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DOI
10.1007/s43621-025-01008-z

Publication date
2025

Document Version
Final published version

Published in
Discover Sustainability

Citation (APA)
Okur, Ö., Huang, M., Angeli, L., van der Voort, H., & Huang, Y. (2025). Sustainable digital education technologies: an analysis of selection processes in European universities. *Discover Sustainability*, *6*(1), Article 204. https://doi.org/10.1007/s43621-025-01008-z

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Research

Sustainable digital education technologies: an analysis of selection processes in European universities

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Received: 5 November 2024 / Accepted: 12 March 2025
Published online: 25 March 2025

Abstract
The digital transformation of education has rapidly evolved in recent years, driven by advancements in technology and further accelerated by the COVID-19 pandemic. Digital education Technologies (DETs) have become integral to higher education, reshaping how institutions deliver learning and manage resources. However, despite the widespread adoption of DETs, there has been limited focus on the sustainability of these technologies. This paper explores how sustainability considerations are integrated into DET selection processes at European Higher Education Institutions (HEIs) through semi-structured interviews with key decision-makers. The research focuses on three sustainability dimensions-environmental, social, and technological-and their impact on decision-making. The results indicate that while HEIs are making efforts toward sustainability, economic considerations still dominate the decision-making process. Moreover, the emphasis across sustainability dimensions remains unbalanced: social dimensions, such as privacy, are prioritized over environmental dimensions due to the former being treated as knockout criteria and due to a lack of reliable data on the environmental impacts of DETs. This study also identifies several challenges, including long procurement processes, limited financial resources, and heavy dependence on external service providers for digital infrastructure. The findings offer insights into how HEIs can better align their digital strategies with broader sustainability goals.

Keywords Sustainability · Digital education · Higher education institutions · Environment · DET selection

1 Introduction

Digital transformation in education institutions has been on the rise. It was extensively accelerated by the COVID-19 pandemic [1, 2]. This prompted a surge in the adoption of Digital Education Technologies (DETs), encompassing both digital devices and software, designed to support teaching and learning processes. From hosting lectures using video-conferencing software to managing courses through education platforms, DETs have penetrated the education system beyond classrooms and considerably changed how students and teachers interact, and how institutions operate and facilitate education [3, 4]. Despite many reported direct and indirect benefits of DETs, such as improved accessibility and learning experiences in education, the progress in digitalisation of education has also raised many concerns about DETs, including sustainability issues such as environmental impacts, privacy, social relations, and power dynamics between education institutions and corporations supplying the DETs [5–9].

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Sustainability can be understood as a way of working towards the future where "environmental, societal, and economic considerations are balanced in the pursuit of an improved quality of life" [10, 11]. Sustainable education implies a shift in the educational culture that integrates the principles and practices of sustainability while fostering critical awareness [11–13]. Sustainability of DETs, in turn, requires deliberate choices of the design, development, acquisition, utilisation, maintenance and disposal of DETs, so that balanced sustainability considerations can be addressed.

European Higher Education Institutions (HEIs) are increasingly committed to becoming more sustainable through various initiatives aimed at enhancing their environmental and social responsibility [14]. These initiatives include adopting renewable energy sources [15], maintaining extensive green spaces to promote biodiversity [16], implementing energy efficiency programs [17], and fostering diversity and inclusion within the campus community [18]. Given the prevalence of DETs in university settings, their sustainability is crucial for advancing sustainable education practices.

While the literature primarily addresses the role of DETs in supporting sustainable education and the digital transformation of universities [13, 19, 20], the sustainability of the DETs themselves remains largely unexamined. The sustainability of DETs in this paper refers to a comprehensive evaluation of DETs' impacts throughout their life cycle. In the context of higher education, this means assessing how DETs can be implemented in a way that not only supports educational goals but also aligns with broader sustainability objectives. There is a gap in the literature that points to the need for a critical examination of how DETs are selected in a way that aligns with broader sustainability goals. Thus, this paper aims to investigate how HEIs in Europe take sustainability into account while *selecting* DETs, and to identify the challenges HEIs face in this process. For this purpose, interviews are conducted with decision-makers from European HEIs to understand how sustainability - encompassing environmental, social, and technological dimensions - is incorporated into DET selection processes.

The remainder of this paper is organized as follows. Section 2 explains how sustainability is considered with different dimensions within the DET context. The research method employed in this paper is summarized in Section 3. The results are presented in Section 4, and are discussed in Section 5.

2 Sustainability dimensions in DETs

This paper focuses on the environmental, social and technological dimensions of sustainable DETs. They are selected based on the general consideration of sustainability and adapted to the context of education research. As mentioned in the Introduction, the general consideration of sustainability balances three interrelated dimensions: environmental, social, and economic [21]. The economic dimension has been extensively studied in digital education literature [22–25]. Hence, this study did not explicitly focus on this dimension. The economic considerations of DETs nonetheless emerged during the interview conversations (see Section 4).

The technological dimension is added instead in this study to provide a more complete evaluation of sustainable digital education, which is inherently reliant on technologies for course and education development, implementation, etc. In this paper, the technological dimension considers what makes DETs technologically functional and long-lasting from a design and implementation perspective [26].

The pedagogical dimension is at the heart of education. For digital education, the pedagogical forms have evolved to match the introduction of new DETs aiming for better educational experiences and outcomes, especially after the COVID-19 pandemic [27, 28]. In this paper, the focus is only on the environmental, social and technological dimensions, since the pedagogical dimension is already well presented in the literature regarding digital and classical education [29–32].

The following subsections explain the environmental, social and technological dimensions of DETs in relation to the literature. For each dimension, two to three themes most pertinent to this study were identified, based on the literature. Table 1 provides the specific scope of consideration for each dimension in this paper, along with relevant examples.

