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Digital Equity and Sustainability in Higher Education

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Abstract: Digital equity, grounded in principles of equity and the ethics of care, is essential for ensuring quality higher education. It facilitates access, supports sustainability, and promotes inclusive education by addressing the technological dimensions of education. This study explores the relationship between digital equity and sustainability in higher education. A total of 167 students enrolled in initial teacher education programs at the University of Primorska, Faculty of Education, completed a questionnaire featuring the Digital Equity in Higher Education Scale and the Sustainability in Higher Education Scale. To achieve this study's objectives, a principal factor analysis was conducted to validate the scales, and a multiple linear regression was employed to develop a predictive model. The findings revealed that digital equity in higher education comprises five dimensions as follows: (i) access to teachers who support the use of digital technology; (ii) access to digital technology and opportunities for its use; (iii) access to digital resources; (iv) access to culturally relevant software and applications; and (v) access to open-access resources. Sustainability in higher education encompasses two dimensions as follows: (i) collaborative problem solving and (ii) socioemotional aspects of sustainability. These dimensions interact in a complex manner. Key predictors of digital equity and sustainability included access to and use of digital technology, as well as collaborative problem solving. Importantly, this study highlighted the critical role of skilled teachers in facilitating the effective use of digital technology.

Keywords: digitalization; equity; sustainability; student teachers; higher education

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1. Introduction

Promoting the development and enhancement of digital skills among the active population aged 16–74 by 2030 is a key priority for the European Union. Recent analyses indicate that only 59% of the population possesses basic digital skills, with Slovenia performing below the European average [1]. In alignment with the European Union's strategic vision, digital skills and the use of digital technology (DT) are being systematically integrated across all levels of education to address this gap. According to the Eurydice report [2], approximately half of European education systems are currently revising their curricula to incorporate digital competencies [2]. At the Slovenian level, several policy documents address digital equity, both directly and indirectly, by emphasizing the development of digital skills among citizens and the promotion of inclusion. The overarching goal is to ensure digital rights for all and to address socioeconomic inequalities across different segments of society, as outlined in the Digital Slovenia 2030 Strategy [3] and the National Digital Decade Strategic Roadmap [4]. Efforts to enhance digital skills are particularly focused on the education sector. A key priority is to empower teachers and learners by addressing the digital divide, which disproportionately affects disadvantaged groups, such

as individuals with low socioeconomic status (SES) or those from rural backgrounds [5]. A comprehensive study on the digital divide in Slovenia revealed that the gender gap is narrowing. However, socioeconomic disparities continue to significantly influence internet availability and opportunities to develop digital competencies. Although the findings of this study are now somewhat dated, it can be inferred that little has changed in terms of digital competence development, as large-scale initiatives aimed at fostering these skills across various levels of education only began in 2023. As digital competencies—often referred to as transversal skills—are critical for both educational and professional development, ensuring digital equity across all levels of education is essential. Simultaneously, as Resta and Laferrière [6] emphasize, digital equity represents a significant challenge in the pursuit of social justice. Exploring and promoting digital equity within higher education (HE) is also closely linked to ensuring sustainable quality of HE, which emphasizes collaborative approaches and commitment to sustainable knowledge [7].

This paper presents a study that seeks to conceptualize digital equity in relation to the social dimension of sustainability within the context of HE.

1.1. The Principles of Justice and the Ethics of Care Within the Framework of Digital Equity

Digital equity has recently become a central focus in both theoretical discussions and empirical studies examining the structural and procedural conditions of quality assurance in HE [8–11]. The pursuit of digital equity and justice often begins with access to technology. Paulo Freire [12] recognized the significance of technology in education and society at large, advocating for the integration of computers in all schools as a means to promote greater equity [13]. Consequently, digital equity in HE can also be effectively conceptualized using the foundational principles of justice [14] and the ethics of care as a relational process [15], both underpinning the concept of inclusive education. Rawls' [14] theory of justice is in two key principles: the principle of equity and the principle of difference. The first principle asserts that every individual is entitled to the same basic rights and freedoms, including the right to education. The second principle permits deviations from equity when such inequalities address the vulnerabilities of specific groups and enhance their prospects for inclusion and equal opportunities for success. However, an equitable distribution of resources alone does not guarantee equity. Fraser [16] contends that equity must extend beyond the mere distribution of rights and goods, as equal distribution does not inherently ensure equal opportunities for individual development. Access to material resources is insufficient without the knowledge and skills necessary to utilize these resources effectively. Moreover, engaging with the concept of equal opportunities is essential for achieving goals [17] and realizing one's potential or competencies. Equal opportunities should not be understood solely as the ability to achieve goals based on an individual's current choices and abilities. Instead, they must be contextualized, taking into account the limitations of measuring certain factors that contribute to (in)equality of opportunity. For example, socioeconomic status is a reliable and measurable predictor of academic achievement, unlike factors related to luck, which are not as easily quantifiable. In the context of digital equity, while most individuals in the global West own at least one digital device (e.g., phone, computer, laptop), significant disparities persist in opportunities to develop advanced digital skills and access the necessary support to use DT meaningfully. From the perspective of M. Nussbaum [18] (p. 6) and her advocacy of the capability approach, this issue extends beyond the assessment of social and individual well-being based solely on gross domestic income (GDP). Instead, Nussbaum [18] emphasizes the evaluation of environments based on the opportunities they provide individuals to realize their potential. She argues that individuals not only desire to be cared for but also aspire to a future in which they can actively participate in shaping their own lives. In the context of HE and

