BUILDING A SUSTAINABLE FUTURE OF EDUCATION

AN INVESTIGATION INTO THE SUSTAINABILITY OF DIGITAL EDUCATION TECHNOLOGIES IN EUROPEAN HIGHER EDUCATION INSTITUTIONS

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MSc Engineering and Policy Analysis

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Thesis report

by

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to obtain the degree of Master of Science
at the Delft University of Technology
to be defended publicly on September 28th, 2023

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Acknowledgements

I would like to start by expressing my gratitude to my thesis committee, Haiko van der Voort, Özge Okur, and Yilin Huang for their guidance, expertise and feedback throughout this project. Your insights have been instrumental in shaping the quality and direction of this research. I would also like to thank Lorenzo Angeli for being a soundboard and organizing the C-FLEX summer school in Trento, Italy, where I was able to dive deep into the topics of sustainability and digital education technologies among amazing peers and teachers. I also appreciate all the interviewees who participated in this study and made time to share their valuable experiences.

To the friends I made along the way, thank you for the laughs and memories. Janel for being a gracious host, friend, and mentor whenever I go to Barcelona and for helping me grow beyond a no-coder. Ash for all the travel recommendations and being a source of positivity. Peter, Maanav, V, Marya, and Shreyas for an unforgettable trip to India where no UNLEASHERs were left behind. Gerdus for all the Peach *ha-chaaas* in Smash and for having a name that I can practice pronouncing the Dutch *G*. Bo for hosting our weekly group lunch and keeping me up-to-date with everything Felix. Michiel for being the unapologetic embodiment of the geek inside all of us, but not necessarily for sharing the 40-minute video on the history of refrigerators. Rhys for your innovative hot chocolate machine invention and sacrificing your phone storage for our glimpses. And of course, Madison for being my partner through it all. From collecting bubble tea stamp cards to planning our next trip while we're already in another country, I'm excited to continue travelling with you once you catch up to One Piece by the end of the year.

Finally, I would like to thank my whole family for their continuous and unconditional support and love. To my parents Tammy and Sky, I am grateful for your constant encouragement and always being there for me. To my sister Maureen for the memes, Steady Hands cardigans, and shared obsession over One Piece. To my grandparents, aunts, and uncles in Taiwan who, while physically distant, have always made your presence felt over the past two decades. I look forward to spending the next year in Asia reconnecting with you and my roots.

Morris Huang
Den Haag, September 2023

Executive Summary

The digitalization of European universities' tool infrastructure has transformed how institutions operate and deliver education to students, from sharing content on learning management systems to hosting lectures on video-conferencing platforms. However, despite many new benefits of digital education technologies (DETs) and their contribution to reaching the United Nations Sustainable Development Goal 4 targets for Quality Education, it also comes with new challenges like user privacy, environmental impacts, and shifting power dynamics between institutions and service providers. Additionally, concerns have been raised regarding the responsible development and longevity of the university's digital infrastructure given the recent rapid digitalization trend and how new DETs are selected.

Sustainability assessment can be a useful model to evaluate an institution's DET selection process as it provides a holistic evaluation through a multidimensional perspective to develop a more responsible and future-proof approach to digital education infrastructure. However, a multidimensional sustainability analysis has not been applied in the context of DET selection. Therefore, it is unclear to decision-makers what sustainable DET looks like and what role sustainability plays in the DET selection process. This study addressed this gap by answering the following question: *How are European higher education institutions incorporating sustainability into selecting digital education technologies?*

The sustainability dimensions of DETs were formulated by conducting a literature review of contemporary models, encompassing the environmental, social, and technological aspects. A more sustainable DET increases the positive impact along each of these dimensions. An environmentally sustainable DET preserves and protects natural resources by reducing the environmental impact through its hardware and software. A socially sustainable DET increases equal access to education for all learners, regardless of socioeconomic status, disabilities, or geographic location while preserving individual privacy. A technologically sustainable DET is long-lasting, possesses the necessary functionalities, and balances a tool's simplicity, openness, and ownership. While most sustainability models include the economic dimension, due to the university's non-profit nature and the common prioritization of economic factors above other criteria in decision-making, this study excluded the economic dimension to examine the other dimensions more closely. Furthermore, the pedagogical dimension was omitted due to its sustainability considerations typically arising after the implementation of a DET, rather than during its selection stage and therefore is beyond the scope of this research.

Four key actors involved in the DET selection process were identified through an actor analysis. These include the university's *Head of IT* who oversees the institution's infrastructure system and their *IT tool specialists* who provide technical expertise, *service providers* whose products comprise the DET market, and *education associations* who help universities procure DETs. Ten semi-structured interviews were conducted with European university Heads of IT to gather data on the current DET selection process and the challenges institutions face when incorporating sustainability into DET selection.

The sustainability dimensions were used in conjunction with grounded theory open and axial coding analysis to evaluate the sustainability of current DET selection processes. The results showed that decision-makers predominantly utilize the EU-regulated tendering process to select DETs, which comprises minimal sustainability criteria while assigning significant importance to the economic factor (i.e., DET price). Additionally, interviewees shared they prioritize social and technological sustainability, specifically the privacy, data security, and functionality of DETs over other sustainability criteria. On the other hand, environmental sustainability is underrepresented in DET selection criteria. This is primarily due to the lack of available data and initiatives collecting DET environmental impact metrics, making it difficult for decision-makers to create relevant requirements and kickout criteria to compare DET options on the basis of environmental sustainability. Finally, the analysis illustrated the three most common challenges that hinder sustainable DET selection are the limited financial and human resources, the insignificant or lack of sustainability criterion weighting, and the long and inflexible tender process.

Overall, this study contributes to filling the knowledge gap in understanding the sustainability of current European universities' DET selection process and highlights key challenges decision-makers and researchers should focus on to improve the sustainability of digital education technologies. Future

research can build on this work by expanding the scope beyond Northwestern European institutions, interviewing other decision-maker actors, and developing a standardized selection process for sustainable DET selection.

Additionally, recommendations were made to the four actor groups as well as general advice for universities to increase DET sustainability. The Head of IT should prioritize the environmental aspect in DET criteria and collaborate with service providers to address environmental impact metrics. They should also encourage the development of new tools by teachers and students. The IT tool specialist should engage in co-development with service providers for better tool support and to ensure a secure and functional digital infrastructure. Service providers need to align their products with sustainability criteria, propose pilot projects to universities, and share environmental impact metrics with relevant stakeholders. Education associations should organize collective efforts to enhance the sustainability of the DET tendering process and offer streamlined services like joint procurement and model contracts to simplify the selection process. Universities could transition to renewable energy to reduce DET's carbon footprint, implement e-waste recycling and disposal programs, and support research into sustainable DET.

Contents

1
Introduction

The continuous development over the past couple of decades in digital education technologies (DETs) has unlocked the potential to address many global challenges in education while offering an opportunity to fundamentally transform how humans learn (Volery & Lord, 2000). DETs are technologies that support the digitalization of the learning experience and play a crucial role in reaching the 2030 Sustainable Development Goal 4 (SDG4) targets for *Quality Education* (North Wales Management School, 2022; United Nations, 2022). From hosting lectures using video-conferencing software to managing courses through education platforms, DETs have penetrated the education system beyond the classroom and have changed how students, teachers, and institutions facilitate education (Basilaia & Kvavadze, 2020; Shava, 2021). Furthermore, DETs have also made great impacts beyond SDG4 in reducing gender inequalities, raising people out of poverty, and training people with relevant skills for employment (Sustainable Development Goals Fund, 2017; United Nations, 2022). However, the increasing digitalization of universities' infrastructure has raised concerns about the sustainability of DETs, especially around privacy, environmental impacts, and power dynamics between institutions and corporations supplying the technologies (Bejinaru, 2019; Kagan et al., 2020).

This research addresses issues about increased digitalization in higher education institutions by investigating the sustainability of DETs in European universities. Specifically, how do institutions select DETs, what challenges do decision-makers face when selecting DETs, and to what extent does sustainability factor into the DET selection process? As universities move to become more sustainable, DETs must also be designed and used with sustainability in mind to meet their users' current and future needs (Brundtland, 1987; Velazquez et al., 2006). This study will contribute to bridging this knowledge gap in collaboration with C-FLEX, a project funded by Erasmus+ and the European Commission investigating the sustainability impact of European digital education infrastructure (C-Flex, 2022).

1.1. Digitalization of European universities

The excitement around digital education technologies' supposed power to solve global educational challenges and improve learning outcomes have led to its increased integration into universities over the past couple of decades (Sancho-Gil et al., 2019). This phenomenon of *digitalization*, defined as a process that "transforms existing products or services into digital variants", has changed how institutions operate and has political, technical, and environmental consequences (Angeli et al., 2022; Bejinaru, 2019). The following sections summarize three main trends and educational challenges as a result of university digitalization in European universities.

1.1.1. Increased speed of digitalization of education infrastructure

The general trend of digitalization in European universities has been on the rise and further accelerated by the COVID-19 pandemic when institutions rapidly scrambled together rudimentary digital infrastructures to support online learning (Crawford et al., 2020; Fiebig et al., 2021). DETs have provided great value to institutions by offering solutions to streamline, automate, and connect different actors and aspects of the education experience. Learning management systems, such as Brightspace and Blackboard, have been widely adopted as complementary interfacing platforms to traditional lectures that help facilitate content delivery and administration between students and teachers (Beatty & Ulasewicz, 2006; Francom et al., 2021). Zoom, Google Meets, and other video-conferencing tools became critical components in hosting online education throughout the pandemic and remain a regular tool today in greatly improving education inclusion by connecting people remotely for classes, meetings, and events (Basilaia & Kvavadze, 2020; Shava, 2021). Additionally, new educational tools like virtual reality headsets and games such as Kahoot! are expanding the pedagogical landscape (Campos et al., 2020; Ruiz & González Ruiz, 2021).

While universities doubtlessly have benefited from DETs, the accelerated speed of digitalization also introduced new challenges. A prime use case is users not knowing how to effectively use new DETs, often due to insufficient training or instructions, resulting in poor learning and user experiences. This was commonly exemplified by teachers during the pandemic who lacked the knowledge to use Zoom proficiently to teach virtually and keep students engaged (Soni, 2020; Toquero, 2020). Furthermore, pedagogical best practices take time to develop after DETs are selected by the university, and may not be able to keep pace at the rate new tools are added.

1.1.2. Centralization of digital infrastructure and power towards DET providers

Universities frequently outsource their digital and cloud infrastructure to third-party platforms that are usually owned by profit-driven companies (Angeli et al., 2022). European universities in the Netherlands and the United Kingdom have been migrating their core services to the public cloud since before the pandemic, primarily for its convenience and to reduce cost (Fiebig et al., 2021). Additionally, when the pandemic highlighted the unfulfilled niche in online education, companies and investors turned their eyes to the education technology market and seek an opportunity to capitalize on the growing market, which is expected to reach $429.5 billion USD by 2030 (Grand View Research, 2022).

The digitalization trend shifts the political power and autonomy of education control away from institutions and centralizes them in the hands of a few for-profit actors who increasingly monetize and monopolize the DET market. The cloud platforms that host universities' data are dominated by Google, Amazon, and Microsoft, whose primary objective is profit (Fiebig et al., 2021). This profit-first mindset puts the company's interest above those of the DET users and universities' primary objective of educating students. As universities become more dependent on these companies by outsourcing their infrastructure to them, institutions often have to comply with the company's choices and demands in order to operate at the detriment of the education system and people.

A recent example of this is Zoom, which has become the default tool for remote learning at universities since the pandemic (Soni, 2020). The institution's decision to use Zoom for hosting its classes forces its users to either accept Zoom's privacy agreements or not participate in class (Fiebig et al., 2021). Zoom has been under scrutiny for its use and control of user data, raising privacy and security concerns (Kagan et al., 2020). However, if students want to attend class, they are limited in the option and have to risk giving their data to Zoom. Similar cases are commonplace but universities continue to outsource and put their students, staff, and the education system itself into the control of companies.

1.1.3. Overemphasis on DET's ability to solve educational challenges

A trend seen in digitalization is getting tunnel-visioned and placing unfounded confidence in that technology can solve all problems while ignoring other variables and the complexity of the problem. This applies to education and can be seen in the increased number of policies corporations and schools propose to integrate more DETs into universities (Sancho-Gil et al., 2019). Setting aside obvious profit incentives for companies to push for more of their products in schools, these policies inappropriately claim DETs will be the key to solving educational challenges like increasing inclusion, promoting equality, or improving learning outcomes. Education is a complex and multivariate process, and previous research has found that while DETs play a critical role in solving educational challenges, technology alone does not improve learning or transform education significantly, and can sometimes even negatively impact the situation (Facer & Selwyn, 2021).

An example is SDG4's target to increase all people's access to education (United Nations, 2022). Learning platforms and digital content were scalable solutions that continue to educate millions of students, and have increased accessibility for people who are in remote and distant locations. However, they also exacerbated the digital divide for individuals who have unreliable internet and predominantly hurt those in lower socio-economic classes (Azad, 2021; Khan et al., 2021). During the pandemic, those without digital access were worse off before online education because now they cannot participate in classes that require DETs. Similar examples of mixed impact are observed for other metrics, such as alleviating teachers' workload and improving learning outcomes, and shows how these impacts are "context-specific" and "tied with socio-technical factors" (Facer & Selwyn, 2021). Universities need to face the challenge of discovering how new technologies may benefit and harm their students and staff in the broader education and social context and not be too narrowly focused on the DET itself.