2.1 Environmental dimension

While DETs arguably benefit the education system, the adoption and use of these technologies also have environmental impacts that shall be considered. The environmental dimension focuses on the protection and preservation of natural resources, ecosystems, and biodiversity. Morelli [37] framed this as the "maintenance of natural capital" that involves the management of human activities in ways that minimize negative impacts on the environment which provides the foundation for human societies to exist and thrive.

Table 1 Sustainability dimensions for digital education technologies (DETs), how their scope is considered in this paper, and examples

Dimension	Scope of consideration in this paper	Example
Environmental	DET protects and preserves natural resources, and biodiversity through the environmental impact of its *hardware* [33] and *software* [34]	E-waste recycling, CO2 emission equivalent
Social	DET ensures all learners have equal opportunities to education, considering *access* and *accessibility*, regardless of socio-economic status, disabilities, or geographic location [35] while preserving their *privacy* [36]	Language translation feature, transcriptions, video recordings
Technological	DET is long-lasting, possesses the necessary functionalities and balances the *simplicity*, *openness*, and *ownership* components [26]	Open sourced software, simple user experience

Environmental sustainability encompasses a range of issues regarding climate change, air and water pollution, the depletion of natural resources, etc. In the context of DET, the production and disposal of hardware, and the carbon emissions caused by software are the top contributors to environmental pollution [34, 38].

With increased digitalization, HEIs increasingly need hardware such as servers, computers, tablets and smartphones. The extraction of raw materials and inappropriate disposal of e-waste, typically in open air without any special handling, introduce hazardous substances into our ecosystems [19]. The increasing global demand paired with the shortening lifespan and significant unused number of electronic devices has made e-waste one of the fastest growing global waste streams [8]. In 2019, 12.1 million tonnes of e-waste was generated in Europe alone [33].

The energy consumption of DET software by the operation of servers, data centers, and the internet is a significant contributor to greenhouse gas emissions. Despite reportedly a 90% decrease in carbon emissions by hosting lectures online as opposed to in-person lectures removing the need for travelling, the mounting use of video conferencing is neither energy-efficient nor energy-saving [39]. For example, an online lecture hosted in Trento, Italy has its data routed to Germany and back, which is a substantial distance travelled when most of the participants join online from the same city [8]. The increased use of videoconferencing during and after the COVID-19 pandemic has scaled the inefficiency of DETs and is reflected in the rise of its energy consumption [40].

2.2 Social dimension

Social sustainability promotes social equity, equal access, privacy, autonomy, and fairness for individuals and communities [41]. Chiu [42] defines social sustainability as "maintaining or improving the well-being of people in this and future generations ... [with] the aims [of] social cohesion and integrity, social stability and improvement in the quality of life." Common across the social dimension definitions is that social equity and well-being are fundamental human rights, and promoting them is necessary for creating a sustainable and just society [43].

In the context of DETs, social sustainability aims to ensure all learners have equal opportunities for education, regardless of socioeconomic status, disabilities, or geographic location [35], while preserving individual privacy [36]. Several key themes emerged from the literature on the social sustainability of DETs: access, accessibility, and privacy. First, DETs have been demonstrated to promote access to education, particularly in underserved, marginalized, and rural populations [44]. Since the 2000s, communication platforms like Skype and Moodle significantly increased education participation from these groups, with the most recent example stemming from the mass online education shift during the pandemic [45]. However, DETs can also limit access by increasing digital dependency, thus gatekeeping learning and content from already marginalized groups who do not have devices or stable internet to access content and lectures [46].

Second, DETs, directly and indirectly, influence accessibility in education. Accessibility builds upon the concept of access by focusing on making things easier to reach, understand, or use for everyone, especially those with disabilities or other challenges [47]. LMS, online learning, and increased digital device ownership are some factors that have positively increased accessibility in education by accommodating different learning styles, reducing inequalities (e.g. gender), and enhancing educational experiences for students with disabilities [48–50]. While DETs have the potential to enhance accessibility, it can also exacerbate certain challenges and introduce new barriers if not implemented thoughtfully. For example, platforms with inaccessible user interfaces, navigation structures, or multimedia content may be difficult or impossible for students with certain disabilities or challenges to use effectively [51]. The concept of inclusion encompasses both access (to education) and accessibility (in education) by focusing on DETs that actively involve and embrace the participation of all individuals, regardless of their backgrounds or abilities [52].

Third, the collection and use of sensitive data, such as personal information, user behaviour, and student performance, have been repeatedly highlighted in research as major security and privacy concerns for DET users [53]. Certain videoconferencing tools have been exemplified as a platform where user data can be easily exacted and shared publicly, thus jeopardizing users by posing serious privacy breaches [7]. Additionally, DETs, including artificial intelligence learning support, have design limitations that have racial, cultural, and gender bias, thus contributing to social unsustainability [54].

2.3 Technological dimension

Technological sustainability investigates what makes DETs technologically functional and long-lasting from a design and implementation perspective. There are three key components considered in this dimension: simplicity, openness, and ownership [26].

Simplicity refers to how easy a DET is to understand and use for the educator, learner, and other stakeholders. Intuitive interfaces, clear instructions, and simple design are critical in creating a user-friendly DET that lowers the barrier to entry for new users. [55] found that students prefer using similar technology for learning to those they use in their personal lives. In addition to increasing adoption rate and integration into educational settings, simple DETs have been demonstrated to increase student learning outcomes and increase teachers' confidence in using the DET in the classroom [56].

Openness of DETs promotes collaboration, sharing, and joint innovation between users [57]. The concept of openness in DETs is not new, and various definitions have existed over the past 40 years, but they all centre around the idea of open educational resources. Schaffert and Geser [58] defines open educational resources through its four core attributes: open access, open licensed, open format, and open software. Increasing each of these openness attributes improves the openness of the DET, which ultimately contributes to overall sustainability by making the DET more affordable, accessible, and equitable.