digital equity, the capability approach underscores the idea that mere access to HE and technology is insufficient. Individuals must also be afforded the right opportunities to develop the knowledge and skills necessary to participate fully and meaningfully in their personal and social lives.

1.2. Digital Equity in Higher Education

The concept of digital equity encompasses a range of practices and attitudes related to the use of DT, of which access to digital tools and technologies represents only one component [16]. This multi-dimensional concept also includes access to high-quality, culturally relevant content, as well as opportunities to develop knowledge and skills for creation, sharing, and exchange. These objectives can also be advanced through the right to access and participate in HE [6]. In this paper, digital equity is conceptualized in alignment with Fraser's [16] perspective, which posits that the mere distribution of goods alone does not guarantee equality.

Resta et al. [6] outline five key aspects of digital equity as follows: (1) access to hardware, software, and the internet; (2) availability of high-quality, meaningful, and culturally relevant content in the local language; (3) opportunities to create, share, and exchange digital resources; (4) access to teachers trained in the effective use of digital tools; and (5) high-quality research on the use of DT to enhance learning experiences. Mere physical access to DT does not ensure digital equity; it is only one of these five dimensions. The quality of access—determined by the meaningful use of DT and the support of teachers in designing learning experiences [19,20]—is of far greater importance. Additionally, learners must be empowered to use DT responsibly, critically, and inquisitively while focusing on educational goals [13]. However, achieving digital equity also requires addressing the digital divide. Scheerder et al. [21] identify three levels of digital divide in relation to internet use, each increasing in complexity. The first level concerns physical internet access; the second pertains to internet skills and usage; and the third relates to the outcomes of (un)critical internet use. Furthermore, according to Soomro et al. [22], the digital divide extends beyond mere physical access to DT, encompassing different perspectives, such as motivational aspects, digital skills, and the actual use of DT for everyday tasks. Neglecting the digital divide can lead to social exclusion [21], particularly when there is insufficient support for the development of skills necessary for the critical and effective use of digital tools.

Understanding the complexity of diversity is important for addressing digital equity in all its dimensions. Individuals considered vulnerable due to their socioeconomic position or status often lack meaningful and high-quality experiences with DT. Research indicates that learners from low socioeconomic status (SES) backgrounds or multilingual environments are less likely to engage with DT innovatively, as they frequently experience limited access to quality learning experiences and insufficient teacher support [23,24]. Moreover, studies suggest that women tend to have lower levels of digital competence [6,25,26]. Therefore, digital (in)equity must be analyzed at three primary levels [19]. The first level concerns the quality of teaching. DT should be meaningfully integrated into the learning process to foster active and collaborative learning rather than merely serving as a tool for content delivery. The second level pertains to access to the internet, hardware, and software, as providing these resources within educational institutions helps mitigate digital inequalities. The third level emphasizes the direct and meaningful use of DT by students for learning purposes [19].

In this context, the Technological Pedagogical Content Knowledge (TPACK) model is particularly relevant, as it provides a framework for teachers to effectively integrate DT into the learning process while considering factors such as students' prior knowledge

and the existing infrastructure [27]. The TPACK model synthesizes three core domains: technological knowledge (understanding and application of DT), pedagogical knowledge (effective teaching methodologies), and content knowledge (subject-specific expertise). The three domains are interdependent and highlight the necessity of comprehensively understanding DT in order to implement effective teaching strategies and enhance subject-specific learning of subject content. Although the TPACK model underscores the direct role of teachers in incorporating DT into the learning process, it also implies that achieving digital equity necessitates digitally competent teachers. However, the effective use of DT for teaching and learning is influenced by university teachers' backgrounds [25–28] and their attitude toward the digitalization of HE [29]. Fernandez-Marquez, Leiva-Olivencia, and Lopez-Meneses [30] suggest that HE teachers often develop their digital competencies independently and may not always recognize their role in fostering students' digital competencies. Generally, DT is employed at a basic level, primarily for the dissemination of materials, information sharing, and communication with students [28–31]. However, HE institutions that prioritize digital competence acknowledge its significance in the learning process, thereby enhancing students' digital skills [31]. Additionally, access to open educational resources supports inclusive education by promoting digital equity [32].

