was carried out. For this purpose, the non-parametric Mann–Whitney *U* test was applied. The choice of this technique was motivated, above all, by the lack of normality in the responses and the ordinal level of measurement of the data of the

study variables (items). The normality of the distribution was evaluated by means of the Kolmogorov–Smirnov test ($p < 0.05$). In addition, the Mann–Whitney U technique facilitates the understanding of the association between a nominal dichotomous variable and another ordinal variable with numerical reading (1–5). Its use made it possible to test the hypothesis of the equality of mean ranks in the different item ratings according to the degree studied. Likewise, in order to distinguish the effect size, the R-index was calculated. According to this, a score between 0.10 and 0.29 indicated a small effect; between 0.30 and 0.49 indicated a medium effect; between 0.50 and 0.69 indicated a large effect; and ≥ 0.70 indicated a very large effect [58].

3. Results

The findings are presented according to the integral dimensions of the data collection instrument.

3.1. The Learning of General Competences for E-Sustainability According to the Degree Studied

In relation to general e-sustainability competences, statistically significant differences were observed between some items on the scale (Table 1). In all cases, the BDECE students obtained higher mean ranks than the BDPE students, which means that BDECE students have a higher degree of mastery of the skills and abilities related to this area. Specifically, male and female BDECE students have a deeper knowledge of the social, economic and environmental problems caused by ICTs, as well as a greater mastery of the concepts of creativity and innovation and their associated techniques. In addition, they are also more capable of suggesting ideas to make a project sustainable, considering the environmental, economic, and social dimension of sustainability and its ethical principles. Nevertheless, it should be noted that in all cases the effect size of the differences was small.

Table 1. General competences in e-sustainability according to the degree studied.

Items	Degree	Mean Rank	U	p	z	r
1. I know the causes, consequences and solutions proposed in the literature regarding the social, economic and environmental problems generated by ICTs	BDECE	197.37	10,687.5	0.001	−3.30	−0.17
	BDPE	162.27				
2. In solving an ICT-related problem, I can analyze sustainability from an environmental, social and economic perspective	BDECE	187.25	11,861.5	0.060	−1.87	-
	BDPE	167.35				
3. I am able to identify the causes of an ICT-related problem and foresee its possible consequences. I can relate the problem to other known problems and solutions already applied	BDECE	180.64	12,628.0	0.318	−0.998	-
	BDPE	170.67				
4. I know the concepts of creativity and innovation and strategies to develop them	BDECE	198.02	10,612.0	<0.001	−3.70	−0.19
	BDPE	161.94				
5. I understand innovation and idea generation techniques and participate when they are used	BDECE	194.51	11,018.5	0.002	−3.08	−0.16
	BDPE	163.70				
6. I am able to bring new ideas and solutions to a technological project to make it more sustainable	BDECE	191.29	11,392.0	0.014	−2.46	−0.13
	BDPE	165.32				
7. I am able to propose sustainable ICT projects, taking into account, in a holistic way, environmental, economic and social aspects	BDECE	200.88	10,279.5	<0.001	−3.77	−0.20
	BDPE	160.50				
8. I know the ethical principles related to sustainability	BDECE	185.61	12,051.0	0.102	−1.63	-
	BDPE	168.17				
9. I can assess the implications of ethical principles related to sustainability in an ICT project	BDECE	186.70	11,925.0	0.071	−1.80	-
	BDPE	167.62				
10. I am able to propose solutions and strategies to promote ICT projects consistent with ethical principles related to sustainability	BDECE	192.58	11,242.5	0.008	−2.65	−0.14
	BDPE	164.67				

3.2. The Learning of Digital Competences in Environmental Sustainability According to the Degree Studied

When it came to assessing their digital competences in environmental matters (Table 2), it was again the BDECE students who claimed to have a greater knowledge of sustainable

technologies applicable to ICT projects and the role that this type of tool plays in the sustainability of the planet. However, the magnitude of these differences was also small.

Table 2. Competences in the environmental dimension of e-sustainability according to the degree studied.