1.2. Sustainability in education and DETs

Over the past two decades, sustainability has become a guiding principle for many policies, projects, and organizations to balance development and the environment to not impair future generation's ability to meet their needs while fulfilling current needs (Brundtland, 1987; Matthews et al., 2009; Velazquez et al., 2006). The establishment of the UN Sustainable Development Goals places sustainability at the centre of tackling the world's most pressing issues of climate change, social inequalities, and economic challenges (Purvis et al., 2019). With a looming future that will require urgent initiative in addressing these issues, it is essential to reflect on the development of education and DETs through sustainability.

Education is one of the most effective ways of achieving the SDGs and utilizing DETs has been an important factor in eliminating inequalities and reducing poverty (Muñoz-Rodríguez et al., 2020). However, as revealed by the recent pandemic, the current education system is fragile and incomplete with many shortcomings. In addition to the necessity to improve education systems to better foster future generations, the sustainability of education and DET also need to be evaluated to ensure longevity and contribute towards a sustainable future.

From a preliminary literature search, it was found that recent trends in educational technology research published in the Education Resources Information Center (ERIC), a database used by education researchers worldwide, did not focus on sustainability and was the second least researched DET topic between 2015 to 2020 (Yildiz et al., 2020). Most DET research focused on applications and impacts of DETs, students' and teachers' views on DET, and technology standards. The literature search highlighted the surprising absence of definitions of *sustainable digital education technology* or theories incorporating the multidimensional concept of sustainability into the DET selection process. These gaps contribute to the fragile education infrastructure as institutions lack a goal and process in why and how they can achieve DET sustainability.

While the literature on sustainability and DETs is smaller compared to other educational research areas, there are important insights to be found. With the trend of remote learning on the rise, many studies investigated the carbon emissions and the environmental impacts of digital education compared to face-to-face learning. It was found that online classes hosted on video conferencing platforms emit at most 7% of carbon emissions compared to similar classes run on school campuses (Andrae, 2019). Additionally, when combining the total carbon emission of a fully remote education that uses all digital content compared to printed books and supplementary materials, students only contribute 13% to 15% of the emissions of their in-person study counterparts (Roy et al., 2008). The main contributor to the reduction in emissions is the elimination of commuting to campus and allowing students to access classes from their homes. However, the carbon savings from running lecture hall appliances and printed materials also contribute to lower emission (Utaraskul, 2015).

Related environmental research on DETs has been conducted for both software and hardware emissions. While digital learning has demonstrated it can reduce overall environmental impact, software tools like Zoom still contribute to carbon emissions that can be reduced (Angeli et al., 2022). The accelerated rate of digitalization outlined in Section 1.1 has exponentially increased the amount of electronic waste (e-waste) generated on university campuses (Saldaña-Durán & Messina-Fernández, 2021).

Although environmental impact is a critical part of sustainability for education, it is only one perspective. Most of the literature on DET sustainability studied the environmental impacts of universities and DETs. Another cluster of literature discussed how to teach sustainability or advocate for sustainability initiatives in universities, but these do not directly answer how to make DET selection more sustainable (Colás-Bravo et al., 2021; Velazquez et al., 2006).

While recent papers since 2020 have shifted towards investigating the impact and aftermath of the digital education shift, there is currently a gap in a holistic look at how can actors and institutions make education infrastructure more sustainable. The importance of including additional sustainable perspectives in research such as social and economic dimensions relates to the trends highlighted in Section 1.1. Economic factors have already been demonstrated to influence institutions' willingness to integrate DETs for a lower cost. Increased corporate control and inappropriate use of user privacy and data are social challenges that need to be considered alongside the environmental impacts of education.

1.3. Knowledge gaps

Several knowledge gaps in digital education technology research have been identified above:

- Although the importance of sustainable education is stressed by the UN SDGs and research studies, the overall education literature does not focus on evaluating the sustainability of education digital infrastructure. Furthermore, the literature lacks explanations of the critical factors in building sustainable education infrastructure.
- The digital education technology research on the topic of sustainability focuses heavily on the environmental impacts of DETs and how to teach sustainability in universities. However, the literature is relatively lacking in other areas, such as social and economic dimensions, and generally does not explain how to make DET itself more sustainable. Furthermore, the sustainability dimensions are not well articulated on how they apply to DETs.
- Digital education technologies are increasingly introduced into European universities, but theories and processes around how to select appropriate DETs for a sustainable education system are absent or under-researched.

1.4. Research questions

Based on the research gaps and the scope of this project on European universities, this thesis will attempt to answer the following:

How are European higher education institutions incorporating sustainability into selecting digital education technologies?

Sub-research question:

1. What dimensions of sustainability should be considered in the context of digital education technologies?
2. How do decision-makers take sustainability dimensions into account during digital education technology selection?
3. What challenges do institutions face when incorporating sustainability into their digital education technologies?

These sub-research questions (SQ) follow a logical pattern to answer the main research question. By conducting a literature review, SQ1 attempts to understand how sustainability applies to DETs and which dimensions to include in evaluating DETs for sustainability. A subset of dimensions will be scoped from existing multidimensional sustainability models to be used for this study's data analysis. However, the excluded dimensions may be utilized in later discussions of research findings and provide necessary context. SQ2 takes the dimensions defined in SQ1 and investigates how these dimensions play a role in the current selection process of DETs through semi-structured interviews. Additionally, this question aims to understand how decision-makers prioritize the relative importance of each sustainability dimension in the selection process. Lastly, SQ3 uses actor analysis and SQ2's interview data to identify the challenges institutions encounter when incorporating sustainability factors into their decision-making process.

1.5. Report structure

The structure of the report is as follows. Chapter 2 delves into the literature to identify the sustainability dimensions for DETs to be used in later sections. Chapter 3 covers the methods chosen to answer each research question and relevant data collection and analysis approaches. Afterward, Chapter 4 presents the results from interviews and data analysis. Chapter 5 discusses the key findings and limitations. Finally, Chapter 6 summarizes the research, recommendations for actors, and shares suggestions for future work.

2
Literature Review

This chapter presents relevant literature and definitions for digital education technologies, sustainable digital education technologies, and sustainability dimensions for DET. Section 2.1 expands on the topic of DETs mentioned in Chapter 1 while Section 2.3 incorporates sustainability into the context of DETs. Definitions for both concepts will be included and used for the rest of the report. Finally, Section 2.4 establishes the set of sustainability dimensions for DETs to answer SQ1 and to be used for this study's data analysis.

The literature review for this study is collected through a variety of methods. First, relevant papers from thesis advisors and C-FLEX were reviewed. Next, a search through these papers' citations and articles citing these studies was done to identify the critical literature in the field. Additionally, literature searches followed by a snowballing approach were conducted using Google Scholar, ERIC, and Connected Papers databases to compile the final set of papers. Keyword combinations using ”education”, ”digital education”, ”digital education technology”, ”sustainability”, ”emissions”, ”inclusion”, ”accessibility”, ”university”, and ”Europe” was used and some search queries included the following. The asterisk wildcard was also used to expand the search possibilities by inputting the root word and adding ***** at the end (i.e. ”inclusi*”).

- ”digital education” AND ”university” AND ”Europe”
- ”digital education technology” AND ”emissions” AND ”sustainab*”
- ”digital education” AND ”sustainab*”
- ”university” AND ”inclusi*” AND ”accessibility”

2.1. Digital education technologies

As mentioned in Chapter 1, DETs are technologies that support the digitalization of the learning experience. This concept gained popularity in the 1990s when digital tools were first implemented in higher education institutions in the form of computer-based teaching during the rapid development of information technologies (IT) (Lacka & Wong, 2019; Leidner & Jarvenpaa, 1993). This digital integration marked an important branching in educational technologies, and it is worthwhile to expand on its terminologies. This study uses the term *digital education technologies* to refer to any device or system that creates, manages, and stores data for educational purposes. This is to distinguish from *non-digital educational technologies* such as whiteboards, physical textbooks, and stationaries which are not part of the research scope. It is important to emphasize this distinction since colloquially and in some literature, the term *technology* is often thought of or referred to as digital technology (Pirhonen & Rousi, 2018). To avoid misinterpretations, this study will strictly study and use the term *digital education technologies (DET)* in the rest of the report.

Since the introduction of computers in universities, the concept of DETs has undergone iterations as it expanded beyond the classroom to fill niches in the university infrastructure system. As shown in Table 2.1, the concept of DET clusters into 3 main categories and the definition has shifted through time.

Table 2.1: Selected digital education technologies definitions organized into 3 main categories.

Category	Source	Definition
Theory & pedagogy	Lamb, 1992	- Digital education technology is ”an innovative process linking teaching and learning outcomes rather than a product which is dropped into the black box of teaching and learning outcomes defined as improvements on standardized test scores.”
	Seels et al., 1995	- Digital educational technology is ”the theory and practice of design, development, utilization, management and evaluation of processes and resources for learning.”
Learning management & administrative systems	Januszewski and Molenda, 2013	- Digital ”[e]ducational technology is the study and ethical practice of facilitating learning and improving performance by creating, using, and managing appropriate technological processes and resources.” - ”[E]ducational technology ... facilitate[s] learning rather than to cause or control learning; that is, it can help create an environment in which learning more easily could occur.”
	Guerra Núñez et al., 2014	- Digital education technology is any ”hardware ... or software ... that aid the processes of learning in both school and home settings.”
Connective & communicative tools	Pirhonen and Rousi, 2018	- Digital education technologies are ”artifacts and systems substantiated by IT and designed with the intention of being utilized in the context of learning.”
	Guney, 2019	- Digital ”educational technology allows students to communicate with each other and with instructors across time and space.”
	Cueva and Inga, 2022	- Digital education technologies ”are defined as technological techniques or tools that help teachers and students understand subjects in a better way.”
	Haleem et al., 2022	- ”[D]igital technologies have made a paradigm shift in the entire education system. It is not only a knowledge provider but also a co-creator of information, a mentor, and an assessor.” - ”Digital technologies are a powerful instrument that can help improve education in various ways, such as making it easier for instructors to generate instructional materials and providing new methods for people to learn and collaborate.” - ”Digital technology in the classroom refers to various software and gadgets meant to help students with particular accessibility needs”
	Sokhulu, 2020	- ”Digital [education] technologies refers to hardware and software resources that produce, share, and store information electronically” for educational purposes.
	Kerras et al., 2022	- Digital education technology is ”the implementation of information and communication technologies in education, in order to support learning processes at different levels, both formal and non-formal education.”

The first definitions emerged in the early 1990s when computer-based teaching was first introduced in universities. The early concepts focused on DETs as a **theory and pedagogical practice** of educational approaches to learning. The Association for Educational Communications and Technology (AECT) defines DETs as ”the theory and practice of design, development, utilization, management and evaluation of processes and resources for learning” (Seels et al., 1995). This emphasis on learning theory and design is a result of new pedagogical approaches appearing around this time that utilized the new DETs.

By the late 1990s, DETs and their definitions had evolved from limited-purpose tools to multi-functional systems in the form of **learning management systems (LMS) and administrative sys-**

tems. These systems fundamentally changed the universities' operational infrastructure as DETs began to optimize administration tasks and streamline education delivery. From Table 2.1, definitions in this category highlight DET's role in "facilitating learning ... by creating, using, and managing appropriate technological processes and resources". LMS are platforms that manage educational content, host lectures, and facilitate student-teacher interactions, while administrative systems handle logistical, budgetary, and data management tasks (Beatty & Ulasewicz, 2006). The first LMS, FirstClass, was used by the United Kingdom's Open University and featured "private email and public forums, allowing students to ask questions and clarify theory presented in learning modules" (Chaubey & Bhattacharya, 2015). Since then, LMS has become the most widely used DET and software like Blackboard, Canvas, and Brightspace are part of most European universities(Francom et al., 2021).

As the internet, social media, and videoconferencing platforms became more commonplace in the 2010s, a third category of DET definitions shifted toward tools and media that promote the global **connection and communication** of education. These latest definitions focus on the accessibility and connectivity of DETs, emphasizing the ability to be educated "across time and space" (Table 2.1) (Guney, 2019). From massive open online courses (MOOCs) like Coursera to Khan Academy YouTube videos to virtual classrooms, education is no longer limited to the physical university classrooms (Alario-Hoyos et al., 2013; Haleem et al., 2022). Furthermore, improvements in videoconferencing software, greater access to the internet, and increased ownership of digital devices contributed to hybrid and online education's rise in popularity in recent years and were instrumental in facilitating education throughout the COVID-19 pandemic. Most recently, artificial intelligence like ChatGPT has emerged as a major player that could significantly impact the education system and could bring about a new wave of change for DETs (Halaweh, 2023).

2.2. Definition for DET

While the definition of DET has shifted over the past 3 decades since its introduction to universities, they all share a common description of digital technology's role in enhancing the effectiveness and efficiency of teaching and learning processes. Based on the above analysis, this study defines digital education technologies as *any digital device or software that improves the efficiency, learning outcomes, ease of use, or accessibility of the education system*. In this definition, the education system includes the actors that are part of the system. Therefore, technologies that benefit actors, such as personalized learning paths for students created by an LMS that better suit each learner's need, fit the chosen definition because the students are benefiting from the DET.