1.3. Digital Equity and Sustainability

The concept of sustainability is multifaceted and often fragmented. The United Nations Educational, Scientific, and Cultural Organization (UNESCO) [33] underscores the economic, environmental, and social dimensions of sustainability. However, this paper specifically addresses the social dimension of sustainability. Within this context, Goal 4 of the Sustainable Development Goals (SDGs) is of paramount importance, as it emphasizes the necessity of inclusive, equitable, and quality education, alongside the promotion of lifelong learning opportunities. The integration of sustainability into education has emerged as a priority for HE institutions [7], and the European Union has actively advocated for its inclusion in curricula [34]. Rosario and Dias [31–35] highlight a strong interconnection between the digital transition and sustainability, particularly when the digitalization of society exacerbates inequalities or creates a digital divide. Consequently, addressing the digital divide contributes to the advancement of social sustainability.

Tripon, Gonța, and Bulgac [7] delineate several priority aspects of the digitalization of HE that enhance the sustainability of relationships and knowledge. These include the following: (1) physical accessibility; (2) a collaborative approach emphasizing student participation; (3) personalization of the learning process to accommodate individual educational needs; (4) sustainability of acquired knowledge and skills; (5) increased efficiency through accelerated knowledge and application; and (6) financial sustainability of digital learning compared to traditional delivery methods.

HE institutions play a pivotal role in the implementation of the United Nations Sustainable Development Goals (SDGs) and in cultivating a mindset that fosters the dissemination of the SDGs in the future [36]. While the benefits of digitalization are evident in enhanced access to technology and immediate opportunities for individual learners in HE, it also contributes to (1) sustainable access to HE, (2) the sustainability of knowledge and sustained interest in education for future generations, and (3) the sustainability of the quality of HE, ensuring equitable opportunities for all students to succeed. The societal dimension of sustainability originates from the experiences and opportunities afforded to current generations in HE, who will leverage their knowledge and resolve to future decisions and influence the choices of subsequent generations.

Based on the findings from the literature review, this study has the following aims:

(1) Determine student teachers' attitudes toward digital equity and sustainability in an HE context.
(2) Identify and validate the dimensions of digital equity in higher education (DEHE) and sustainability in higher education (SHE).
(3) Examine the predictive relationships between the dimensions of digital equity and sustainability, determining whether and how each dimension influences the others.

2. Methods

In this study, a quantitative research design was adopted, utilizing a survey research approach [37]. Additionally, both descriptive and causal non-experimental research methods were employed [38].

2.1. Participants

The target population consisted of undergraduate students enrolled in initial teacher education programs at the University of Primorska, Faculty of Education, Slovenia. A random sampling method was employed for this study, providing all the students in the undereducated study programs at the University of Primorska, Faculty of Education, the opportunity to participate by completing the questionnaire. The final sample comprised 167 students, 63.6% of whom came from professional programs and 36.4% from academic programs. Additionally, 39.0% of the students were from urban areas in Slovenia, while 61.0% came from rural areas. As the sample was obtained using random sampling and represents 25.41% of the target population, it is considered representative of the population. However, not all students responded to all Likert-type items, which may have caused variations in the number of participants across factors due to a partial drop-off in survey completions. To ensure the accuracy and reliability of the data, the analysis was conducted using only complete responses for each dimension.

2.2. Data Collection

For the data collection, a questionnaire specifically designed for this study was utilized, based on the theoretical framework of digital equity and sustainability discussed earlier [6,7]. In addressing the concept of digital equity, five aspects identified by Resta et al. [3] were incorporated. Simultaneously, Tripon, Gonța, and Bulgac's [7] aspects of digital sustainability were used to develop items related to sustainability in the context of digitalization. The final version of the questionnaire consists of two scales as follows: (i) the Digital Equity in Higher Education Scale (DEHEs) and (ii) the Sustainability in Higher Education Scale (SHEs).