Items	Degree	Mean Rank	U	p	z	r
1. I understand the environmental costs of ICT-related products throughout their life cycle	BDECE	183.62	12,282.0	0.181	−1.33	-
	BDPE	169.17				
2. I know how to measure the environmental impact of ICT use with the appropriate indicators	BDECE	187.31	11,854.5	0.063	−1.86	-
	BDPE	167.32				
3. I can assess the impact (positive and negative) of ICT products and services on society and on the sustainability of the planet	BDECE	185.09	12,111.0	0.101	−1.63	-
	BDPE	168.43				
4. I know the “sustainable” technologies applicable to an ICT project and the environmental impact indicators	BDECE	197.64	10,656.0	0.001	−3.29	−0.17
	BDPE	162.13				
5. I know the strategic role of ICTs in the sustainability of the planet, as well as the concepts of social justice, reuse of resources and circular economy	BDECE	196.21	10,822.0	0.002	−3.14	−0.16
	BDPE	162.85				

3.3. The Learning of Digital Competences in Social Sustainability According to the Degree Studied

With regard to social e-sustainability, once again the BDECE students obtained the highest mean ranks (Table 3). Specifically, they showed a greater ability to value the contribution of ICT projects to the improvement of society. Again, the effect size was small.

Table 3. Competences in the social dimension of e-sustainability according to the degree studied.

Items	Degree	Mean Rank	U	p	z	r
1. I know the issues related to social justice, equity, diversity and transparency	BDECE	181.61	12,515.0	0.276	−1.08	-
	BDPE	170.18				
2. I know the direct and indirect consequences of ICT products and services on society	BDECE	182.16	12,452.0	0.218	−1.23	-
	BDPE	169.90				
3. I understand the need to introduce social justice, equity, diversity and transparency in ICT projects	BDECE	181.25	12,557.5	0.292	−1.05	-
	BDPE	170.36				
4. I can assess whether an ICT project contributes to improving the common good of society	BDECE	191.44	11,375.5	0.007	−2.70	−0.14
	BDPE	165.24				

3.4. The Learning of Digital Competences in Economic Sustainability According to the Degree Studied

With regard to digital competences in economic sustainability, statistically significant differences were observed between the participants from both degrees (Table 4). Once again, the BDECE students reported a higher level knowledge about accessibility, ergonomics, and security issues in ICT projects, a greater ability to evaluate these features in an ICT product, and a greater consideration of these aspects in technological solutions. Similarly, it was once again the male and female students of this degree who claimed to have a deeper knowledge of technological tools for collaborative work and greater expertise in their use.

Table 4. Competences in the economic dimension of e-sustainability according to the degree studied.

Items	Degree	Mean Rank	U	p	z	r
1. I know the issues related to accessibility, ergonomics and safety of ICT products and projects	BDECE	183.62	12,282.0	0.181	−1.33	-
	BDPE	169.17				
2. I can assess the degree of accessibility, ergonomic quality, safety level and societal impact of an ICT product or service	BDECE	187.31	11,854.5	0.063	−1.86	-
	BDPE	167.32				
3. I take into account accessibility, ergonomics and safety aspects in technological solutions	BDECE	185.09	12,111.0	0.101	−1.63	-
	BDPE	168.43				
4. I know the concept, examples and tools of collaborative work in the field of ICTs	BDECE	197.64	10,656.0	0.001	−3.29	−0.17
	BDPE	162.13				
5. I can assess the implications of collaborative work in an ICT project	BDECE	196.21	10,822.0	0.002	−3.14	−0.16
	BDPE	162.85				
6. I know how to use collaborative work tools related to ICT projects	BDECE	193.09	11,184.0	0.003	−2.92	−0.15
	BDPE	164.42				