2.3. Sustainable digital education technologies

The concept of sustainable education was studied before the establishment of the Sustainable Development Goals but gained more academic interest after its introduction. In 2006, Velazquez et al. proposed a systematic procedural model for transitioning higher education institutions to sustainable universities, and since then much research has gone on to explain the benefits and importance of incorporating sustainability into the education system. From reducing carbon emissions to increasing accessibility through online learning, most research emphasizes the central role DETs play in realizing sustainable education but do not go into the concept of sustainable DET itself (Saldaña-Durán & Messina-Fernández, 2021). The subject of sustainable DET in education research has been reduced to a "means of achieving enhanced learning outcomes" "to enable the development of a sustainable education system" (Grebennikova et al., 2021; Napal et al., 2020). This section addresses this literature gap by exploring the concept of sustainable digital education technologies and generating a definition by reviewing the role of DETs in the context of sustainable education. The sustainability dimensions will not be discussed here as they will be covered extensively in Section 2.4.

To discuss sustainable DETs, the terminology for *sustainable education* needs to first be introduced. Sterling and E.F. Schumacher Society. (2001) defined sustainable education as "a systemic change of educational culture towards the realization of human potential and the interdependence of social, economic and ecological well-being", echoing Velazquez et al.'s systemic model and Purvis et al.'s three pillars of sustainability. Similarly, Anghel and Neculau (2022) describes it as a "result of some continuous actions of design and implementation of an educational process, adapted to the challenges of the future, for all sectors of social life". This integrates Brundtland's sustainability concept of meeting both current and future needs. Finally, the United Nations defines sustainable education through its

SDG4 as a system that ”ensure[s] inclusive and equitable quality education and promote[s] lifelong learning opportunities for all” (United Nations, 2022). For this study, the SDG terminology will be taken as the definition for sustainable education as it broadly encapsulates the other definitions.

As a subset of DETs, sustainable DET shares the core definition with additional characteristics added to it. Primarily, sustainable DETs promote or incorporate sustainability into their design, development, use, and disposal. For example, LMS promotes equity and lifelong learning through its flexible and personalized curricula (Grebennikova et al., 2021). Alternatively, hosting lectures on videoconferencing software incorporates sustainability into its usage by removing the need for people to commute to classes, thus removing the potential carbon emissions (Andrae, 2019). The additional characteristics shift the DET to align with the mission of achieving sustainable education.

The impact of sustainable digital education technologies can be significant. They can contribute to achieving the SDG targets by promoting environmental awareness, social equity, and economic prosperity. For example, digital textbooks and online learning platforms can reduce paper waste and decrease the carbon footprint of education by eliminating the need for physical textbooks and reducing travel to and from traditional classroom settings (Roy et al., 2008). Moreover, virtual and augmented reality simulations can provide immersive and interactive learning experiences that promote environmental stewardship and social responsibility, such as simulations of sustainable urban planning and renewable energy technologies (Freitas & Neumann, 2009).

It is important to note that sustainable DETs differ from conventional DETs in that they prioritize sustainability considerations. Sustainable DET may aim to minimize its environmental impact, whereas a conventional DET may contribute to environmental degradation through the production, use, and disposal of e-waste (Saldaña-Durán & Messina-Fernández, 2021). Furthermore, sustainable DET aims to promote environmental, social, or economic sustainability through their educational content and design, while conventional DETs may prioritize efficiency and cost-effectiveness over sustainability considerations (Purvis et al., 2019).

2.4. Sustainability dimensions for DETs

Sustainability is a subject that has gained increasing attention in recent decades due to its importance in promoting a healthy environment and equitable society. While Brundtland defined the concept broadly as ”meet[ing] the needs of the present without compromising the ability of future generations to meet their own needs” in 1987, sustainability remains an open concept with many context-specific interpretations. A dominant description of sustainability is composed of three interrelated dimensions: environmental, social, and economic (Purvis et al., 2019). Without considering all three dimensions simultaneously in sustainability development, environmental degradation can negatively impact social and economic well-being, while social inequality and economic instability can have detrimental effects on the environment. An interdependent dimensional model brings the discussion of trade-offs between dimensions to the forefront and helps problem solvers address multiple perspectives holistically to better achieve a sustainable society.

In the context of sustainability for DETs, additional dimensions have been proposed to provide a more complete evaluation of the topic, predominantly the technological and pedagogical dimensions (C-Flex, 2022). In this section, the five aforementioned dimensions will be examined for their relevance to this study by expanding on each concept through a literature review to justify its inclusion or exclusion from the final set of dimensions to be used in this study’s analysis. It is important to note that while a dimension may be excluded from analysis, it may still be incorporated later in discussing research results, such as illustrating trade-offs between dimensions decision-makers encounter when selecting for DETs.

2.4.1. Environmental

The environmental dimension focuses on the protection and preservation of natural resources, ecosystems, and biodiversity. According to Morelli (2013), the ”maintenance of natural capital” involves the management of human activities in ways that minimize negative impacts on the environment as it provides the foundation for human societies to exist and thrive. Consequently, environmental sustainability encompasses a range of issues, such as climate change, air and water pollution, and the depletion of natural resources. Addressing these issues requires the development of policies and practices that balance human needs with the need to protect and preserve the natural world. While digital education technologies bring benefits to the education system, the adoption and use of these technologies also have environmental impacts that need to be considered. In the context of digitalizing education, hardware (i.e. electronic waste) and software (i.e. carbon emissions) are the top contributors to environmental pollution (Iyer, 2014; Ong et al., 2014).

The production and disposal of electronic devices such as computers, smartphones, and tablets used in universities contribute to environmental degradation. The extraction of raw materials and inappropriate disposal of e-waste, typically in open-air dumps without any special handling, introduce hazardous substances into ecosystems (Saldaña-Durán & Messina-Fernández, 2021). Furthermore, the increased 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 (Angeli et al., 2022). In 2019, 12.1 million tonnes of e-waste was generated in Europe alone (Andeobu et al., 2021).

Similarly, while DET software usage may not generate physical waste, the energy consumption associated with the operation of servers, data centers, and the internet are significant contributors to greenhouse gas emissions. For example, despite the more than 90% decrease in carbon emissions by hosting lectures online as opposed to in person by removing the need for commuting, the use of much videoconferencing software such as Zoom is not energy-efficient (Roy et al., 2008). A Zoom lecture hosted in Trento, Italy has its data routed to Germany and back, which is a substantial distance travelled when most of the participants are joining from the same city (Angeli et al., 2022). Additionally, 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 (El Geneidy et al., 2021).

In view of the environmental impact of the adoption and use of DETs from both hardware and software, it is critical to include the environmental dimension in this research. Its relevance can also be seen by the call to action for European higher education institutions to adopt sustainable strategies to address their contribution to environmental degradation (Saldaña-Durán & Messina-Fernández, 2021). Universities, such as the Delft University of Technology, have begun to study the direct and indirect carbon emissions at their institutions to quantify the environmental impacts of DETs (Herth & Blok, 2022). Additional research topics are proposed to study the number of unused and underused DETs, upcycling hardware to extend the technology's life cycle, and self-host DET systems to reduce energy consumption (Angeli et al., 2022). Many European institutions have also started operating e-waste management systems and getting formally certified by conforming to international environmental standards, with the best known being the International Standardization Organization's ISO 14001 and European Union's EMAS (Eco-Management and Audit Scheme) (Disterheft et al., 2012; Saldaña-Durán & Messina-Fernández, 2021).

2.4.2. Social

Social sustainability is the dimension that promotes social equity, equal access, privacy, autonomy, and fairness for individuals and communities (Waas et al., 2011). Chiu (2006) 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 the underlying assumption that social equity and well-being are fundamental human rights, and promoting them is necessary for creating a sustainable and just society (Soken-Huberty, 2022). In the context of DETs, social sustainability involves ensuring all learners have equal access to education, regardless of socioeconomic status, disabilities, or geographic location while preserving individual privacy. This includes addressing issues of social exclusion and inequality that may arise from the use of DETs, such as the digital divide between rural and urban communities (Esteban-Navarro et al., 2020). Additionally, social sustainability in DETs involves promoting digital literacy and digital citizenship, and ensuring that learners have the skills and knowledge to use digital technologies in ways that support sustainable development (Ghosn-Chelala, 2019). Several key themes emerged from the literature on the social sustainability of DET.

First, DETs have been demonstrated to promote access to education, particularly in underserved, marginalized, and rural populations (Lai, 2011). 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 (Crick, 2021). 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 (Azad, 2021).

Second, DETs, directly and indirectly, influence inclusivity in education. LMS, online learning, and increased digital device ownership are some factors that have positively increased inclusion in education by accommodating different learning styles, reducing inequalities (e.g. gender), and enhancing educational experiences for students with disabilities (Beyene et al., 2020; Kerras et al., 2022; Silver, 2019). However, inclusive education research has also shown that while mobile phone penetration, internet penetration, and fixed broadband subscription positively influence gender parity, cultural and socioeconomic factors have greater influence than DETs because they limit a person's access to technologies (Asongu et al., 2019). Therefore, it's important to influence the cultural and socioeconomic factors in tangent with implementing DETs to increase access.

Third, the collection and use of sensitive data, such as user behaviour, personal information, and student performance, have been repeatedly highlighted in research as major security and privacy concerns for DET users (Kim, 2021). Zoom has been exemplified as a platform where user data can be easily exacted and shared publically, thus jeopardizing users by posing serious privacy breaches (Kagan et al., 2020). Additionally, DETs including artificial intelligence learning support have design limitations that have racial, cultural, and gender bias, thus contributing to social unsustainability (Santos et al., 2022).

Considering the accessibility, inclusion, and security concerns is essential to ensure that DETs are used responsibly and ethically, safeguarding the rights and privacy of all individuals and promoting social sustainability. Therefore, the social dimension will be included in this study's sustainability analysis.

2.4.3. Economic

The economic dimension has historically been a main source of disagreement in sustainability research, with a spectrum of competing thoughts on the economic dimension and how it relates to the environmental and social dimensions (Purvis et al., 2019). One end subscribes to the idea that economic growth, at least at the current rate, perpetuates inequalities and is repeatedly the cause of social and environmental sustainability. The frequent sustainability imbalance due to the prioritization of economic growth over the other dimensions has prompted some researchers to limit the economy's role in sustainability discussions. Hancock (1993) calls for the economy to be "subservient" to the community and environment, while Milne (1996) similarly states "sustainability requires the subordination of traditional economic criteria to criteria based on social and ecological values". Proponents of this side of the sustainability spectrum view economic growth as an entity that needs to be restricted, rather than something where trade-offs should be made (Purvis et al., 2019).

On the other side, economic growth is believed to be a solution to sustainability issues. The advocates argue that growth is the key to meeting social and environmental goals since economic growth will have trickle-down effects, such as alleviating poverty, which will, in turn, reduce environmental degradation and improve human well-being (Castro, 2004). Brundtland (1987) calls for economic "growth that is forceful and at the same time socially and environmentally sustainable". The UN is a supporter of this view and the SDGs are created with the implicit assumption that economic development is required to reach its SDG targets. However, this circular argument of placing economic growth as the solution to sustainability as opposed to a barrier deflects criticisms from the other side of the spectrum and blurs the definition of sustainability (Purvis et al., 2019). While some researchers have taken a more neutral stance toward economic growth's role in sustainability, many compromise the dimensional trade-offs by suggesting "economic growth as an engine for long-term welfare creation" that should "not [be] at the expense of the environment or social well-being" (Purvis et al., 2019; Waas et al., 2011).

In the context of DETs, the economic cost and efficiency have played a significant role in how and where digital infrastructure has been built, both in Europe and globally. A prime example is the economics behind the outsourcing of digital infrastructure in universities. By externalizing services and infrastructure to third-party providers, the institutions reduce both infrastructural and human costs (Angeli et al., 2022). Additionally, as technological advances make services more effective and efficient, data centres can be relocated to countries with cheaper electricity, land, and wages at the expense of increasing the distance data travels and carbon emissions. This practice benefits these institutions and their countries, such as the Netherlands, as they outsource their pollution to other countries that host the data centres (Fiebig et al., 2021).

While there are major conflicting schools of thought on the economic dimension, it has been frequently prioritized over other sustainable dimensions in the pursuit of economic growth and efficiency, thus resulting in net negative sustainability progress. Although it is clear this dimension is important in the discussion of sustainability, it often takes the spotlight and does not allow a thorough examination of potential solutions that may have higher costs but yield positive results in other sustainability dimensions.

This study will exclude the economic dimension in its analysis to examine the other dimensions without the potential derailment into discussions of economic cost-benefit. Since a university's primary objective is fostering an environment for education and is not profit-seeking, it is not the most critical to focus on minimizing economic cost if the cost significantly improves other sustainable dimensions. However, this does not mean this research will ignore any economic components in its analysis. As it is necessary for any recommendations for decision-makers to be economically viable, research findings will be discussed alongside financial and budgetary factors. Specifically, insights are examined for trade-offs between a DET's cost and other dimensions during the DET selection process and how decision-makers can mitigate this traditional trade-off to maximize sustainability along all its dimensions. Furthermore, by removing the focus on the economic dimensions, trade-offs between other dimensions may emerge.

2.4.4. Technological

Technological sustainability investigates what makes DETs technologically functional and long-lasting from a design and implementation perspective. There are three key components to this dimension: simplicity, openness, and ownership (Davis et al., 2010). Similar to the three pillars model for sustainability (environmental, social, economic), the interrelationship and trade-offs between these components are essential in creating sustainable digital education technologies that are user-friendly, inclusive, and viably long-term.