Ownership refers to the degree to which the user or education institution can exert change to the DET and can be visualized as a spectrum. On one end, the user has full ownership of the DET, typically through a one-time purchase license, and can use the product forever. On the other end, the user has minimal ownership, often having to pay a regular subscription fee to use the product and is subject to any product changes the provider decides to implement. The latter category has been analogized by [59] as a renter-rentee relationship as companies rent out DETs to institutions who pay a monetary rent to access the product, while the users (i.e. teachers, students) pay data rent in the form of digital traces left behind through interacting with DETs. Data rent includes metadata such as user location and content including discussion forums and posts [59]. Increasing DET ownership can reduce institutions' dependency on DET providers and increase user data security.

3 Interview process

This paper collects data on the sustainability of DETs through semi-structured interviews with DET decision-makers in European universities. Interviews are chosen over other data collection methods, such as surveys, because of the option to follow up on the respondents' answers and investigate topics more deeply. Semi-structured interviews are used to flexibly adapt the question order and allow for the interviewee's expertise and answers to dictate the conversation direction.

3.1 Actors involved

For DET selection in European HEIs, actors are diverse, ranging from university personnel and national education associations to private companies. This study identified four main actors directly participating in the DET selection and decision-making process, namely (1) the head of IT, (2) the IT (DET) tool specialist, (3) the service provider, and (4) the education association.

Head of IT is a university actor whose main responsibilities include managing the IT team, collaborating with multidisciplinary stakeholders, and developing and implementing the university's IT strategy. They act as the bridge to translate the high-level objectives from the upper echelons of the university government into actionable initiatives for the IT team. They have insights into how a DET tool fits within the broader university IT infrastructure to make decisions during the tendering process. The head of IT also balances the IT budget and resources to efficiently support the university's IT needs. This can take the form of evaluating current systems for areas of improvement, green-lighting pilot DET projects of new technologies, and developing and enforcing policies to align with relevant data protection regulations such as GDPR. This actor holds significant power in directing an institution's DET selection and digital infrastructure development while operating under the constraints of the university board.

IT tool specialist is the second university actor with in-depth technical knowledge about DETs. This actor supports the DET selection process by providing evaluations of a tool, including its functionalities, trade-offs, and scalability from a technical perspective. Outside of researching DETs, an IT tool specialist is often involved in pilot projects to test emerging technologies, gather user feedback, and assess the tool's effectiveness. A tool specialist's knowledge of a certain tool may be a significant factor in which DET is selected since they are the people who integrate the tool into the existing infrastructure and provide maintenance.

Service provider is the third actor responsible for the development and implementation of DETs. Established and startup companies both fall into this actor role as they both can provide solutions to an HEI's infrastructural needs. However, established corporations are typically involved in larger tenders, while startups receive smaller contracts or work with pilot projects. A service provider fills the niche in providing services for university's increasing demand to digitalize their education, especially since HEIs lack the funding, manpower, and expertise to maintain in-house development teams. A service provider assesses the needs of educational institutions and often collaborates with HEIs to co-develop specific solutions to fit each university's requests.

Lastly, *education association* is a cooperative organization of educational and research institutions that work collectively towards an open education network, usually assembled on a national level. The Netherlands' SURF and Ireland's HEAnet are two examples of this type of actor [60, 61]. Education associations can also play a big role in assisting universities in making DET procurement by establishing tendering frameworks that universities follow to select a new tool [62]. These frameworks act similarly to standards as they are used widely by institutions since individual universities do not need to develop their own frameworks, which may be costly and time-consuming.

3.2 Interviewees

The interviewees were selected based on their experience with DETs and their position and degree of involvement in the DET selection process. This study only referred to key decision-makers who participate in their institution's selection of DETs and often have the power to significantly affect the decision outcomes. This distinction is made due to the complex and bureaucratic nature of the DET selection process as it undergoes highly regulated channels, and the actors capable of exerting great influence to increase the process's sustainability are those in formal positions.

The key decision-makers, as identified in Section 3.1 Actors Involved, are in the Head of IT group. They typically hold titles such as Head of IT, Chief Information Officer (CIO), Vice-president for IT, or those who exert influence on the Head of IT group. They are the main target for this study as they have a deep understanding of the institutional context and have a strong influence over DET selection and the inclusion of sustainability in the selection process.

The initial candidates were proposed from the authors' professional networks, with additional candidates identified through snowballing and referrals. A total of ten interviews were conducted with decision-makers from four Dutch, two Finnish, two Irish, one Italian, and one German HEIs. Note that the end users of DETs such as students, teachers and other university staff are not categorized in this study as key decision-makers, although they may influence the selection.

3.3 Interview setup

All interviews were conducted online (in April and May of 2023) since interviewees were across Europe, which made in-person interviews impractical. Each interview lasted about sixty minutes and was conducted as a semi-structured interview. The procedure for the interviews of this study was approved by the Human Research Ethics Committee of Delft University of Technology. The informed consent to participate was obtained from all the participants. Data from the interviews cannot be shared openly to protect the participants' privacy.

The questions asked in the interviews were divided into four categories: how sustainability dimensions are ranked in terms of importance while selecting DETs, how sustainability is taken into account at the university, challenges the university faces while selecting DETs, and possible changes that can be made to address the challenges. The complete list of questions for the interview can be found in Appendix A.

3.4 Interview transcript coding

For interviews, a three-stage coding of the transcripts was conducted. The goal of coding is to break interview transcripts down into individual *codes* (concerning the key topics of the interview), identify and group similar codes into broader but interrelated *sub-categories* and continue to reconnect them until all codes are integrated and a few but more complex *categories* emerge from the initial set of codes [63].