DEHEs comprises 21 Likert-type items with five response options ranging from strong disagreement (1) to strong agreement (5) with the statements. Examples of items include the following: "*I know, and I use open access data*", "*The teachers encourage me to use digital technology*", and "*I have access to digital tools*".

SHEs consists of 8 Likert-type items with five response options ranging from strong disagreement (1) to strong agreement (5) with the statements. Examples of items include the following: "*Digital technology promotes more sustainable behaviour towards nature*", "*Digital technology promotes more sustainable behaviour in social relationships*", and "*Digital technology promotes equity in education*".

Both scales were tested for validity and reliability. A principal component analysis was used to test the validity and to extract the factors (subscales) of both scales, and the reliability of the scales and subscales was tested using Cronbach α coefficients.

2.3. Data Processing

The IBM SPSS (version 22.0) statistical software was used to perform all statistical analyses. To test the validity and reliability of both scales (aims 1 and 2), a principal factor analysis and Cronbach's alpha coefficient were conducted. We first performed a principal component analysis (PCA) for the first scale, DEHEs. The Kaiser–Meyer–Olkin test (KMO) yielded a value of 0.846, which exceeds the recommended threshold of 0.6, confirming the sample's adequacy for a factor analysis. Additionally, Bartlett's test of sphericity (χ^2 = 1560.803, df = 210, $p < 0.001$) indicated significant non-identity in the correlation matrix, further supporting the suitability of the data for a factor analysis.

Using Promax rotation with Kaiser Normalization, five factors were extracted (Table 1), which collectively accounted for 65.63% of the total variance.

Table 1. Total initial eigenvalues of DEHEs.

Component	Initial Eigenvalues		
	Total	**% of Variance**	**Cumulative %**
Access to Teachers Supporting DT Use	7.551	35.957	35.957
Access to DT and Usage Opportunities	2.168	10.322	46.279
Access to Digital Resources	1.560	7.428	53.706
Access to Culturally Relevant Software and Applications	1.439	6.850	60.557
Access to Openly Available Resources and Software	1.066	5.078	65.634

Based on the PCA results, we identified five factors (subscales) of the DEHEs. The overall reliability of the scale was excellent (α = 0.917), although the reliability values for individual factors ranged from 0.655 to 0.890. According to Field [39], a reliability value of 0.6 can be considered acceptable in research measuring statements, although caution should be exercised when interpreting values below 0.7.

1. Access to Teachers Supporting Digital Technology Use. This factor comprises 7 items with good reliability (α = 0.890). It reflects the availability of HE teachers who actively support the meaningful and creative use of digital technology.
2. Access to Digital Technology and Usage Opportunities. This factor includes 6 items with good reliability (α = 0.838). It focuses on student teachers' access to hardware and software within the faculty, enabling them to create and publish digital content.
3. Access to Digital Resources. This factor consists of 3 items with good reliability (α = 0.858). It covers freely available study resources, such as e-libraries, relevant websites, and databases for student teachers' use.
4. Access to Culturally Relevant Software and Applications. This factor comprises 2 items with moderate reliability (α = 0.798). It addresses the availability of resources in student teachers' first or native language, where they can express themselves most fluently.
5. Access to Openly Available Resources and Software. This factor consists of 3 items with acceptable reliability (α = 0.655). It reflects student teachers' awareness and active use of openly accessible resources and software.

In addition, we performed PCA for the SHEs. The Kaiser–Meyer–Olkin Test (KMO) yielded a value of 0.855, which exceeds the recommended threshold of 0.6, confirming the adequacy of the sample [40]. Bartlett's test of sphericity (χ^2 = 415.772, df = 28, $p < 0.001$) indicated significant non-identity in the correlation matrix, confirming the suitability of the data for a factor analysis. Using Promax rotation with Kaiser Normalization, two factors were extracted (Table 2), which together explain 61.443% of the total variance.

Table 2. Total initial eigenvalues of SHEs.

Component	Initial Eigenvalues		
	Total	**% of Variance**	**Cumulative %**
Collaborative Problem Solving	3.842	48.030	48.030
Socioenvironmental Aspects of Sustainability	1.073	13.413	61.443

Based on these results, we identified two subscales of the SHEs. The overall reliability of the scale was good ($\alpha = 0.826$).

1. Collaborative Problem Solving: This scale consists of four items with moderate reliability ($\alpha = 0.762$). It reflects the perception of how DT contributes to sustaining relationships and knowledge in educational contexts, as well as the perception of opportunities to develop the ability to understand complex situations.
2. Socioenvironmental Aspects of Sustainability: This subscale comprises four items with moderate reliability ($\alpha = 0.770$). It pertains to the understanding that DT can help ensure care for others and the environment as well as promote greater equity in education.