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. Naveh and Shelef (2021) found that students prefer using similar technology for learning to those they use in their personal lives. Using a familiar tool increases the simplicity and ease of use because instead of viewing the DET as an administrative or logistical learning tool, it is perceived as an extension of what they are used to and the DET is more appealing to use. 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 (OCED, 2015)

Openness refers to the accessibility and inclusivity of the DET and promotes collaboration, sharing, and joint innovation between users (Lane, 2009). The concept of openness in DETs is not new and various definitions have existed over the past 40 years, but all centre around the idea of open educational resources. Schaffert and Geser (2008) defines open educational resources through its four core attributes, listed below. 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.

- **Access**: Educational content, such as lecture resources, assignment materials, and metadata, are provided free of charge.
- **License**: DET licenses are provided for re-use in educational activities. Ideally, the licensing is free, but it can have different paid tiers that grant various levels of access such as editing privileges.
- **Format**: The format of the DET is designed for easy re-use. This means that in addition to the content being open, the user interfaces, user flow, and user experience allows for easy access and use of the content.
- **Software**: The DET is produced with open-source software. This also ensures that all new DETs developed with this software are also open-source.

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

Komljenovic (2021) 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 (Komljenovic, 2021). Increasing DET ownership can reduce institutions' dependency on DET providers and increase user data security.

However, digitalization has led to an increasing amount of European universities, such as institutions in the Netherlands and the United Kingdom, to become less simple, less open, and less ownership (Fiebig et al., 2021). In Figure 2.1, a couple of trends can be observed. First, there is a general increase in digitalization across all universities, including institutions in countries like Germany and France where total digitalization is less than 50%. Second, digitalization is largely dominated by the same selected Big Tech companies (i.e. Microsoft, Google, Amazon), indicating universities are becoming increasingly dependent on DET renters. These trends indicate a gradual erosion of ownership as Big Tech companies move towards more subscription cloud services and rent out licenses to institutions for DET access. This introduces a less open and fragile education infrastructure as universities are dependent on these companies for major aspects of their operations, data storage, and digital platforms. For example, if Google decides a service is no longer financially viable, it could shut the service down, impacting many universities' that are using that service.

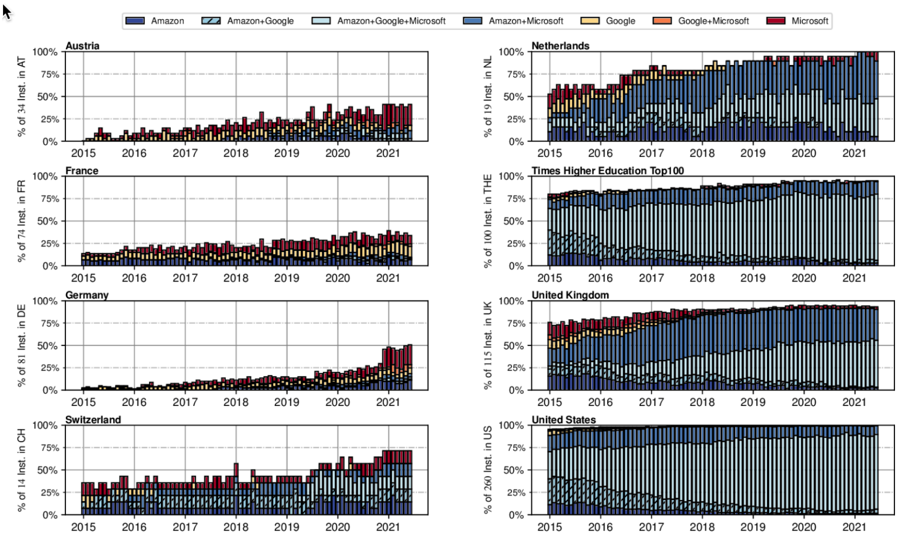

Figure 2.1: Increasing digitalization of European universities (Fiebig et al., 2021)

In summary, it is critical to consider the technological dimension of a DET for this study to understand how to make education functional and long-lasting. This can be evaluated by considering the simplicity, openness, and ownership components of the DET across its design and implementation.

2.4.5. Pedagogical

The pedagogical dimension examines how teaching and learning methods adapt to new DETs. As they have come to play a more significant role in different aspects of the education system, pedagogical forms have evolved concurrently to match the introduction of new DETs in order to utilize these tools to deliver better educational experiences and outcomes. Leshchenko et al. (2021) describes the assessment of DET pedagogy to involve the study of the DET's "purpose, objectives, [and] teaching strategies". Some criteria researchers used to study DET pedagogy include the degree of students' ability to use the DET to access educational resources, interactivity on the platform (e.g. feedback, student-teacher communication), and quality of teaching approaches. These criteria help educators and technology designers better understand how effective their current pedagogy method is in relation to the DET and inform them how the technology and pedagogy may improve to achieve better outcomes.

The pedagogy of personalized learning through LMS has been studied in recent years as it is one of DET's most anticipated opportunities. Due to the immense burden of tailoring learning for each student based on their interests, strengths, and needs, this type of education can only be attempted by utilizing DETs. This causes a pedagogical shift away from the traditional lecture-style method to a blended learning method that employs a mixture of digital learning and teacher-led schooling (Basham et al., 2016). In addition to changes in how educators teach, personalized learning also places a greater responsibility on the students as they now have to self-regulate in following their individual online curricula. Dabbagh and Kitsantas (2005) highlighted that additional DETs should be implemented to provide scaffolds for self-regulated learning so students are supported and are not lagging behind. This example demonstrates the complexity and the large number of pedagogical iterations required based on the decision to implement DETs for personalized learning.

However, pedagogical evaluations and iterations typically come after the DET has already been selected and implemented. As shown by the swift adoption of videoconferencing software during the COVID-19 pandemic, pedagogical adaptations for online learning largely occurred after universities' decision for the digital shift (Puffelen et al., 2022). While educators may estimate and prepare for pedagogical changes, it is only after the DET has been integrated into the infrastructure can these new methods be tested. Therefore, this study will exclude this dimension from its analysis as it does not fall within the scope of DET selection.

2.5. Definition for sustainable DET

The final set of sustainability dimensions this study will use are **environmental**, **social**, and **technological** (Table 2.2). While the economic and pedagogical dimensions are excluded for falling outside the scope, both dimensions are important and can be future research topics. From the above analysis, sustainable digital education technologies can be defined as *any digital education technology that promotes or incorporates environmental, social, and technological sustainability in its design, development, use, and disposal*. This may include the technologies that reduce the carbon footprint of education, promote social equity, or increase ownership of DETs.

Table 2.2: Sustainability dimensions with definitions, examples of what a more sustainable DET for each dimension could be, and the total number of papers from the literature review that references each dimension.

Dimension	**Definition**	**Example of greater sustainability**	**Number of papers**
Environmental	DET that protects and preserves natural resources, ecosystems, and biodiversity through the environmental impact of its hardware and software.	Less CO2 emission, recycling e-waste	17
Social	DET that ensures all learners have equal access to education, regardless of socioeconomic status, disabilities, or geographic location while preserving individual privacy.	Language translation feature, transcriptions, video recordings	10
Technological	DET that is long-lasting, possesses the necessary functionalities, and balances the simplicity, openness, and ownership components.	Open sourced software, simple user experience	6

Similar to the three pillar models described by Purvis et al. (2019), the three selected dimensions are considered to be interconnected. Therefore, the *overall sustainability* of a DET will be composed of optimizing the three dimensions and considering context-dependent variables. The optimization of dimensions will include the exercise of managing trade-offs between dimensions during the decision-making process. An example could be choosing a less functional DET for its lower carbon emission. Additionally, sustainability needs to be evaluated in the context the tool is chosen. For example, during the COVID pandemic, speed of integration was the most important criterion as universities shifted to online education within weeks. Less sustainable DETs were selected by institutions over their more sustainable alternatives on account of their faster implementation. However, these choices have led to vendor lock-ins and switching costs as universities now face challenges replacing less sustainable tools after re-evaluating these DETs in a post-pandemic scenario.

3
Research Methods

This chapter details the research design, methodology, and data sources to answer the research questions presented in Chapter 1. First, the choice of semi-structured interviews for the data collection step is explained along with the interview protocol, candidate persona, and questions. Next, the actor analysis and grounded theory approaches are introduced for the data analysis step to process the interview data and extract insights.

3.1. Data collection

To answer SQ2 and SQ3 using the sustainability dimensions defined in Section 2.4, the perspectives of DET decision-makers in European universities were collected through semi-structured interviews. Semi-structured interviews were used to flexibly adapt the question order and allow for the interviewee's expertise and answers to dictate the conversation direction. Interviews were chosen over other data collection methods such as surveys because of the option to follow up on the respondent's answers and investigate topics more deeply. While surveys can reach a wider audience and gain a more representative sample group, semi-structured interviews were deemed more appropriate for this research because of the knowledge depth achievable through these conversations. Appendix A includes the interview protocol and questions developed in alignment with the research questions. All interviews were conducted online out of convenience and because interviewees were sampled across Europe, making in-person interviews impractical. However, there are no significant differences in hosting interviews virtually since all interviewees had access to and were familiar with the Microsoft (MS) Teams platform and the interview required no physical aids or materials.

The interview questions were constructed based on the findings from Chapter 2 using strategic interviewing theory and grouped into the following sections. *Introduction & context-setting* questions ask for the interviewee's background and set the context for the rest of the conversation. The *sustainability & DETs* questions introduce this study's sustainability dimensions and invite the interviewees to share their current understanding of DET sustainability. The *sustainable DET dimensions* sections include questions framed specifically along each of the three dimensions to deeply explore the sustainability of the DET selection process. *Selecting DETs* questions walk through the institutions' current DET selection process while *challenges & struggles* questions examine the roadblocks decision-makers face when incorporating sustainability into these processes. Finally, the *wrap-up & organizational change* questions conclude the conversation with final recommendations and brainstorms with the interviewee on how they may increase the sustainability of their university's DET selection process.

The required questions for each section can be found in Table 3.1 and the complete set of questions are listed in Appendix A. Questions were identified to be required if it was necessary to answer either SQ2 or SQ3. Optional questions were asked if there was extra time or were relevant in the context of the conversation. Strategic interviews ask the subject to place themselves in different possible future scenarios to better understand the subject's thought process, mental models, and underlying assumptions (Ratcliffe, 2002). Many strategic interviewing questions revolve around talking out loud about desirable/undesirable outcomes, how to achieve/avoid these outcomes, and what current events contribute to these different outcomes.

Strategic interviewing techniques were implemented to devise this study's questions and interview flow for several reasons (Ratcliffe, 2002). First, strategic conversations are useful to conceptualize the mental models of the decision-makers. Question 5 (Q5) asks interviewees to rank the sustainability dimensions in order of importance when selecting DETs, which explores the framework they use for decision-making. MS Powerpoint was screen-shared during the call to aid interviewees during this ranking exercise. Second, it surfaces challenges the interviewee is concerned about in the future and constructs potential actionable steps to address them. Q17 leads the interviewee to verbalize the key hardest challenge they face with selecting DET for sustainability and Q19 asks them to define what is one change they can make today to start addressing that issue. Third, strategic interviews help elicit insights into the interviewee's decision-making process. Q3 navigates the interviewee's selection criteria and processes, which can shed light on their decision assumptions and primary concerns.

Table 3.1: Required interview questions

Category	Question
Introduction	Q1. How would you describe your role/position at your institution? What are your main responsibilities?
	Q3. What criteria do you consider when selecting DET for your university?
Sustainability & DETs	Q5. 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 (below). How would you rank these dimensions in terms of importance when selecting DETs for your institution? Please explain your choice.
Selecting DETs	Q12. How are the sustainability dimensions incorporated into the DET selection process?
	Q13. When was the last time you saw one of these dimensions considered in your university's DET decision-making process?
Challenges & struggles	Q17. Tell me about the hardest challenge you've faced with respect to selecting DET for sustainability.
	Q18. How did you solve the challenge?
Wrap-up & organizational change	Q20. 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?
	Q22. Is there anything you wanted to mention that we didn't cover today?
	Q23. Is there anyone involved in DET selection you would recommend I speak with? Either within or outside your institution.

A critical aspect across the interviews was to align the interviewees with the research's definition of sustainability, its three dimensions, and its application in the context of DET selection to ensure the interviewees' responses were comparable during the data analysis step. This was done during Q5's dimensional ranking exercise. When the Figure 3.1 template was screen-shared, the interviewee was presented with short descriptions of the three dimensions. Using these descriptions, the interviewee was given a quick explanation of the research's sustainability definition and dimensions and asked if they understood. If they had questions, they were answered appropriately before starting the ranking exercise.

Interviews were conducted virtually through MS Teams following Busetto et al.'s (2020) qualitative interview method and the strategic conversation techniques outlined above. The audio and video for all decision-maker interviews were recorded for transcription purposes and stored on secure TU Delft OneDrive. MS Powerpoint was used during Q5's dimensional ranking exercise and stored on OneDrive. A total of 13 interviews were conducted between April and May of 2023. Information on the interview persona, dates, and further details are summarized in Appendix A.

3.2. Interview candidates & personas

The interview candidates were selected based on their experience with their institution's DETs along with their position and degree of involvement in the DET selection process and can be categorized into

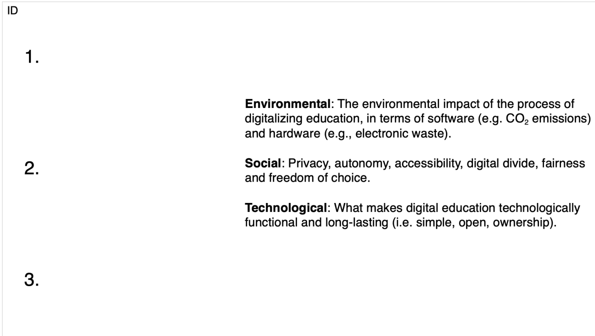

Figure 3.1: Q5 Dimensional ranking template

two candidate personas: **decision-makers** and **subject experts**.