Using Smit [64]'s three-step grounded theory analysis method, the transcripts for each interview were analyzed with *Atlas.ti* in the following steps. *Atlas.ti* is a qualitative data analysis software for processing transcripts and data coding commonly used for interview analysis. Based on the interview transcripts, three coding themes are identified: (1) the

DET selection process, (2) sustainability criteria in the DET selection, and (3) challenges HEIs face while incorporating sustainability into DETs.

4 Interview results

The section provides the results of the interviews, which are divided into three sections: stages of the DET selection process, sustainability criteria in DET selection, and challenges in sustainable DET selection.

4.1 Seven stages of DET selection process

All interviewees explained the DET selection process in their institutions. Based on this, seven key stages in the process were identified. They are common across the HEIs interviewed and are as follows: *Initialization, Research, Criteria Setting, Exploration, Experimentation, Evaluation, Decision*. The stages are in general consistent with those reported in the literature [see, e.g., 65–67], and are presented as follows.

At the first stage *Initialization*, an actor proposes the search or need of a new DET. The proposer could be a decision-maker, such as the Head of IT, or a non-decision-maker, such as a user. Initialization could also be part of a recurring process. For example, one interviewee was required to re-evaluate a DET after a certain number of years in a regular renewal process. This ensures that the university is not using outdated technology and the infrastructure continues to meet the needs of its users.

The second stage is *Research*, where actors learn more about the technology, research the DET market, and identify their needs and requirements. Service providers may be engaged during this step and invited to share more about their product. University actors may also contact colleagues or their counterparts in other institutions to ask about their DET selection experience that may be relevant.

Once the actors think they have done sufficient research, they move to the *Criteria setting* stage. Selection criteria are, as one interviewee explains, "your must-haves, should-haves, and could-haves". Using the information from the previous step in combination with existing selection frameworks, such as those provided by education associations, decision-makers now have a method to evaluate and compare different DET products (See Section 4.2 for more information about selection criteria for evaluation).

Next, actors actively search for potential DETs in the *Exploration* stage. This may be a formal tendering process with defined steps, such as a call for proposals, which actors have to follow. At this stage, actors commonly have to re-examine the list of criteria as the market often does not present a product that meets all the needs. As one interviewee stated, "you make this list of requirements and go to the market, [and often] you have to skip many of your wishes."

After gathering a list of product options, the actors may choose to proceed to an *Experimentation* stage. This stage allows IT tool specialists to test the alternative products on a smaller scale with service providers and obtain initial results. Experimentation can rule out options that are unfit earlier on without having first sign a long-term contract, thus de-risking the situation for the university. It can also give service providers feedback on how to customize their products to better fit the university's needs and be more competitive in the following stage.

During the *Evaluation* stage, the final set of DET products is assessed using the criteria. If necessary, the criteria could be adjusted based on the evaluations, returning to the criteria setting stage. A DET is ultimately chosen in the *Decision* stage, which then concludes the selection process, and the actors move towards the implementation of the tool.

4.2 Sustainability criteria in DET selection

Selection criteria are attributes by which the decision-makers assess a DET and compare it with other options in the selection process. Criteria creation occurs during the Criteria-setting stage and can be iteratively added, removed, or updated throughout the selection process as more information is gathered. Interviewees were asked how sustainability and its three dimensions were taken into account in their selection process. The transcript analysis yielded many criteria for each of the three dimensions.

4.2.1 Selection criteria in environmental dimension

As universities move towards being more environmentally aware, intending to be carbon neutral in 2025, environmental sustainability is more integrated into university policy and decision-making. Several interviewees have noticed a trend towards incorporating more environmental criteria in the DET selection process. One interviewee stated that during discussions for procuring new software, actors are increasingly concerned with the environmental footprint of products. Another interviewee said their university implemented a pilot, where students participate in laboratory activities from home, and found a significant reduction in carbon emissions by removing the need to commute to campus. Despite these, the data on DET's environmental impact (e.g., CO2 emissions) are mostly not available as it is difficult to measure environmental impacts accurately, or the data is entirely missing, either because service providers do not provide or have the data or universities are not tracking the environmental impacts internally.

Two interviewees mentioned that they asked service providers about how e-waste was handled and sometimes also asked the companies to provide evidence (e.g., certificates) on their process for e-waste recycling. One interviewee explained that this helped the decision-makers understand how the service providers addressed environmental sustainability which can be considered in the evaluation stage.

4.2.2 Selection criteria in social dimension

One interviewee framed selection criteria in the social dimension as *people-first*, which entails putting the people and users of DETs above other requirements such as cost. The interviewee mentioned that people-first works to preserve the *privacy* of the users, which in the context of digital and online technologies is a primary concern for users, given that corporations have a history of selling user data and putting their users at risk. All ten interviewees indicated privacy is a major knockout criterion, especially since GDPR is a mandatory requirement all companies must comply with. One interviewee indicated privacy is the "biggest priority in all [selection] cases" and has data protection officers to establish a strong data management system. Another interviewee mentioned their university would "not acquire a tool" even if it has "great functionalities" if it fails to provide adequate data protection.

One goal of people-first is incorporating *accessible* techniques for learning and teaching to reach more students. Accessibility is a common criterion that six interviewees cited as a knockout criterion because universities cannot choose a "new technology but exclude certain users". One interviewee stated that student organizations at their university have requested more tools to be accessible to students with special requirements, such as blind students. This was translated into an accessibility criterion when selecting a videoconferencing DET, leading to the decision-makers choosing a solution that supported screen readers that allowed users to read text on screen using a speech synthesizer or braille display. Related to inclusion and accessibility is the criterion of *inclusion*. One interviewee remarked on a recent trend at universities that increasingly emphasize inclusion in their decision-making to ensure equitable opportunities and treatment for all users, regardless of their background, socioeconomic status, or personal circumstances.