In addition, descriptive statistics were used to analyze student teachers' attitudes toward DEHEs and the SHEs, along with their respective dimensions. To examine whether and how each of these dimensions predicted the other dimensions, multiple regression analyses were conducted using the stepwise method (aim 3).

3. Results

3.1. Dimensions of Digital Equity in Higher Education

As shown in Table 3, student teachers express the highest degree of agreement regarding the accessibility of culturally relevant software and apps (M = 3.85, SD = 0.85), followed by access to digital resources (M = 3.75, SD = 0.78). Student teachers also highly valued access to teachers who support the use of DT (M = 3.61, SD = 0.67). Their level of agreement was slightly lower but still relatively high for access to DT and opportunities for its use (M = 3.44, SD = 0.79) and access to open-access resources (M = 3.39, SD = 0.67). The results in Table 3 indicate that the five dimensions of digital equity exhibit a negative skewness value, suggesting a left-skewed distribution. Additionally, the kurtosis values for all dimensions were below 3, indicating a light-tailed distribution.

Table 3. Descriptive statistics for dimensions of digital equity.

Dimensions	N	Min	Max	M	SD	Skew	Kurt.
Access to teachers who support the use of DT	158	1.14	5.00	3.61	0.67	−0.397	1.020
Access to DT and opportunities for its use	167	1.50	5.00	3.44	0.79	−0.509	−0.132
Access to digital resources	156	1.67	5.00	3.75	0.78	−0.471	0.045
Access to culturally relevant software and apps	167	1.50	5.00	3.85	0.85	−0.486	−0.237
Access to open-access resources	166	1.33	5.00	3.39	0.67	−0.122	0.291

Legend: N = numerus; M = mean; SD = standard deviation; Skew = skewness; Kurt = kurtosis.

3.2. Access to Teachers Who Support the Use of Digital Technologies

The next analysis aimed to examine the role of different aspects of access and the role of both dimensions of sustainability in predicting access to teachers who support the use of DT. The results of a stepwise multiple linear regression analysis indicated two predictors included in the model. As shown in Table 4, a significant regression equation was obtained

(F (2, 150) = 13.254, $p < 0.001$), with an R^2 of 0.399. The analysis revealed that access to DT and the opportunities for its use (β = 0.505, $p < 0.001$) and collaborative problem solving (β = 0.250, $p < 0.001$) were both positive predictors of access to teachers who support the use of DT.

Table 4. Multiple regression results for access to teachers who support the use of DT.

	B	SE	β	t	*p*
Access to DT and the opportunities for its use	0.482	0.064	0.505	7.548	<0.001
Cooperation for problem solving	0.284	0.076	0.250	3.744	<0.001

Note: constant = 0.831, F (2, 150) = 13.254, $p < 0.001$, $R^2 = 0.399$.

3.3. Access to Digital Technology and Opportunities for Its Use

The next analysis aimed to examine the role of different aspects of access and the role of both dimensions of sustainability in predicting access to DT and opportunities for its use. A stepwise multiple linear regression analysis indicated that five predictors were included in the model. As shown in Table 5, a significant regression equation was obtained (F (5, 147) = 8.119, $p < 0.001$), with an R^2 of 0.558. The analysis revealed that access to digital resources (β = 0.345, $p < 0.001$), access to teachers who support the use of DT (β = 0.357, $p < 0.001$), socioenvironmental aspects of sustainability (β = 0.273, $p < 0.001$), and access to culturally relevant software and apps (β = 0.202, $p < 0.001$) were positive predictors of access to DT and opportunities for its use. In contrast, collaborative problem solving (β = −0.149 $p = 0.038$) was a negative predictor of access to DT and opportunities for its use.

Table 5. Multiple regression results for access to DT and opportunities for its use.

	B	SE	β	t	*p*
Access to digital resources	0.308	0.059	0.345	5.271	<0.001
Access to teachers who support the use of DT	0.374	0.069	0.357	5.427	<0.001
Socioenvironmental aspects of sustainability	0.263	0.067	0.273	3.924	<0.001
Access to culturally relevant software and apps	0.172	0.048	0.202	3.581	<0.001
Cooperation for problem solving	−0.177	0.084	−0.149	−2.097	0.038

Note: constant = 0.118, F (5, 147) = 8.119, $p < 0.001$, $R^2 = 0.558$.