This study defines decision-makers in the formal sense and refers to key actors who participate in their institution's selection of DETs and often have the power to significantly affect the decision outcomes. Therefore, it does not include actors who may possess informal power and influence. This distinction is made due to the bureaucratic nature of the DET selection process as it undergoes highly regulated channels and the actors capable of exerting the greatest influence to increase the process's sustainability are those in formal positions. Hence, while students, teachers, and university staff may have an influence on a tool's selection as they are the end users, they are not categorized as decision-makers. People considered to be in this group typically hold titles such as *Head of IT, Chief Information Officer* or *Vice-president for ICT*, or are deeply involved with those individuals. These candidates are the main target for this study as their responsibilities for coordinating their university's IT strategies, processing DET requests, and applying relevant IT regulations such as the European Union's General Data Protection Regulation (GDPR) largely determine the institution's DET selection criteria, objectives, and processes. Therefore, these candidates have the most context and influence over DETs and the inclusion of sustainability in their selection. A total of ten 1-hour interviews were conducted as described in the interview protocol with 4 Dutch, 2 Finnish, 2 Irish, 1 Italian, and 1 German decision-maker. These interviews were recorded and transcribed for the data analysis step described in Section 3.3. Due to candidate availabilities, the NL3 interview was conducted with 2 decision-makers in a single call and the NL4 interview was only 30 minutes long. In both cases, only the required questions outlined in Table 3.1 were asked due to time constraints. This did not greatly affect the data collection from these interviews as they were able to provide insight into the required questions.

Subject experts on the other hand are individuals whose responsibilities are adjacent to the decision-makers but are not directly involved in DET selection. These candidates may be working in the IT department or conducting open education research. While they may not have the same level of power as decision-makers, these people can help provide information on the institution's organizational structure, IT strategies, and the DETs used. Additionally, subject experts can help identify appropriate individuals at their universities who are decision-makers and make warm introductions, thus acting as a top-of-funnel for the previous persona. Subject experts were not interviewed in accordance with the interview protocol, but instead invited to a casual 30-minute unstructured and unrecorded online meeting that mainly revolved around understanding their institution's DET context and brainstorming decision-maker interview candidates they could introduce. These meetings were not included in this research's data analysis. A total of three subject expert calls were conducted with 2 Dutch and 1 Irish candidate. The IRE1 subject expert proved to qualify for the decision-maker persona, and so the IRE2 interview was conducted as a follow-up call with the same candidate.

The initial candidates were sampled from the author and thesis advisors' professional network, with additional candidates identified through snowballing sampling and referrals. The C-FLEX consortium and partners were also contacted and asked for candidate recommendations at their institutions. Finally, a list of candidates for both personas was compiled by searching through university department staff and was sent cold interview requests. Interviews will be referenced in Chapter 4 by their interview IDs found in Appendix A.

3.3. Data analysis

3.3.1. Actor analysis

To properly understand the complex dynamics in the multi-actor environment where DET selection takes place, an actor analysis was conducted using the interview data. Actor analysis is a method to provide insight into a network of actors involved in a decision-making arena where no single actor has the power to unilaterally impose their desired solution (Enserink et al., 2022). The analysis can illustrate the interdependencies, power dynamics, and decision-making implications for actors to complement the coding results. Enserink et al. (2022) defines an *actor* as ”a social entity, a person, or an organization able to act on or exert influence on a decision” who are interdependent on other actors and have various interests, objectives, and possible actions. The relationships between actors shape the actor *network* which operates within an *arena* dedicated to strategic decision-making. The arena could have formal boundaries such as a governmental body or informal social spaces where actors interact (Hermans et al., 2018).

This study follows Enserink et al.'s (2022) actor analysis method to examine actor dynamics and networks:

1. **Problem formulation**: Identify the problem on which actors are making decisions. The research question introduced in Section 1.4 serves as the problem for this research.

2. **Actor identification**: A list of all relevant actors involved in the problem is compiled in an iterative process. Actors can be removed or added based on the scope of the research or at different stages of the decision-making process. However, since this study's actor analysis only aims to highlight the key dynamics and actors in the DET selection process, it will be smaller in scope and not include many actors. Actors include the decision-maker persona from Section 3.2 and are also identified during the interview conversations.

3. **Relationship mapping**: The relationships between actors are mapped on a *formal chart* that depicts the most important relationships relevant for the actor analysis. Relationships are indicated by arrows between two actors. The direction of the arrow indicates a hierarchical flow of influence, power, or control of one actor over another. For example. If the arrow points from A to B, A has some power over B. A short description is written next to each arrow to indicate the actor's directional relationship. A formal chart for this study's actors is illustrated in Figure 4.1 in Chapter 4.

4. **Actor characteristics**: The interests, objectives, resources, and possible actions for all identified actors are assessed to compare each actor systematically. *Interests* are what is most important to an actor, have a direction, and are often not directly linked to the defined problem. For example, businesses have an interest in making economic profit and the direction is to increase profit. *Objectives* are what actors want to achieve in specific situations and are directly linked to the defined problem. *Resources* are formal (e.g. authority) and informal (e.g. information) means available to the actor to realize their objectives. *Possible actions* are things an actor can do to achieve their objectives. The summary tables for actor characteristics are provided in Tables 4.1 to 4.4 in Chapter 4.

5. **Summarizing interdependencies**: Using the actor relationships and characteristics identified above, the interdependencies between actors can be illustrated. A common method to map interdependencies is through a power-interest diagram to characterize actors into four groups and actors in each group can be managed similarly. A power interest matrix can be found in Figure 4.2 in Chapter 4.

3.3.2. Grounded theory & coding

A grounded theory approach was chosen to analyze the interview data with the goal of identifying key concepts to answer the research questions by extracting insights from interviews. Grounded theory is a qualitative method used when no theories currently exist on the topic to develop a new scientific theory with two distinguishing features: *iterative data collection and analysis* and *coding*. Instead of clearly defined collection and analysis steps, grounded theory analyzes the data as they are collected, typically through open-ended interviews (Ratcliffe, 2002). This creates an iterative process where analysis results can help better structure how and what data is collected to generate more useful insights.

The data analysis is conducted through a three-stage process called coding, with each stage yielding an increasingly more complex level of insight by building on previous stages' findings. The stages are *opening coding*, *axial coding*, and *selective coding*. These produce the corresponding *codes*, *sub-categories*, and *categories* in the grounded theory process flow illustrated in Figure 3.2. The final set of categories is used to construct the new grounded theory. Since this thesis's aim is not to develop a grounded theory but rather to employ this approach for its data analysis technique, the *selective coding* step is out of scope and will not be used for this research. However, as the knowledge gap in Section 1.3 points out, the lack of current theory on sustainable DET selection justifies this research's choice to use the grounded theory approach.

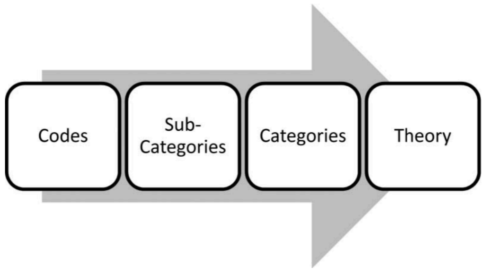

Figure 3.2: Grounded theory data analysis (Noble & Mitchell, 2016)

The core concept of coding is to break interview transcripts down into individual conceptual components called *codes*, 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 complex *categories* emerge from the initial set of codes (Gallicano, 2013). This bottom-up approach removes initial preconceptions and assumptions of what codes should exist and how categories should be formed. Using Smit's (2002) three-step grounded theory analysis method, the transcripts for each interview were analyzed with *Atlas.ti* in the following steps. *Atlas.ti* is qualitative data analysis software that was chosen for processing the transcriptions and data coding as it is commonly used for interview analysis.

1. **Memos**: After the interview has concluded, memos of key ideas and themes from the conversation were recorded immediately as reflective notes to track the main learnings from the data.

2. **Open coding**: As mentioned above, codes are generated descriptively through inductive reasoning by a detailed line-by-line transcript reading where specific phrases or words are quoted and labelled. These labels are the codes that were used later in other interview analyses, therefore creating a repository of codes and quotes. By building this repository at each interview analysis step, the data from each participant were constantly compared with each other for similarities. Due to the organic emergence of this process, no codes were created before this iterative analysis process as all codes were generated throughout open coding. Therefore, codes were typically generated quickly at the beginning while new codes may arise from later interviews.

3. **Axial coding**: Using the codes generated from open coding in combination with the interview memos, the individual codes were organized into sub-categories and reconnected based on common themes or exact phrases/words from the quotes. This process reduces the total amount of codes by omitting less relevant codes or merging codes together while allowing more complex concepts to emerge. Axial coding can uncover previously subtle or hidden linkages between codes that would not have been observed.

After the codes were analyzed, they were organized into a codebook following Heldal et al.'s (2023) example. A codebook formalizes the interview data and coding analysis by presenting the codes and thematic hierarchy along with each code's definition, the circumstance when the code is applied, a quote from transcripts, and the total number of quotations. The codes are organized into three levels. The deeper the level, the more detailed the code is in answering an aspect of the research question. The accompanying codebook can be found **here** with additional details in Appendix B. Codes are used to explain the results in Chapter 4 and highlighted in **bold** the first time they are referenced.

4 Results

This chapter presents the results obtained from interviews, actor and coding analyses. First, the actor analysis is presented on the four relevant actors in Section 4.1. Next, the four themes derived from the coding analysis are explained in Sections 4.2 to 4.5 using the related codes that can be found in the accompanying codebook **here**. Each thematic section is further organized based on their level 1 codes to more clearly explain the deeper code levels. Codes are **bolded** the first time they are referenced. The sustainability dimensional ranking results are included in Section 4.4.

4.1. Actor analysis

Following the process described by Enserink et al. (2022), the most relevant actors in the context of this research were analyzed. However, given the scope of this study, this analysis only examined the actors on a surface level as the goal is to provide a general understanding of the key actor dynamics rather than an in-depth investigation. In Section 4.1.1, a list of relevant actors was first identified who relate to the formulated research problem. After mapping the actor relationship into a formal chart in Section 4.1.2, each actor's interests, objectives, available resources, and potential actions were examined in Section 4.1.3. Finally, the interdependencies that emerge from previous steps were summarized in a power-interest diagram in Section 4.1.4.

4.1.1. Actor identification

For the European higher education DET selection arena, actors in this space are diverse and range from university personnel to national education associations to private companies. This study considers four actors who are integral in DET selection and fulfill unique roles in the decision-making process. Actors were identified in Section 3.2's actor persona or during the interviews.

First, **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. While they may not have a deep understanding of specific DETs, they have insights into how the tool fits within the broader 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, greenlighting pilot DET projects of new technologies, and developing and enforcing policies to align with relevant data protection regulations such as GDPR. These actors hold significant power in directing their institutions' DET selection and digital infrastructure development while operating under the constraints of the university board.

Complementary to the Head of IT, the **IT tool specialist** is the second university actor who has in-depth knowledge about one or more DET. These actors support the DET selection process by providing evaluations of a tool including its functionalities, trade-offs, and scalability from a technical perspective. Outside of researching a DET to obtain these data, these actors are often involved in pilot projects to test emerging technologies, gather user feedback, and assess the tool's effectiveness. In some contexts, a tool specialist's understanding of a certain tool may be a significant factor in which DET is selected since they are the people who integrate and maintain the tool into the existing infrastructure. For example from the FIN1 interview, the university decided on using Moodle for their new LMS because the tool specialists had experience building and maintaining its infrastructure over alternative products. Tool specialists may also work closely with companies and users to co-develop the DET, thus improving the capabilities of the tool.

Service provider is the third group of actors and is responsible for the development and implementation of DETs. Established and startup companies both fall into this category as they play a similar role in providing solutions to institutions' infrastructural needs. However, established corporations are typically involved in larger tenders given their abundance of resources while startups receive smaller contracts or work with pilot projects. These actors fill the niche in providing services for university's increasing demand to digitalize their infrastructure, especially since institutions lack the funding, manpower, and expertise to maintain in-house development teams. Service providers assess the needs of educational institutions and often collaborate 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 (HEAnet, 2023b; SURF, 2023e). The associated institutions share solutions to various education-related challenges, including digital infrastructure services that pertain to DET selection. For example, HEAnet assists IT departments in how to best maintain and stay up-to-date with IT security services through IT policy development, risk assessment, and security awareness training (HEAnet, 2023c). 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 (SURF, 2023b). 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. Furthermore, SURF supports universities in transforming their IT infrastructure to be more sustainable by reducing energy consumption, procuring from socially responsible service providers, and sustainably disposing of e-waste (SURF, 2023f).

4.1.2. Relationship mapping

The relationships of the identified actors are shown in Figure 4.1. It can be seen that the Head of IT and Education Association has the greatest influence as they have the highest number of outgoing arrows and exert influence over every other actor. The Head of IT has the authority to distribute resources that affect IT tool specialists who need these resources to perform their jobs and the Education association who need access to the institution's expertise and network. Additionally, IT tool specialists are directly under the management of the Head of IT in the university's organizational structure, so they have formal influence over the IT tool specialists as well.