In addition to people-first criteria, decision-makers believe giving users autonomy to choose what tools they can use can be an important asset for the digital infrastructure. One interviewee explains that the feeling of having the freedom of choice helps increase user adoption and makes the users feel they are being heard by the decision-makers. However, some interviewees pointed out that autonomy can also conflict with privacy. Users may want to choose a DET that is not compliant with the university's privacy rules, and thus the university cannot allow the user to use the tool which limits the user's autonomy. Often in these situations, the criterion for privacy trumps the autonomy of individual users because decision-makers have the obligation to ensure the overall digital infrastructure and its users' data are not compromised. As one interviewee said, "freedom of choice is sometimes the opposite of privacy".

4.2.3 Selection criteria in technological dimension

The three components of the technological dimension introduced in Sect. 2.3 were all discussed during the interviews. The *simplicity* of a tool is an important criterion from the decision-makers' perspective because it has implications for a tool's *adoption* with its users. One of the reasons universities run pilot projects is to get user experience feedback because there have been situations like at a university in the Netherlands where a tool meets all the needs and requirements on paper but in practice, it was not easy to use, and users did not like the tool. While ease of use can refer to how intuitive and simple the user interface is, it can also refer to how easy it is to set up the tool. One interviewee stated that their university selected the videoconferencing software because it required almost no time to set up the system as it can be

accessed directly on a web browser instead of installing a separate application. A DET's simplicity also applies to IT tool specialists in its *integrability* with the existing digital infrastructure. Another interviewee mentioned that decision-makers may "favor services that are easy to integrate with our existing services" as the data can easily flow between the tools and users do not need to create new accounts.

Openness was the least mentioned component out of the three in the technological dimension. While some open-source DETs are prominently used in the interviewees' universities, they were typically not chosen for open-source features but because of their functionality and customizability that allowed actors to solve their problems. One interviewee indicated their preference for open-source DETs "but if there is another tool that fits our needs better that is not open source, then we go for that solution." Similarly, another interviewee mentioned their university actors "do not consider too much on the openness of the software" but if they do use open-sourced tools, it is because its functions best fit their needs.

Lastly, the topic of DET *ownership* was discussed extensively, especially on *in-house development* versus *outsourcing*. The increased digitalization in universities has led to more outsourcing of digital infrastructure to service providers. Interviewees explained the motivation to outsource with three main reasons. The first is to reduce the cost, both the financial cost to develop and maintain the infrastructure and the human labour cost of hosting an internal development team. Second, the core function of universities is to deliver quality education, not the tool development. As some interviewees highlighted, the IT tool specialists lack the expertise to compete with service providers in providing the best tool support while additional investment into DET development is taken out of potential investment into creating better education content, hiring professors, and building facilities. Third, the DET market has grown sufficiently large that a product that meets the needs of the university exists. Therefore, the university saves time by outsourcing rather than developing a more expensive but inferior product. However, there are also risks associated with these licenses because institutions have less ownership. For instance, they are subject to service provider's price increases, changes to privacy agreements, and updates to the tool's functionalities.

4.2.4 Sustainability dimension ranking

In the interviews, decision-makers were asked to rank the three sustainability dimensions in order of importance in DET selection, which are depicted in Fig. 1. The social or technological dimensions were consistently ranked as the most important dimension because "there are knockout criteria from the technological, functional, and social perspectives." Between these two dimensions, the social dimension outranked the technological dimension, with seven instances

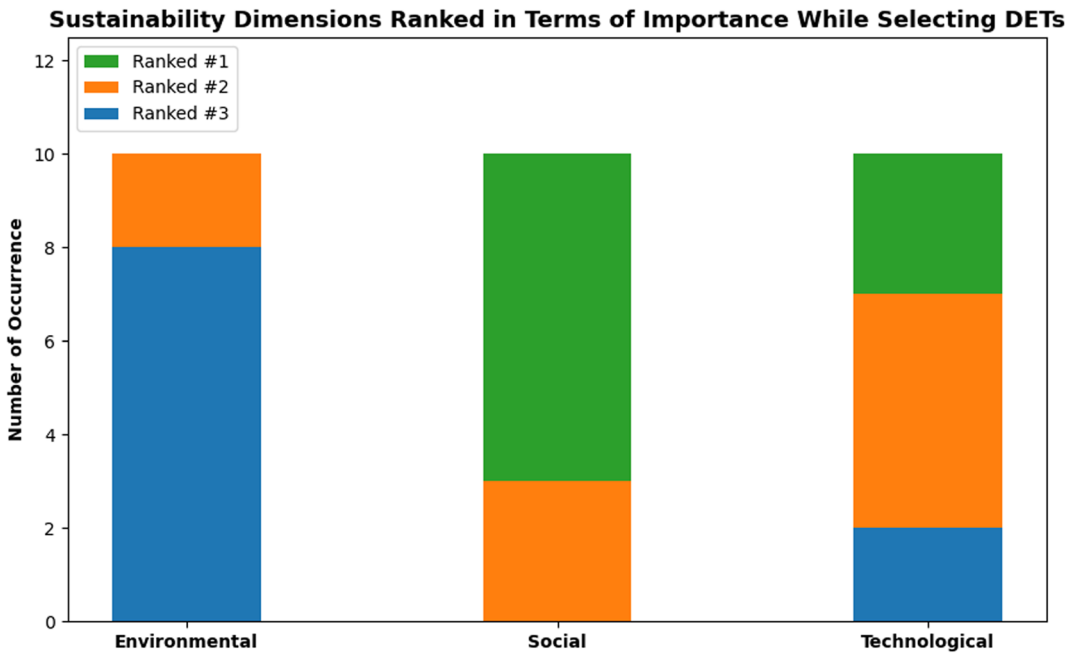

Fig. 1 Ranking of sustainability dimensions, in terms of importance while selecting DETs

ranked as the top priority versus three instances, respectively, with zero instances for the environmental dimension. One interviewee explains this by citing that the privacy concern under social sustainability has "many rules and regulations such as GDPR" that strictly define the types of DETs decision-makers can consider.