3.4. Access to Digital Resources

In addition, we aimed to examine the role of different aspects of access and the role of both dimensions of sustainability in predicting access to digital resources. The results of a stepwise multiple linear regression analysis indicated that three predictors were included in the model (Table 6). A significant regression equation was obtained (F (3, 149) = 12.504, $p < 0.001$), with an R^2 of 0.412. The analysis revealed that access to DT and opportunities for its use (β = 0.514, $p < 0.001$), collaborative problem solving (β = 0.171, $p < 0.001$), and access to open resources (β = 0.139, $p = 0.034$) were all positive predictors of access to digital resources.

3.5. Access to Culturally Relevant Software and Apps

We also aimed to examine the role of different aspects of access and the role of both dimensions of sustainability in predicting access to culturally relevant software and apps. The multiple linear regression, using the stepwise method, identified a single significant predictor (Table 7). The regression model was significant (F (1, 151) = 114.751, $p < 0.001$),

with an R^2 of 0.089. The results indicated that only access to DT and opportunities for its use (β = 0.298, $p < 0.001$) significantly predicted access to culturally relevant software and apps.

Table 6. Multiple regression results for access to digital resources.

	B	SE	β	t	*p*
Access to DT and opportunities for its use	0.575	0.076	0.514	7.590	<0.001
Cooperation for problem solving	0.227	0.089	0.171	2.561	0.011
Access to open resources	0.164	0.077	0.139	2.141	0.034

Note: constant = 0.274, F (3, 149) = 12.504, $p < 0.001$, $R^2 = 0.412$.

Table 7. Multiple regression results for access to culturally relevant software and apps.

	B	SE	β	t	*p*
Access to DT and opportunities for its use	0.350	0.091	0.298	3.841	<0.001

Note: constant = 2.656, F (1, 151) = 14.751, $p < 0.001$, $R^2 = 0.089$.

3.6. Access to Open-Access Resources

Finally, we examined the role of different aspects of access and the role of both dimensions of sustainability in predicting access to open-access resources. A multiple linear regression, using the stepwise method, identified a single significant predictor (Table 8). The regression model was significant (F (1, 151) = 14.075, $p < 0.001$), with an R^2 of 0.085. The results indicated that only access to digital resources (β = 0.298, $p < 0.001$) significantly predicted access to open-access resources.

Table 8. Multiple regression results for access to open-access resources.

	B	SE	β	t	*p*
Access to digital resources	0.248	0.066	0.292	3.752	<0.001

Note: constant = 2.471, F (1, 151) = 14.075, $p < 0.001$, $R^2 = 0.085$.

3.7. Dimensions of Sustainability in Higher Education

As shown in Table 9, student teachers on average mostly agree (M = 3.79, SD = 0.59) with the importance of collaboration for problem solving as well as with the importance of implementing the socioenvironmental aspects of sustainability (M = 3.53, SD = 0.72).

Table 9. Descriptive statistics for dimensions of sustainability.

Dimensions	N	Min	Max	M	SD	Skew.	Kurt.
Collaborative problem solving	158	2.00	5.00	3.79	0.59	−0.304	0.329
Socioenvironmental aspects of sustainability	158	1.00	5.00	3.53	0.72	−0.543	0.777

Legend: N = numerus; M = mean; SD = standard deviation; Skew = skewness; Kurt = kurtosis.

3.8. Collaborative Problem Solving

We proceeded with the analysis of the role of various dimensions of access and the influence of socioenvironmental aspects of sustainability in predicting collaborative problem solving. Using a multiple linear regression with the stepwise method, three predictors were included in the model (Table 10). A significant regression equation was identified (F (3, 149) = 32.810, $p < 0.001$), with an R^2 of 0.398. The analysis revealed that the socioenvironmental aspects of sustainability (β = 0.482, $p < 0.001$), access to teachers who

support the use of DT (β = 0.221, p = 0.002), and access to culturally relevant software and apps (β = 0.136, p = 0.035) were positive predictors of collaborative problem solving.

Table 10. Multiple regression results for collaborative problem solving.

	B	SE	β	t	p
Socioenvironmental aspects of sustainability	0.392	0.056	0.482	7.040	<0.001
Access to teachers, who support the use of DT	0.195	0.060	0.221	3.222	0.002
Access to culturally relevant software and apps	0.098	0.046	0.136	2.124	0.035

Note: constant = 1.336, F (3, 149) = 32.810, p < 0.001, R^2 = 0.398.