Education associations have influence over the Head of IT as they create and provide resources critical to DET procurement. Without these tendering frameworks, the university will need to allocate more time and resources to develop these themselves. The association also hosts training and technical resources for IT tool specialists. Similar to the Head of IT, education associations streamline and save tool specialists time and money by sharing these services with partnered institutions. Service providers are also influenced by Education associations because the tendering framework and requirements can greatly influence how universities select DETs. Changes to these could negatively impact or outright disqualify institutions from choosing a provider's product, such as setting a mandatory GDPR-compliant constraint. Therefore, providers need to be aware of the association's tendering framework and modify their product accordingly.

Service providers have the second highest influence in this decision arena, influencing two actors. The provider's product influences the Head of IT because they comprise the available solutions in the DET market. Since many universities have been downsizing their in-house development team, the providers have an increasing influence over the Head of IT. Additionally, the service providers can provide tool expertise and specific product support to the IT tool specialists who are their main point of contact from the university.

Lastly, the IT tool specialists have the least amount of influence and only have some influence over the service providers since they are able to provide institutional context. This could be important information providers can use to improve their products. Furthermore, because the tool specialists have technical knowledge, they are often the only people who can work with the provider's developers.

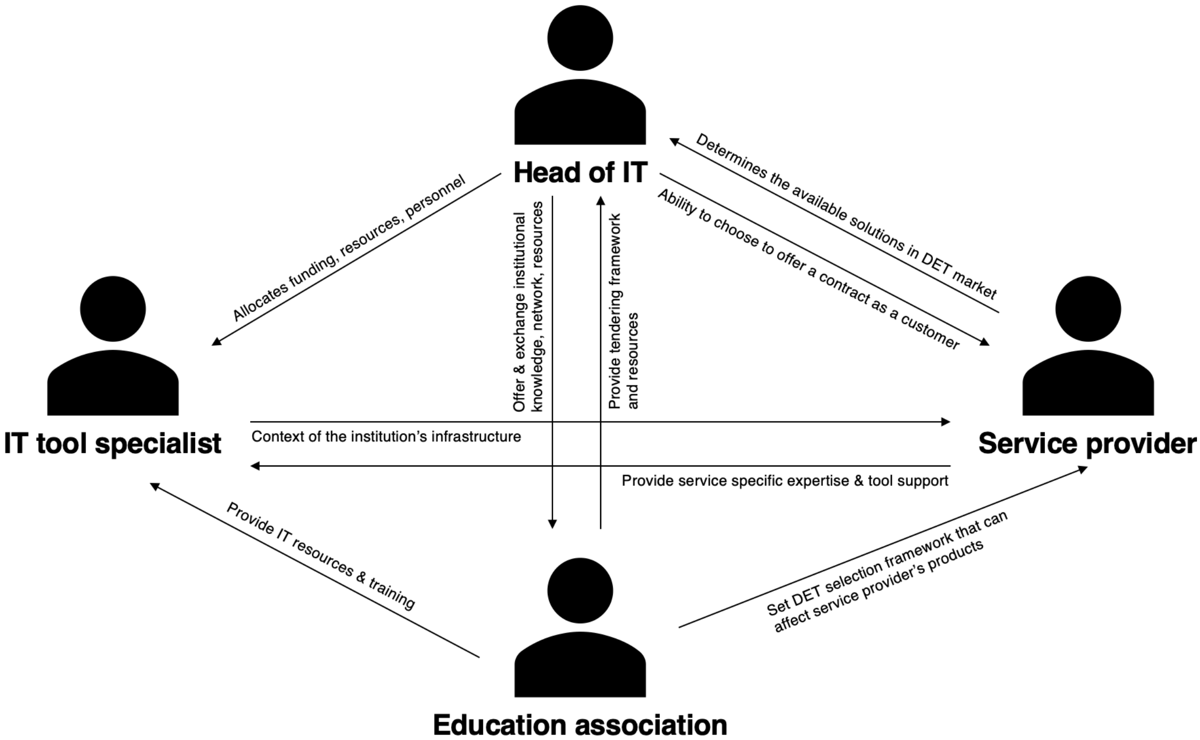

Figure 4.1: Formal chart of actor's relationship

4.1.3. Actor characteristics

Building on the identified actors and their network relationship, each actor's interests, objectives, resources, and possible actions are summarized in Tables 4.1 to 4.4.

Table 4.1: Actor characteristics of Head of IT

Actor	**Head of IT**
Interests	• Achieve broader university goals to provide quality education • Develop a safe & functional university digital infrastructure • Support staff, teachers, and students in using DETs
Objectives	• Select DETs that optimally fit the university's selection criteria • Increase the sustainability in DETs selected in the university's digital infrastructure • Manage limited departmental budget and resources efficiently • Abide by relevant data/privacy/IT regulations (e.g. GDPR) • Innovate and improve the existing digital infrastructure
Resources	• University departmental budget • Human resources (e.g. departmental employees) • Organizational authority to influence/create policies and decisions • Central actor in actor network; has direct access and influence over all actors • Knowledge of the university's infrastructure and DETs
Possible actions	• Translate university/national/EU sustainability goals into DET selection metrics • Set university and department objectives to promote a more sustainable selection of DETs • Collaborate with other universities and organizations to jointly achieve broader sustainability and educational goals • Act as a bridge between the university and businesses • Create and support DET pilot initiatives

Table 4.2: Actor characteristics of IT tool specialist

Actor	**IT tool specialist**
Interests	• Achieve IT department's goals to provide a safe & functional digital infrastructure • Support staff, teachers, and students in using DETs
Objectives	• Stay up-to-date with the latest DET development and tool alternatives • Select DETs that optimally fit the university's selection criteria • Increase the sustainability in DETs selected in the university's digital infrastructure • Innovate and improve the existing digital infrastructure
Resources	• Technical knowledge and expertise in specific DET tools • IT department budget • Human resources (e.g. team members) • Access to service provider's technical team
Possible actions	• Conduct technical evaluation of DETs to advise Head of IT in DET selection • Work with users and companies to co-develop tools • Participate in pilot projects as a technical expert to guide its development towards achieving university's sustainable DET goals

Table 4.3: Actor characteristics of Service provider

Actor	**Service provider**
Interests	• Maintain/increase the profitability of the company • Maintain/achieve market dominance in their respective DET sector
Objectives	• Obtain university tender contract • Increase adoption of DET in universities (increase digitalization) • Keep the customers' satisfaction and demand of their products high • Pursue opportunities to grow the business
Resources	• Technical expertise and knowledge of their DET technology • Investor/VC funding opportunities • Human resources (e.g. employees, contractors) • Holds unique influence in the actor-network as they make up the DET market universities can select from • Established companies may have brand recognition to indicate legitimacy
Possible actions	• Respond to tendering requests by universities • Co-develop DETs with universities to improve their product • Raise prices of product to maintain a profit margin • Modify product to abide by relevant regulations and other sustainability criteria

Table 4.4: Actor characteristics of Education association

Actor	**Education association**
Interests	• Establish a national open educational network of universities and corporations to collectively achieve educational goals
Objectives	• Streamline university DET tendering process • Create resource repositories on DET selection best practices and processes • Develop an open & cross-institutional digital infrastructure between universities
Resources	• Possesses some formal power as they act as a broker in the actor-network since they can connect universities with each other • Human resources (e.g. employees) • High degree of knowledge on DETs, tendering, and digital infrastructure • Can gain legitimacy if large or established universities are part of the association
Possible actions	• Provide resources, training, and partnerships to universities related to digital infrastructure and sustainability • Streamline tendering process by creating frameworks for DET selection • Coordinate collaborations between universities on various initiatives

4.1.4. Summarizing interdependencies

Considering the interdependencies of the identified actors and their respective interests, objectives, resources, and possible actions, the actors can be mapped in the power-interest matrix with respect to the problem formulation in Figure 4.2. There are two players, one player and context setter, and one subject actor.

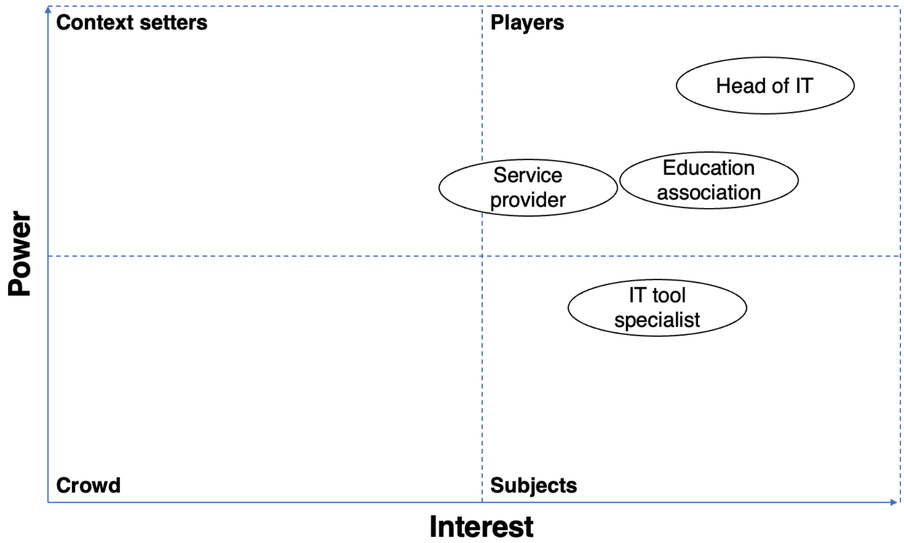

Figure 4.2: Power interest diagram

The Head of IT holds the most power and interest and is the main player in this decision-making arena. This is due to their power to influence and create policy regarding the university's IT department and infrastructure as well as being a major contributor throughout the selection and tendering process. Their formal power over IT tool specialists influences their resources and objectives, and their connection with education associations and upper echelons of university staff can influence their organizational goals. Education associations and service providers have comparable power, although in some cases education associations may have slightly higher power due to their ability to create DET selection frameworks that may influence the DET market. However, education associations have a greater interest in DET selection because it shapes the digital infrastructure of the universities. Given their objectives related to an open and cross-institutional digital system, the tools selected can greatly impact this goal. This combination makes education associations a player in this arena. Service providers on the other hand have less overall interest in the DET selection because they are more concerned with the success of their business. While gaining additional customers through university tender contracts can help achieve this goal, they also need to consider their existing customer's satisfaction with their product, potential competitors, and further development and growth of their services. Due to the additional considerations they need to balance, service providers have less interest. However, since most universities have been on a trend of outsourcing their infrastructure, this gives service providers considerable power because their products make up the available solutions that universities have to choose from. This places service providers in a hybrid position of being both a player and a context setter. Lastly, IT tool specialists are considered the sole subject in this analysis. As alluded to earlier, they are subject to formal authority from the Head of IT as they are part of the IT department and therefore possess less power. Their technical expertise can occasionally be used towards making decisions in DET selection, such as in the case of IRE1's selection of Moodle, but in most circumstances, they serve in an advisory capacity. They are relatively highly interested in the DET selection because they are the main actors from the university who will be using the tool on a regular basis and will be responsible for maintaining and developing it, either in collaboration with service providers or individually.

4.2. Digital education technologies

The first theme emerged from the interviewees' sharing the context to *why* they choose for new DETs. In most cases, the dominant reason is motivated by the goal to **enhance existing systems**. The following sections will expand on how universities achieve this and the variety of **tools** that compose universities’ current digital infrastructure.

Theme	Code level 1	Code level 2	Code level 3
Digital education technologies	Enhancing existing systems	Co-development with service providers	Co-develop tools
			Demonstrating value
			Startups
			Validation
		Pilot	Pilot projects
			Scaling pilots
		Innovation	
	Tools	Cloud computing server	AWS
			Azure
		Community	Discord
			Slack
			Zulip
		Generative AI	ChatGPT
		Learning management system	Blackboard
			Canvas
			Moodle
			Noope
			Premium
			Sakai
		Video	Panopto
			YouTube
		Videoconferencing	Big Blue Button
			Google Meet
			MS Teams
			Webex
			Zoom
		Virtual reality	Labster
		Multiple systems	

Figure 4.3: Codebook theme 1 - Digital education technologies

4.2.1. Enhancing existing systems

As with most systems, a primary objective for the system actors is **innovation** and to continuously improve different aspects of the system. Actors responsible for the university’s digital infrastructure, in particular Heads of IT and IT tool specialists, have multiple methods to realize this objective. They can phase out outdated tools, expand current tools’ functionalities, or bring in new tools that better fit their needs and requirements. The latter two options pertain to this thesis’s topic.

As alluded to in previous chapters, universities partner with service providers to **co-develop tools**. This mutually benefits both parties as the service providers can test their products to get user feedback, identify areas of improvement, and make product adjustments. Co-development often allows **startups** to get their products in front of customers quickly and get **validation**, which can be critical to a young company’s development. On the other hand, universities gain the option to explore new DETs at a smaller scale and lower costs in controlled environments (e.g. classrooms). This creates minimal disturbance and does not require conducting a long formal tender. Furthermore, working directly with service providers gives the university actors a channel to communicate with the developers about their specific needs to customize the tool. NL3 stated that co-development is less resource-intensive for the university and you can work ” with partners to get exactly what you need.”