On the other hand, as one interviewee observed, "there are no knockout criteria" for the environmental dimension. The main reason for the absence of environmental knockout criteria is that it is difficult to measure environmental impacts accurately, or the data is entirely missing.

While some recent initiatives in universities have begun to measure carbon emissions at the university, these are not conducted on the scale of individual DETs [68, 69]. Additionally, it may not be financially viable to measure carbon emissions that finely since current weightings for environmental metrics are between five to ten percent while the cost metric has forty percent weighting. This means even if universities do have the environmental impact data, selecting a less carbon-intensive DET is not as significantly impactful in the evaluation as choosing a cheaper tool.

4.3 Challenges in sustainable DET selection

The interviewees discussed the challenges they faced in selecting DETs for sustainability. Eight challenges emerged during the discussion. They are grouped into three *interrelated* categories – Resources, Selection Processes, Selection Criteria & Decision Power – as shown in Fig. 2.

4.3.1 Category A: resources

For the available resources for DET selection, three main challenges are common to the interviewees: limited *financial resources* for DETs, limited *IT human resources*, and dependency on *in-house DET tool expertise*.

Limited Financial Resources for DETs The most common challenge, discussed by all ten interviewees, was limited financial resources available for choosing a preferred DET option. The economic consideration (mainly cost weighting) is, as a matter of fact, a significant factor for decision-makers, often taking up to forty percent in criteria weighting. This significantly reduces the impact of sustainability dimensions influencing the evaluation of DETs. It was not uncommon that although decision-makers would prefer to procure a DET that meets most of their requirements, they were forced to choose another alternative due to the immense cost, e.g., for a notably more expensive data security license. Economic factors often overshadow other considerations.

Limited IT Human Resources Resources need to be considered beyond just DET procurement but also for its maintenance and system upkeep, which require trained IT experts and a well-staffed team. Because a HEI's core function is not DET development but education and research, there has been (understandably) "a handful of" IT specialists and in-house developers to create minimal viable products and adjustments to the IT infrastructure. The IT human resources are not

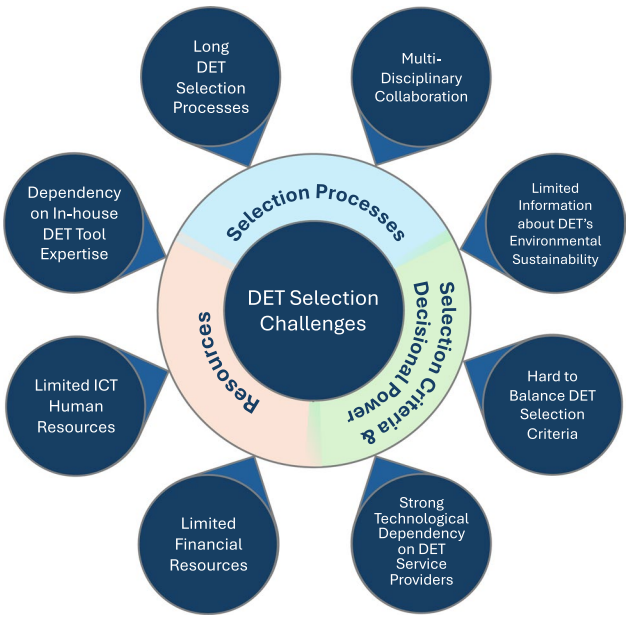

Fig. 2 Digital education technologies (DETs) selection challenges in three categories: resources, selection processes, and selection criteria and decisional power

sufficient to properly support a full team to fulfill the fast-growing demand for new DETs, including the expertise and support needed after the procurement. This is also a reason for the outsourcing trend in HEIs since DET service providers can fill the demands.

Dependency on In-house DET Tool Expertise The type of in-house IT expertise for tool support also plays a role in DET selection. New DETs would often solely rely on external service providers, who lack the organisational context and priority to provide tailored support and can take longer to respond, compared to internal IT experts. The latter can provide the needed support much faster, but it takes time and experience to gain expertise in new DET tools. This is why, sometimes decision-makers choose older and more mature DET tools, which are typically less sustainable than their newer counterparts and better embody the recent trends of people-first, privacy, and data security values.

4.3.2 Category B: selection processes

Two challenges are prominent regarding the DET selection processes: *long selection processes*, and that the processes require *multi-disciplinary collaboration*.

Long DET Selection Processes There are often long formal tender processes for DET selections. This makes the procurement of different tools or technologies complex to manage. The lengthy time span comes from various selection stages, where typically research, exploration, and experimentation are longer than other stages. Due to the length and complexity of the process, decision-makers often "want to ensure that the tool can serve us for a long time". Long DET contracts provide stability, but they also prevent HEIs from tendering for new products, which may be better and more sustainable.

DET Selection requires Multi-disciplinary Collaboration DET selection processes often require multi-disciplinary collaboration across different departments and actor groups. This is necessary and beneficial, but at the same time complex to manage. Many actors are involved in the DET selection (and maintenance), and they can have different perspectives and even conflicts on issues such as the selection criteria, how weights are distributed, and what tools to eliminate. Sometimes, actors may (consciously or unconsciously) approach a selection process fixated on a DET they plan on selecting for, even before the research stage has started. Such biases negatively affect a selection process and hinder a fair decision.