3.9. Socioenvironmental Aspects of Sustainability

The subsequent analysis aimed to examine the role of different dimensions of access and the influence of cooperation for problem solving in predicting the socioenvironmental aspects of sustainability. The results of a multiple linear regression, using the stepwise method, indicated that two predictors were included in the model (Table 11). A significant regression equation was identified (F (2, 150) = 16.529, p < 0.001), with an R^2 of 0.423. The analysis revealed that collaborative problem solving (β = 0.473, p < 0.001) and access to DT and opportunities for its use (β = 0.319, p < 0.001) were both positive predictors of socioenvironmental aspects of sustainability.

Table 11. Multiple regression results for socioenvironmental aspects of sustainability.

	B	SE	β	t	p
Cooperation for problem solving	0.582	0.081	0.473	7.220	<0.001
Access to DT and opportunities for its use	0.330	0.068	0.319	4.864	<0.001

Note: constant = 0.138, F (2, 150) = 16.529, p < 0.001, R^2 = 0.423.

The multiple regression analysis (Figure 1) reveals a complex network of interactions between the dimensions of DEHEs and SHEs. Access to and use of DT significantly predicted four dimensions: three from DEHEs and one from SHEs. Similarly, collaborative problem solving predicted one dimension of SHEs and three dimensions of DEHEs, though it had a negative impact on access to and use of DT. Despite these interactions, the dimensions of access to teachers who support the use of DT emerged as a primary influence, affecting both access to and use of DT and collaborative problem solving.

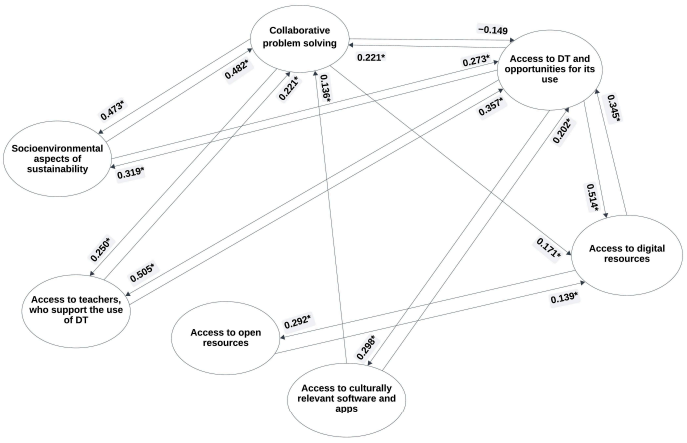

Figure 1. Model illustrating the relationships between the dimensions of DEHEs and SHEs. * denotes variables that are statistically significant in the model.

4. Discussion

The results of this study provide insights into student teachers' attitudes toward digital equity and sustainability in HE. Firstly, the dimensions of digital equity and sustainability were identified. DEHE comprises five main dimensions, with student teachers emphasizing the importance of access to digital tools in their native language. This is often a challenge in the Slovenian context, as many applications are not available in the official languages. In contrast, the SHE comprises two dimensions. The collaborative aspect is reflected in the cooperation between student teachers at university, with the impact on the sustainability of relationships and knowledge being considered particularly significant. Previous research has also shown that culturally relevant content in local languages is a crucial element of digital equity [6] and that the digitalization of HE can enhance collaboration between student teachers [7]. In the context of an ethic of care, it can be argued that this is a significant aspect for sustainable access to knowledge and digital opportunities in the future [16]. Furthermore, it is important to acknowledge that this extends beyond the conclusion of HE.

The study emphasizes that access to DT and the opportunities for its use are integral factors in determining student teachers' capacity to utilize digital resources and engage with educators who support and facilitate the integration of DT. This access enables student teachers to use digital resources, such as e-libraries, relevant websites, and databases, which are typically not free. However, access to paid digital resources also predicts access to open resources. Consequently, university student teachers with structural access to technology—a crucial aspect from the perspective of an ethic of justice [14]—also acquire knowledge, skills, and opportunities to utilize free resources. Nevertheless, the material environment alone is not the only significant aspect of digital equity, a finding that is consistent with other studies [6,19]. Another critical step is the provision of qualified teachers to support the use of DT. This includes teachers (1) promoting the use of DT for professional and academic purposes; (2) supporting the integration of DT into courses; (3) having a positive attitude toward DT; (4) being proficient in the technology themselves; (5) effectively integrating DT into courses to achieve the expected outcomes; (6) justifying the use of DT in the learning process; and (7) encouraging the creative use of DT by student teachers. Furthermore, the data suggest that access to digitally competent teachers helps create sustainable opportunities for student teachers to use DT in their studies. The importance of teachers' ability to support and facilitate the learning process as a fundamental aspect of ensuring digital equity has been recognized in other studies [19,23,24]. Access to DT and the opportunities for its use also appear to influence the socioecological aspects of sustainability. The findings suggest that when DT is used effectively with the support of skilled teachers, student teachers can engage in activities that address environmental sustainability and social issues, promote caring for others, and improve equity in education. This aligns with Nussbaum's [18] capabilities approach, which emphasizes that the opportunities provided by the environment help to develop individual potential and enable active participation.