4. Discussion

Fulfilling the 2030 Agenda necessarily requires the improvement of digital competences across society. In this scenario, the training of future teachers becomes a fundamental element, since the attitudes and behaviours of subsequent generations are, to a large extent, dependent on their knowledge of the sustainable use of technology [31,32]. Based on this premise, the aim of this study was to identify the existence of possible differences in the learning of digital competences in sustainability among future Early Childhood and Primary School teachers. In this sense, and according to the results, it is the former who seem to have a higher degree of e-sustainable skills and abilities. However, the discrepancies were particularly marked in general knowledge, especially with regard to the design of sustainable ICT projects, the capacity for creativity and innovation, and the understanding of the problems generated by technological tools. Nevertheless, these differences were less noticeable in economic, environmental and, in particular, social areas, where there were hardly any differences between the students of both degrees. These findings, however, contradict most of the accumulated research in this area. Thus, in contrast to the study by Briones et al. [48], it was the future Early Childhood Education teachers who claimed to have a higher level of digital competences. On the other hand, and in relation to sustainability, the evidence from the present research also contradicted the results of Estrada-Vidal et al. [49]. In contrast to their study, BDECE students again reported higher proficiency in sustainability.

The possible explanations for these discrepancies are multiple and varied. First of all, the divergences in the configuration of the curricula of both degrees must be considered. Although both pursue the same goal, i.e., to provide students with the knowledge and skills necessary for the exercise of teaching, the peculiarities of each stage entail different subjects, competences and content [59,60]. However, as highlighted by Dziminska et al. [33] and Zamora-Polo and Sánchez-Martín [34], Higher Education institutions, committed to achieving the 2030 Agenda, must make additional efforts to ensure the integration of the SDGs in the syllabuses of all curricula. Only in this way will they fulfil their commitment to society and contribute to building a more supportive and sustainable future [37,39].

Another possible reason for these differences lies in the characteristics of the students in each speciality. In this sense, it is worth highlighting the clear feminisation of BDECE students and the proactive tendency shown by women towards sustainability [9,15,61]. Hence, these variations in results may also be closely related to some gender issues. In addition, the results only reflect the participants' perception of themselves, so that, as in other studies of a similar nature, there could be some divergences from their real level of e-sustainability competences [41]. However, considering the small size of the differences

identified and the lack of training of future teachers in this area, the need to strengthen their knowledge in digital sustainability is highlighted [44–46,49,50].

A possible strategy for this involves the design of training activities that combine the potential of ICT and the reflective, collaborative, and experiential nature of active methodologies [12,15]. Among other actions, and considering the existing evidence, a good alternative could be the use of educational robotics and Project-Based Learning (PBL). Through this type of experience, future teachers will not only have the opportunity to develop their digital competences and acquire knowledge about programming, but will also be able to learn how to develop interdisciplinary projects to work on sustainability and the responsible use of technology [52]. Another valid formula for this objective is training through massive open online courses (MOOCs), which, according to Ortega-Sánchez and Gómez-Trigueros [17], are particularly valid for optimising teacher training in SDGs formation. However, regardless of the methodology used, one of the basic requirements that this type of initiative must meet is the commitment and involvement of responsible teachers, as their example stimulates motivation and the meaningfulness of learning [39].

5. Conclusions

This study presented a comparative analysis of the learning of e-sustainability competences between BDPE and BDECE students. The results obtained show that the latter have a higher level of skills and abilities in all the dimensions assessed. Despite this, and considering the small size of the differences, the need to design teaching activities aimed at strengthening the knowledge of future teachers in this area is suggested. This type of action will be particularly effective in increasing their level of awareness and sensitivity in matters of sustainability and, indirectly, in strengthening society's commitment to the achievement of the 2030 Agenda. It is also expected that the results will contribute to the improvement of the role of universities in this area. As social references, Higher Education institutions must assume their leadership and responsibility in this race towards a more sustainable and supportive future. In this sense, the analysis presented highlights the urgent need to embed, SDGs in the curricula of all degree programmes in an effective and real way, but especially in those that are responsible for promoting the values of equality, justice, and social peace.

Finally, with regard to the limitations of the study, it should be pointed out that it was carried out in the UA, which makes it difficult to generalise the results to other contexts. As a consequence, in future research it is proposed to extend the comparative study to other contexts. On the other hand, the use of a single data collection instrument, which was also based on the subjects' self-assessment, must be mentioned. Hence, we suggest that future studies combine the use of other techniques and tools to triangulate the results and to establish, with a greater degree of precision, the existence of possible differences. This prospective research will, in turn, be used to determine the influence of gender on the identified divergences.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available because they are presented together with other data that will be the subject of future research.

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