4.3.3 Category C: selection criteria and decisional power

Three main challenges are grouped into this category: decision-makers in HEIs have *limited information about the environmental sustainability of DETs*; it is *hard to balance DET selection criteria*, particularly those across different sustainability dimensions; and that HEIs increasingly have *strong technological dependency on DET service providers* due to decreased DET ownership.

Limited Information about Environmental Sustainability of DETs The rapid pace of digitisation leads to a scramble for solutions prioritising immediate needs such as functionality and remote access over long-term sustainability considerations, including environmental sustainability. Data about the environmental impact of DETs is not gathered or held by any of the universities interviewed or their service providers, presumably because it is difficult to measure. Thus, environmental metrics are often excluded from selection criteria due to lack of information. This gap makes switching to more sustainable DET options challenging. There is a shortage of expertise, instruments, and resources within institutions to evaluate and implement sustainable DETs effectively.

Hard to Balance DET Selection Criteria It is challenging to balance different DET selection criteria, particularly those across different sustainability dimensions. For example, privacy (and data security) in the social sustainability dimension is currently widely considered: nine interviewees cited GDPR compliance as the top DET selection (and knockout) criterion. This reduced the DET options such that often a little or sometimes only one option in the market remains to a university even if the remaining option(s) may not be great functionally or not meet other criteria. Moreover, cost and functionality are strong determinants, as mentioned earlier. They give less attention to other criteria, e.g., accessibility (and inclusion) in the social sustainability dimension and the environmental impact of hardware and software, which are less or much less considered during decisions.

Strong Technological Dependency on DET Service Providers due to Decreased DET Ownership The trend towards a renter-rentee relationship, i.e., HEIs increasingly outsource digital infrastructures and services, creates HEIs' strong dependency on DET providers. There are clear benefits to outsourcing, which, however, also has associated risks. For example, when the service providers change DET functionalities or service conditions for support or prices later on, HEIs are limited in the actions they can take and often are subject to companies' decisions. Vendor lock-ins weaken HEIs' autonomy and decision-making power in the DET selection process. Vendor lock-ins often occur when HEIs choose a

service provider that is an established corporation that offers a bundle of DETs, that interoperate well together. Such an arrangement makes HEIs hard to choose alternative DETs from other service providers in the future because of the high switching cost.

5 Discussions and recommendations

The interview results suggest that although European HEIs are making growing efforts towards sustainability through numerous initiatives and pilot programs, there is still considerable room for improvement in incorporating sustainability into the selection of DETs [5, 13, 20]. These points are discussed in this section.

The interview results show the focus on sustainability dimensions is imbalanced. Knockout criteria such as privacy receive greater priority, whereas accessibility and environmental considerations are given less emphasis [7, 18, 70]. For instance, the findings reveal that the environmental dimension is of lower priority for DET decision-makers compared to the social and technological dimensions. While the interviewees ranked the environmental dimension as a lower priority, many expressed their personal opinion that it should be ranked higher, especially given their institution's sustainability goals. The primary reason for this is the lack of relevant and good quality information and initiatives collecting DET environmental impact data [68] .

The underrepresented environmental criteria in DET selection also contrasts with the education research literature, where discussions about environmental sustainability have been ongoing for at least twenty years back [12, 71], and with the authors' observations at universities, where climate actions are in prominent presence. Notably, this contrast is more applicable to software environmental impacts (e.g., carbon emissions) than hardware impacts (e.g., e-waste) [33, 34]. A few interviewees mentioned existing e-waste recycling and disposal programs and hardware selection criteria but little policy and criteria regarding software impacts.

The availability of high-quality environmental impact data is essential for integrating the environmental dimension into DET selection criteria, which are largely absent today. Herth and Blok [68] reported an analysis of HEI's carbon footprint, highlighted the "poor data accuracy" and "high aggregation level" as limitations, and encouraged future investigations into more accurate "calculation approaches". As they put it, "real progress regarding these issues only seems possible when suppliers make their product's carbon footprint or material data available". The interviewees in our study also advocated for the important role of service providers in collecting and sharing accurate carbon emission data of their products with their clients.

It is informative to highlight the important role of the economic dimension and its implications for DET selection [22–25]. Although this study did not explicitly focus on the economic dimension, the interviewees unexceptionally brought up the topic of procurement price and maintenance cost as major criteria in their decision-making. Given that HEIs (and their IT departments) have limited financial and human resources, it is not surprising that economics plays a big role in procuring tools, often taking up to forty percent in criteria weightings. In DET selection, the economic factor is typically calculated as the total cumulative cost throughout the selection process, not only the cost of the tool and its services but also legal costs, tender costs, experimentation costs, etc.

The DET selection processes are often long and complex [65–67]. As mentioned in Sect. 4.1, the long and complex processes often motivate decision-makers to sign long (and often expensive) contracts so that they do not need to frequently repeat the selection process. The long process and long contracts reinforce the high costs and limit a university's ability to try new DETs and remove outdated DETs from its infrastructure. To that regard, an alternative shorter process could allow for a faster selection timeline, with shorter contracts that, in turn, allow decision-makers to essentially experiment with DETs with no long-term obligation. However, the trade-off therefrom is the potential pedagogical impacts and behaviour change push-backs users may experience if DETs are changed too frequently or if a significant minority of users do not want to switch DETs.

In response to that, HEIs could consider a multiple-systems approach by procuring a group of DETs users can choose from, and filtering out DETs based on the actual usage and users' feedback. This way, most users can use a tool they are satisfied with, while universities can procure DETs with shorter timelines and lower financial concerns. To achieve this systemic change, universities and grassroots actors (such as schools and other education institutions) can make collective efforts, e.g, to form a shared pool of DETs, and collectively negotiate with (often Big Tech) service providers regarding service conditions, including those of different sustainability dimensions. The collective may potentially influence the national and EU actors to modify the regulated tender process regarding DET procurement.