The second most important dimension, collaborative problem solving, has a significant impact on the socioecological aspects of sustainability, and vice versa. This suggests that opportunities for collaborative problem solving, supported by access to digitally skilled teachers, could promote the development of environmental and social sustainability in society. This finding is also supported by the other literature that identifies student teachers' engagement, focusing on student teachers' participation, as a critical element in maintaining relationships and knowledge through digitalization [7]. However, the data suggests that collaborative problem solving has a negative impact on access to DT and opportunities to utilize it. This can be explained by the fact that the dimension of access to DT and

opportunities to use it in DEHE primarily focuses on individual aspects of use and does not include a social element, although DT can also be used for collaborative purposes in the learning process and is encouraged by teachers (e.g., peer review, peer assessment, collaborative work on shared documents).

A further key finding of this study is a clearer understanding of the necessity to ensure the accessibility of DT in HE through the development of diverse learning opportunities where teachers effectively integrate DT into their courses and promote collaborative approaches to fulfill study requirements and improve educational equity. This finding is consistent with the TPACK model, which emphasizes the integration of both DT and the pedagogical framework [24]. Relying solely on the accessibility of DT can lead to significant gaps [23,24], particularly due to a lack of teachers who critically evaluate and competently use DT to support the learning process and encourage student teachers to use DT to search, create, and share content.

The generalizability of the results is constrained by the relatively small and homogeneous sample, which hinders the validation of the DEHEs and SHEs. However, the construct validity of the DEHEs in the SHEs was not within the scope of this study.

5. Conclusions

With the growing importance of digital transformation in HE, the issue of digital equity has gained considerable attention. The present study has been designed with the objective of empirically conceptualizing the notion of equity in higher education. To this end, it focuses on two fundamental issues: firstly, access to DT, and, secondly, the equity experienced by student teachers throughout the higher education process. Given that equitable and quality education is a key objective of the SDGs, it is equally important to conceptualize sustainability in HE. By exploring the meaning of sustainability in this context and examining its relationship with digitalization, we can foster sustainable academic relationships and knowledge development in HE.

The present study has successfully addressed all three aims. For the first aim, it provided a comprehensive understanding of student teachers' perspectives on the key aspects of accessibility. The results highlight the importance of culturally relevant software and apps, accessibility of digital resources, and support from digitally competent teachers. For the second aim, five dimensions of digital equity in HE were identified (i.e., access to teachers who support the use of DT, access to DT and opportunities for its use, access to digital resources, access to culturally relevant software and applications, and access to open-access resources). Additionally, two dimensions of sustainability in HE (collaborative problem solving and socioemotional aspects) answer to the second aim. For the third aim, this study examined predictive relationships between the dimensions of digital equity and sustainability, revealing significant interactions. Notably, access to DT and collaborative problem solving emerged as key predictors.

5.1. Findings and Implications

The findings underscore the critical role of access to DT and its effective use in fostering academic success. However, achieving digital equity also depends on supporting teachers in the meaningful integration of digital tools. This way, teachers can personalize and individualize the learning process, address educational needs, and promote active participation in collaborative problem solving. Supporting teachers in the meaningful use of DT is essential for achieving digital equity. Effective support for DT use enables teachers to provide opportunities for personalized and individualized learning, addressing student teachers' educational needs while facilitating active participation in collaborative problem solving.

5.2. Limitations and Future Research

Although construct reliability was not within the scope of this study, future research should confirm the stability of DEHEs and SHEs by obtaining a more diverse sample, including individuals from a wide range of academic disciplines and cultural backgrounds. The dimension access to DT and opportunities for its use should be revised, as it currently focuses more on the individual use of DT and neglects the collaborative dimension. Nevertheless, the study can inform the revision of educational program curricula to support student teachers in developing their digital competencies.

Further research is needed to explore the specific role of teachers in supporting and facilitating the use of DT for teaching and learning, particularly its actual impact on digital equity. The findings of this research could significantly contribute to emphasizing the role of publicly funded universities in closing the gaps in opportunities for the meaningful use of DT in education. Ensuring access to DT and qualified teachers, aligned with the principles of ethics of care and justice, appears to be the most important factor in achieving sustainable digital equity in society.

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