In addition to collaborating with service providers, universities can also initiate innovative projects through **pilots**. All interviewees indicated their university hosts some form of **pilot projects** with the aim to self-develop or test new DETs. NL3 has ”110 pilots” at their university over the past five years aiming to ”personalize and increase the flexibility of education.” Heads of IT are typically involved in greenlighting pilots as they manage the department’s budget and staff, and IT tool specialists are consulted or directly contribute to the project. Service providers may also be involved if their products are the ones being tested. Pilot projects are regularly assessed for their progress and to extract insights, which can be used for DET selection. NL2 indicated pilots are ”super helpful in making these [selection] decisions” and use the project insights to create selection criteria. If projects achieve substantial success, universities may be interested in **scaling pilots** and implement the tool in larger settings, such as in other departments, across the university, or beyond the institution.

Both co-development and pilot projects are ways for **demonstrating value** to users first-hand and to convince potential users. Getting users involved early in the development process is a strategy used by NL6, who explained that to ”successfully adopt a new tool, you need to show them what are the added value and learning effects of the tool.” Without a track record of demonstrated value, it is more difficult to reach the critical mass of satisfied users.

4.2.2. Tools

Across the interviews, interviewees shared a variety of DETs currently or previously used by their university. As NL4 stated with the digitalization of university infrastructure over the past 40 years, ”it's now almost impossible to teach without a learning management system, without video tools, without assessment tools, without all kinds of exercise tools”. While this is not an accurate market representation of DETs used in EU universities, it provides a snapshot of the common tools found in today's education digital infrastructure.

The most common type of DET used in all universities is **learning management systems**. While most universities use established LMS products such as GER1's **Blackboard**, IRE2's **Canvas**, and FIN1's **Premium**, universities are also experimenting with newer open-source systems. This is exemplified by **Sakai**, which GER1 adopted in recent years for its open-source and customization features that better fit their needs over the old Blackboard system. Additionally, FIN2 previously self-developed an LMS called **Noope** which they used before the developmental and maintenance cost became too great and switched to **Moodle**.

Beyond LMS, **videoconferencing** tools are ubiquitous amongst universities, especially after the pandemic where many videoconferencing DETs were adopted to facilitate online learning. **Zoom** and **MS Teams** are the two main alternatives all 10 interviewee's universities use, often at the same time, as they have ”been on the market for some time”, thus gaining brand recognition and market capture with limited competition. Outside of Zoom and MS Teams, institutions including GER1 have chosen to use Cisco's **Webex** as ”many of [their] systems are Cisco”, so the adoption and implementation process for Webex was smoother. Similarly, universities such as ITA1 choose **Google Meet**, since they own Google licenses and the product was ”easy to set up.” **Big Blue Button** was another option that differentiates itself from other products since it is open-sourced and requires less bandwidth than cloud services like Zoom (Suga, 2021).

Video recording and hosting platforms are used widely in parallel with LMS and videoconferencing systems for users to access content asynchronously, which according to ITA1's student feedback, ”students really appreciated having offline recordings”. Most videoconferencing platforms offer video recording and sharing, but institutions may use additional recording software, such as IRE3's **Panopto** if the videoconferencing tool does not offer those options. In addition to the native video hosting option on LMS, **YouTube** has been used by some institutions such as ITA1 and GER1. However, a challenge both institutions' Heads of IT mentioned is security because some professors do not want their content to be publicly accessible and only open to students. Therefore, professors have moved away from using YouTube and opting for posting videos privately within the LMS.

Outside of the aforementioned categories of DETs, universities use a collection of other tools for departmental or specific needs. **Cloud computing server** including Amazon's **AWS** and Microsoft's **Azure** are central to universities as they move their infrastructure to the cloud in a cost-effective, scalable, and secure way. **Community** tools create spaces for teams and people to communicate. Popular platforms include **Slack** and **Discord** used in FIN1 and GER1, respectively, while open-source options like **Zulip** can offer cheaper and more security as it is run on local servers.

Disruptive breakthroughs in technology have also impacted the DET space and often bring about mixed responses, with **ChatGPT** being the primary service amongst its **generative AI** alternatives making its way into classrooms. While IRE2 mentions ChatGPT could ”unlock more capabilities to better serve people”, NL2 balances this view by ”implementing updated policies” around its appropriate and safe usage. **Virtual reality** and augmented reality pilots have become more commonplace, especially during the pandemic as universities seek innovative ways to deliver education. **Labster** is a virtual reality tool IRE3 adopted that allowed students to conduct chemical experiments in a virtual space throughout the lockdown which saw a positive impact, prompting the university to invest more into using this tool.

As shown in the list of DETs above, there are many options decision-makers can select for specific purposes, and it is common for institutions to use **multiple systems** for the same type of task. For example, ITA1 uses MS Teams, Google Meets, and Zoom for videoconferencing instead of only one single tool. GER1 has roughly 40% and 60% Sakai to Blackboard usage for LMS. Not being locked into a single product allows users to have some freedom to choose what tool they prefer. As NL3 explained, decision-makers do not aim for a one-size-fits-all solution but instead prefer a 80% solution that allows room for customization, flexibility, and experimentation. Sakai was first experimented with by a GER1 professor who ran a pilot to address user profile creation issues for high school students taking university courses. Sakai's customizability was able to solve the problem, which demonstrated value to other departments who caught on and after 7 years, it now became a widely used tool for GER1's LMS.

4.3. DET selection

The second theme entails the process for **tool selection**. From Q3 and Q16, interviewees were asked to explain their decision-making framework, how DET selections were initiated, and the types of selection criteria. This provided a good foundation for understanding how institutions approach DET selection and where in the process decision-makers have more control, which is useful as they can be areas for incorporating sustainability.

Theme	Code level 1	Code level 2	Code level 3
DET Selection	Selection criteria	Regulation	GDPR
		Criteria creation	
		Existing criteria	
		Kickout criteria	
		Weighting	
	Selection framework	Education association	HEAnet
			SURF
	Selection process	Iterative process	
		Research DET market	
		Trade-offs	
		Methods	Bottom-up development
			Tender
			Tool request
	Tool selection		

Figure 4.4: Codebook theme 2 - DET Selection

4.3.1. Selection process

The DET selection process is an **iterative** exercise as it entails multiple stages of research, experimentation, and evaluation. NL3 describes it as a "long process of continuous development of exploring the needs, implementing, changing", often working with multiple actors and companies to find the best tool that optimally fits the institution's needs. Figure 4.5 outlines the seven key stages of the selection process identified through the interview conversations.

The process starts at the *initialization* stage, where 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. The initialization could also be part of a recurring process. For example, IRE3 is required to re-evaluate a DET after a certain number of years in a regular renewal process. This ensures the university is not using outdated technology and the infrastructure continues to meet the needs of its users. After initiation, the process undergoes a list of iterative stages that may take months to years as any of these 5 stages could revisit previous steps to fill knowledge gaps, find alternative tools, or update the selection criteria.

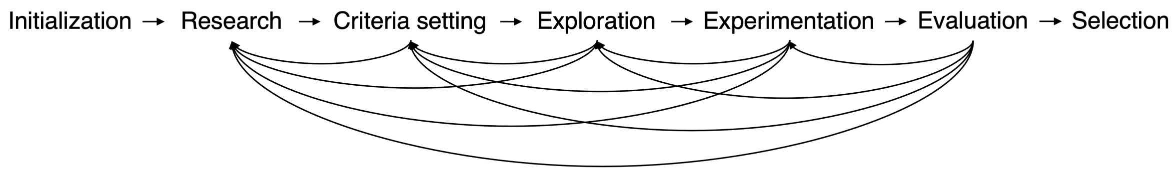

Figure 4.5: DET selection process stages

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 actors feel they have done sufficient research, they move to the *criteria setting* stage. Selection criteria are as NL3 explains ”your must-haves, should-haves, and could-haves”. Using the information from the previous step in combination with existing selection frameworks, such as ones provided by education associations, the decision-maker now has a method to evaluate and compare different DET products. Next, actors actively search for potential DETs in the *exploration* stage. This may be a formal tendering process with rigid steps actors have to follow, such as a call for proposals, or a more informal process if the actors already have a product in mind. At this stage, actors commonly have to re-examine the list of criteria as often the market does not present a product that meets all the needs. As NL3 stated, ”you make this list of requirements and go to the market, [and often] you have to skip many of your wishes”.

After a list of potential candidates has been gathered, the actors may choose to proceed to an *experimentation* stage. Similar to conducting pilots, 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 longer-term contract, thus derisking the situation for the university. It can also give service providers feedback on how to customize their product to better fit the university's needs and be more competitive in the following *evaluation* stage. During the evaluation, the final set of DET products is assessed using the criteria and framework created earlier. Typically, the evaluation translates qualitative metrics to a quantitative measurement to more easily compare products. **Trade-offs** between selection criteria generally occur in this stage as actors work towards balancing the different needs and requirements. From NL3's experience, ”sometimes you cannot meet all of your criteria” but ”you still have to choose” an option because the university still needs the tool for its operations. A DET is ultimately chosen in the *selection* stage, which then concludes the selection process and the actors move towards the implementation of the tool.

The decision-makers listed three main **methods** the selection process typically follows. These are bottom-up development, tool requests, and tendering. Often, all three methods occur within an institution and are not mutually exclusive. However, each method affects each stage's scope, timeline, and actors involved and certain stages may be entirely skipped.

Bottom-up development is a grassroots initiative where non-decision-maker actors like teachers explore new DETs, usually to solve their own problems, and want to get the university to further investigate the tool. This could be because the actor demonstrated the product's value to other users (e.g. colleagues) who also want to use the tool, found the DET to be superior to the existing tool the university uses, or simply want the university to purchase the tool so they can continue to use it. For this method, the aim of the actor is not to explore potential alternatives but instead to get the specific tool approved. The selection process does not have or have shorter research and exploration stages but instead focuses on the experimental and evaluation stages. These proposals are usually presented to the Head of IT actors or their delegates who process the requests. If the request is positively received, a pilot experimental project for the DET is set up to rigorously test the product. In NL4 and FIN2, many pilot projects originate from bottom-up proposals because teachers want to use the tools they find and prefer. As mentioned before, Sakai was a grassroots pilot project initiated by a professor to solve a problem they were facing with high school students' profile creation, which gained a significant number of users amongst multiple departments and became a leading LMS at GER1. Sometimes the non-decision-makers would contact the service providers, often startups, as they experiment with the tool themselves and if the bottom-up proposal is approved for a pilot, the service providers would join to co-develop the project.

Tool request is a formal request submitted by both non-decision makers and decision-makers for a particular DET. Similar to bottom-up development, the focus for this selection process is on the experimental and evaluation stages since the product is already identified and the goal is to assess if it is appropriate for the university. The key difference between these two methods is often the bottom-up development requests already garnered significant experience with the tool, either through small-scale testing or user experience. This allows the pilot project to do deeper investigations faster and the actors would already have an idea of how they believe the tool would integrate into the existing infrastructure. Formal tool requesters have less experience with the tool, which necessitates more experimentation and more time spent on the criteria-setting stage to get a clear set of needs, requirements, and nice-to-haves. ITA1 explains the delegates for the Department of Education receive many tool requests where teachers have seen their colleagues at other institutions use a different tool and want to try that tool at their own university. However, both tool requests and bottom-up developments are great methods for decision-makers to understand users' preferences and criteria because to submit a request, there is already some motivation to use the tool. This helps address user adoption in the implementation stage. In NL6, one initiative under the education and IT departments only greenlights pilot projects that are submitted by teachers because these people are already interested in using the tool and willing to be part of the pilot.

Tendering is a long formal selection process universities are required by the EU to follow to procure DETs if the contract exceeds €50,000 and in most cases involves all four actor groups. A small tender is necessary where at least three companies need to react to the university's request for proposals if the contract is between €50,000 and €214,000, and if it exceeds €214,000, then a European-wide tender is required (SURF, 2023a). If a tendering process is required, which could be due to the previous contract expiring or the institution wanting to switch to another tool, the university actors do not have much flexibility and have to follow the ”stringent process” described by NL4. Broadly, the tendering stages overlap with the selection process stages shown in Figure 4.5, starting with the research and criteria setting stages to outline the requirements and strategy for the procurement. Next, tender documents are drafted including these requirements and criteria to be used in the exploration stage where the formal tendering process occurs. A request for proposals is submitted to the market where interested companies can respond before a deadline. Afterwards, an evaluation stage assesses all the responses and the university chooses the best option by rewarding them with a contract. Every interviewee's university does tender on a regular basis, especially for large infrastructures such as LMS and videoconferencing tools. Because it is a formal and highly regulated process with a large scope, the process is time-consuming and may take years to complete a single tender. Some education associations offer services to universities to help them in the tendering process and provide advice while saving costs. SURF historically and continues to work with NL2, NL3, NL4, and NL6 while HEAnet works with IRE2 and IRE3. The contracts are also often over long periods. NL2 has tender contracts for up to 10 years. This can make switching to a different tool much more difficult given the length of the contracts.

4.3.2. Selection framework

Selection frameworks serve as standardized methods for actors to procure DETs and act as ”guidelines concerning confidentiality, privacy, ownership and the availability of data” (SURF, 2023d). The frameworks are developed by legal experts and used to protect the customers (i.e. university) and their end users (e.g. students and teachers). These protections can take the form of legal requirements regarding user data service providers must follow or periodic assessments by independent auditing parties. Often, selection frameworks are mandatory in procurement negotiations with service providers as they are expected to meet these guidelines (SURF, 2023d). However, developing these frameworks could be expensive, time-consuming, and require expertise. Therefore, some **education associations** collaborate with universities to create frameworks that decision-makers can then use. In the Netherlands, **SURF** developed the *Framework of Legal Standards for Cloud Services* in 2018 that has been used by NL2, NL3, and NL4 in their tendering processes (SURF, 2023d). Similarly, IRE2 and IRE3 uses **HEAnet**'s *2020 IaaS+ Framework* for procuring cloud services (HEAnet, 2023a).