Given the importance of privacy and data security in European legislation [35, 36], many DET companies have begun adjusting their products to be GDPR compliant, hence gaining access to the European market. The so-called Big Techs are leading the market in this regard, while DET products from smaller companies have less presence in the market, especially during and shortly after the Covid-19 pandemic. While digitalization in HEIs is maturing, a more competitive DET market is anticipated, offering diverse options that incorporate different dimensions of sustainability. This will empower HEIs in DET selection and improve the quality of DETs in the long term. To that end, HEIs can also experiment with alternative products and adopt more pilot projects, which are not always included in DET selection processes, to get early user feedback, tool customization and smooth integration into the existing system and workflow.

6 Conclusion and future work

This paper explores how European Higher Education Institutions (HEIs) incorporate sustainability into their decision-making processes when selecting Digital Education Technologies (DETs). Related works in the literature primarily addressed the role of DETs in supporting sustainable education and the digital transformation of universities [13, 19, 20]. The sustainability of the DETs themselves is largely unexamined. A few that studied DET sustainability focused on individual dimensions of sustainability [33, 34]. This paper advocates a more holistic view of environmental, social, and technological dimensions of sustainability, highlights critical challenges and provides insight into the integration of sustainability considerations within digital education strategies. The findings indicate that while HEIs are making growing efforts toward sustainability through various initiatives and pilot projects, significant gaps remain in the incorporation of balanced sustainability criteria during the selection of DETs.

Despite efforts to integrate sustainability, the economic dimension continues to dominate decision-making processes [22–25]. HEIs can consider adopting a multi-criteria evaluation framework that balances economic considerations with sustainability dimensions. This framework can include assigning minimum weight thresholds to environmental, social, and technological dimension in the selection process to ensure they are not overshadowed by cost considerations. Furthermore, the emphasis across sustainability dimensions is unbalanced [7, 18, 70]. For example, knockout criteria like privacy are given more priority, while environmental considerations receive less attention. This is primarily due to the lack of available data and initiatives collecting DET environmental impact metrics [68], making it difficult for decision-makers to create relevant requirements. To address these issues, HEIs should advocate for greater transparency and collaboration with service providers to obtain data on environmental impacts, enabling more informed decision-making

The findings also indicate common challenges faced by decision-makers in sustainable DET selection, including limited resources and lengthy tender processes. By identifying these shared challenges, this research opens opportunities for actors to collaborate and implement potential solutions to enhance sustainability in DET selection. These findings are particularly applicable to institutions aiming to align their digital strategies with broader sustainability goals. They can inform policy-making at both institutional and national levels, ensuring that sustainability becomes a core component of digital transformation. Furthermore, this research underscores the need for cross-sector collaboration, where HEIs, policymakers, and DET providers work together to develop standards for sustainability metrics and criteria.

While the scope of the research is across EU higher education institutions, the interviewees were predominantly from northwestern Europe, with four out of ten from the Netherlands. The main reason for the geographical bias was the limit of the authors' network and responses to interview requests. Future research can include a more geographically diverse range of participants from across Europe to ensure that the findings are representative and applicable to a broader spectrum of European higher education institutions. Additionally, this paper focuses on the key decision-makers at HEIs regarding DET selections. Future research can expand the interviewee scope to actors such as service providers, education associations and tendering regulators. This can provide a more holistic view of the selection process, and can be beneficial to incorporate the voices of end-users, especially as they play a significant role in pilot projects and tool experimentation.

Acknowledgements The authors thank the interviewees of this research for their openness and valuable insights into digital education technologies in higher education.

Author contributions All authors contributed to the conception and design of the study. M.H. did the data collection, analysis, and interpretation. Ö.O., M.H., and Y.H. wrote the main manuscript text. All authors reviewed the manuscript.

Funding Part of this article has been written in the context of the Erasmus+ "C-FLEX" project, awarded with grant number 2021-1-IT02-KA220-HED-000032115. This project has been funded with support from the European Commission. This publication reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Data availability Data from the interviews cannot be shared openly to protect the participants' privacy.

Declarations

Ethics approval and consent to participate The procedure for the interviews of this study was approved by the Human Research Ethics Committee of Delft University of Technology. The informed consent to participate was obtained from all the participants. The informed consent to publish was also obtained from all the participants.

Competing interests The authors declare no competing interests.

Appendix A: Interview Questions

The interview questions are listed below in the order in which they are typically asked and broken down into 5 groups.

Introduction and context setting

1. How would you describe your role/position at your institution? What are your main responsibilities?
2. What criteria do you consider when selecting DET for your university?

Sustainability and DETs

3. For this study, sustainable digital education technology is defined as "any digital education technologies that promote or incorporate environmental, social, and technological sustainability in its design, development, use, and disposal" and contains 3 dimensions. How would you rank these dimensions in terms of importance when selecting DETs for your institution? Please explain your choice.

Selecting DETs

4. How are the sustainability dimensions incorporated into the DET selection process?
5. When was the last time you saw one of these dimensions considered in your university's DET decision-making process?

Challenges and struggles

6. Tell me about the hardest challenge you've faced with respect to selecting DET for sustainability.
7. How did you solve the challenge?

Organizational change and wrap-up

8. What is the most easily achievable change to make selecting DETs more sustainable at your institution, and how would you start going towards making it happen today?

9. Is there anything you wanted to mention that we didn't cover today?
10. Is there anyone involved in DET selection you would recommend I speak with either within or outside your institution?

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