4.3.3. Selection criteria

Selection criteria are attributes by which the decision-makers judge a DET and how to compare it with its competitors. This section will focus on the types of criteria interviewees shared, while the specific list of criteria will be given in Sections 2.4.1 to 2.4.4. **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. Criteria can originate from many places, but the three common origins observed from the interviews were pilots, regulation, and requirements.

As mentioned in Section 4.2.1, criteria can emerge from pilots during the experimentation stage as actors a gain deeper understanding of the tool. User feedback at this stage can help actors realize what are the important attributes to pay attention to or what users care about, thus giving those criteria more attention. **Regulations** are simply rules that actors must follow and are often set by governmental bodies. **GDPR** is a privacy and security regulation universities in the EU must abide by, and therefore all DETs chosen must also comply with GDPR. **Requirements** can stem from the actor's objective (e.g. GER1's sustainability goal to be carbon neutral by 2025) or functional requirements on what the tool must be able to do (e.g. host 500 users in a videoconferencing call). Regulations and requirements can be broadly categorized as **kickout criteria**, which are hard requirements that if not met, the tool is disqualified and removed as a possible candidate. Six out of ten interviewees mentioned kickout criteria as a critical aspect of criteria setting as it scopes the DET market for candidate tools. It also helps simplify the list of alternative tools. For NL4, "any tool that doesn't comply with GDPR, we are not interested in, period." However, FIN2 provides a different view in the scenario where kickout criteria can also "strongly limit a lot of the tools we can buy" if the DET market is already small.

After the criteria have been generated, it is necessary for actors to assign them a **weight**. As NL3 explains, assigning weights to criteria, or "ranking them", indicates the relative importance of each attribute during the evaluation process. Weights for the same criteria may differ or absent between institutions. IRE2 usually assigns a weight of 5% for environmental sustainability while GER1 does not include a weighting at all. However, within the same institution or group of decision-makers, the criteria weights typically are stable within a specified range. IRE3's weight for total DET cost is between 30% to 40% for each tool tender.

4.4. How is sustainability taken into account in DET selection

The third theme relates to answering SQ2. Interviewees were asked how sustainability and its three dimensions from Table 2.2 were integrated into their selection process in Q12 and Q13. Most commonly, the sustainability dimensions were considered during the criteria-setting stage and took the form of selection criteria and metrics. The sustainability dimensional ranking results from Q5 are summarized in Section 4.4.5. The analysis yielded many criteria for each of the three dimensions: **environmental**, **social**, and **technological**. In addition to criteria, some interviewees shared **institutional sustainability initiatives** their universities are currently pursuing to increase sustainability in DET selection and overall sustainability across the institution.

4.4.1. Environmental

Decision-makers highlighted the two key **environmental impacts** resulting from DETs were **carbon emission** and **e-waste**, which are in alignment with the literature from Section 2.4.1. As universities move towards being more environmentally aware, with GER1's goal to be carbon neutral in 2025 and environmental sustainability becoming more integrated into NL3's, FIN2's, and IRE2's university policy and decision-making, interviewees have noticed a trend towards incorporating more environmental criteria in the selection process. GER1 stated they see during discussions for procuring new software, actors are increasingly concerned with the environmental footprint of products. NL3 has implemented a pilot called Remote Labs where students participate in laboratory activities from home and found a significant reduction in carbon emissions by removing the need to commute to campus. FIN1 **repurposes the heat** generated from the local server rooms hosted on the university campus and circulates it to heat its building, thus reducing the use of heating from other sources while saving on cost. Alternatively, ITA1 uses the cold surrounding air to cool its local server rooms during winter to achieve a similar temperature control and lower their environmental impacts.

For electronic wastes, most originate from laboratory equipment and old electronics (e.g. computers). However, much e-waste is disposed of not because it is unusable, but because there are newer

Theme	Code level 1	Code level 2	Code level 3
SQ2: How are sustainability dimensions taken into account in the selection of digital education technologies?	Environmental	Environmental impact	Carbon emission
			E-waste
		Recycling	Recycling e-waste
			Repurposing heat for HVAC
	Social	People first	Accessibility
			Fairness
			Inclusion
			Privacy
		Autonomy	
	Technological	Data	Cloud center
			Data management
			Data storage
			Local server
		Openness	Open source
		Ownership	In-house development
			Outsourcing
			SaaS license
		Simplicity	Adoption
			Easy to use
			Integrability
			User experience
		Customization	
		Functionality	
		Longevity	
		Maturity	
	Institutional sustainability initiatives	Re-evaluating tools for sustainability	
		Sustainability awareness	
		Sustainability goals	

Figure 4.6: Codebook theme 3 - How are sustainability dimensions taken into account in the selection of digital education technologies?

models. Therefore, users and institutions have set up **recycling e-waste** programs for discarded but still operational electronics to reduce e-waste. FIN2 resells used and recycled laptops to students and staff at a lower price. Often these laptops are less than a year old but previous owners decided to replace them with newer models. Both ITA1 and GER1 reuse older computers to run server systems.

During the selection process, universities have begun to require companies to declare how their operations impact the environment and what environmental policies they have set in place. GER1 and IRE2 ask service providers how e-waste is handled and sometimes ask the company to provide evidence (e.g. certificate) on their process for e-waste recycling. NL4 explains this helps the decision-makers understand how the service providers address environmental sustainability, which can be considered in the evaluation stage.

4.4.2. Social

From the interview data, it can be observed a wide range of social issues were considered by decision-makers and translated into selection criteria. NL2 categorized some social criteria under the theme of **people first**, which entails putting the people and users of DETs above other requirements such as cost. One goal of people first as described by NL2 is incorporating ”**inclusive** and **accessible** techniques for learning and teaching” to reach more students. Inclusion is a common criterion that six interviewees cited as a kickout criterion because as GER1 explained, universities cannot choose a ”new technology but exclude certain users”. Accessibility pertains to a more technical aspect of inclusion, as it is more concerned if users can actually use the tool and if they can use it effectively. Student organizations at GER1 have requested more tooling to be accessible to students with special requirements, such as blind students. This was translated into an accessibility and inclusion 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 with a speech synthesizer or braille display. Related to inclusion and accessibility is the criterion of **fairness**. FIN1 remarked on a recent trend at universities that increasingly emphasize fairness and inclusion in their decision-making to ensure equitable opportunities and treatment for all users, regardless of their background, socioeconomic status, or personal circumstances. Lastly, people first work to preserve the **privacy** of their 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 kickout criterion, especially since GDPR is a mandatory requirement all companies must comply with. NL3 indicated privacy is the ”biggest priority in all [selection] cases” and has data protection officers to establish a strong data management system. NL4 mentioned their university would ”not acquire a tool” even if it has ”great functionalities” if it fails to provide adequate data protection.

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. NL6 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, GER1 and NL2 both pointed out that autonomy can also be in 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 NL2 said, ”freedom of choice is sometimes the opposite of privacy”.

4.4.3. Technological

The technological sustainability dimension had the most number of criteria as it dictates the **functionality** of the tool. As IRE2 explained, ”core functionality of an application is critically important, and if it does not do the basics well, [decision-makers] would never buy it because it’s not what we want”. Therefore, a DET’s functionality serves as a kickout criterion during selection. A key part of technological sustainability is in the way digital and cloud tools manage and store **data**. **Data management** involves the collection, organization, and analysis of personal and educational data, while **data storage** retains these data in **local servers**, **cloud centers**, or other storage solutions. Both aspects relate to the privacy criterion as these practices and policies are fundamental in providing security to users and impact a person’s user experience. NL2 and IRE3 shared how their institutions actively limit the types of data the university stores to reduce potential security risks such as leaks. Additionally, data retention policies can decrease the amount of ”unused content sitting in data centers doing nothing” and help keep the data ”clean and lean”. NL4 has observed service providers responding to the university’s emphasis on privacy and data security by focusing their services on delivering these values to be ”unique selling points for [their] software products.”

The three components of the technological dimension introduced in Section 2.4.4 were all discussed during the interviews. **Openness** was the least mentioned aspect out of the three categories. While some **open source** DETs including Sakai and Moodle are prominently used in GER1, FIN2, and ITA1, they were typically not chosen for open source features but because of their functionality and **customizability** that allowed actors to solve their problems. Decision-makers like NL2 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, ITA1 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.

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 in NL3 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. ITA1 chose Google Meet for its 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 like Zoom. A DET’s simplicity also applies to IT tool specialists in its **integrability** with the existing digital infrastructure. Decision-makers like ITA1 may ”favour services that are easy to integrate with our existing services like Microsoft and Google" as the data can easily flow between the tools and users do not need to create new accounts. The integrability criterion has prompted some universities to create centralized systems, such as FIN2's My Courses using Moodle or ITA1's UniTrento where users can access all services from a central platform. A centralized system can support the **longevity** of digital infrastructures as it considers tool integration, data management, and user experience as top priority over other criteria such as cost, thus promoting people first values and creating more accessible and inclusive systems.

Lastly, the topic of DET **ownership** was discussed extensively, especially on **in-house development** versus **outsourcing**. As alluded to in Section 2.4.4 and Figure 2.1, 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 and not tool development. As NL3 and IRE3 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 there exists a product in the market that meets the needs of the university. Therefore, the university saves time by outsourcing rather than developing a more expensive but inferior product. Many outsourced software takes the form of obtaining Software as a Service (SaaS) licenses on a subscription payment basis. For example, universities would pay for a certain number of users for one year and its students and staff can access the tool. Universities like NL3, NL6, and IRE3 prefer SaaS products as they are easier to maintain and relatively easy to tender for. However, there are also risks associated with these licenses because institutions have less ownership so they are subject to service provider's price increases, changes to privacy agreements, and updates to the tool's functionalities

4.4.4. Institutional sustainability initiatives

On top of sharing sustainability criteria, interviewees also noted how their university's overall **sustainability goals** relate to DET selection. As part of the EU, universities are obligated to integrate the EU sustainability goals as part of their strategy. GER1 aims to be a carbon-neutral campus by 2025 and incorporates environmentally friendly procurement into its selection process while IRE2 chooses cloud infrastructure over buying new equipment to reduce generating e-waste. In addition to these initiatives, decision-makers also wish to demonstrate to their students and staff the sustainability progress to raise more **sustainability awareness** on campus. GER1 displays the university's carbon emission savings in campus buildings and NL4 would share their tool selection strategies with users and openly explain why certain tools are being replaced, such as Zoom because it is not as secure, to help with user adoption.

Finally, some institutions **re-evaluate DETs for sustainability** on a regular basis to check if the tool is consistent with their sustainability criteria over time. If the tool is found to not meet certain sustainability criteria, it is replaced or the university works with the service provider to improve the product. NL2 is currently working on "iterative plans to revise and stabilize a [DET] to fit their sustainability principles." During the COVID-19 pandemic, many DETs were introduced without the proper sustainability evaluation. Now universities like NL4 are undergoing the "process to evaluate all the tools in terms of functionality, privacy, security, and other factors" and have already "phased out the most egregious offenders in the past couple of years."

4.4.5. Sustainability dimensional ranking

In the interviews, decision-makers were asked in Q5 to rank the three sustainability dimensions in order of importance in DET selection. Their responses are listed in Table 4.5. There were only three ranking patterns out of a possible six. The most frequent ranking in decreasing order of importance is *social, technological, environmental* (5/10 interviews), then *technological, social, environmental* (3/10 interviews), and finally *social, environmental, technological* (2/10 interviews). The social and technological dimensions were consistently ranked as the most important dimension (8/10) because "there are kickout criteria from the technological, functional, and social perspectives." Sections 4.4.2 and 4.4.3 shared how a tool's functionality, privacy, and data security were the top concerns for decision-makers and if these were not met sufficiently, the DET is disqualified for consideration. The prioritization of these three criteria is supported by the interview data as the most quoted sustainability codes, with 19, 35, and 39 quotes, respectively. Between these two dimensions, it can be seen in Figure 4.7 that the social dimension outranked the technological dimension, with seven instances ranked as the top priority versus three instances, respectively, with zero instances for the environmental dimension. GER1 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. The functionality kickout criteria are usually set by the decision-makers themselves so there is more leeway in what tools can be chosen.

On the other hand, as NL4 observed, ”there are no kickout criteria” for the environmental dimension. The main reason for the absence of environmental kickout criteria is that 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 (e.g. CO_2 emissions) internally. While some recent initiatives in universities, such as TU Delft, have begun to measure carbon emissions at the university, these are not able to be conducted on the scale of individual DETs (Herth & Blok, 2022). Additionally, it may not be financially viable to measure carbon emissions that finely since current weightings for environmental metrics are between 5% to 10% while other more easily metrics like cost have 40% 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.

Table 4.5: Dimensional ranking of sustainability dimensions for DET selection (1 = most important, 3 = least important).

ID	Environmental	Social	Technological
GER1	3	1	2
NL2	2	1	3
NL3	3	1	2
NL4	3	2	1
FIN1	3	1	2
FIN2	3	1	2
ITA1	2	1	3
NL6	3	1	2
IRE2	3	2	1
IRE3	3	2	1

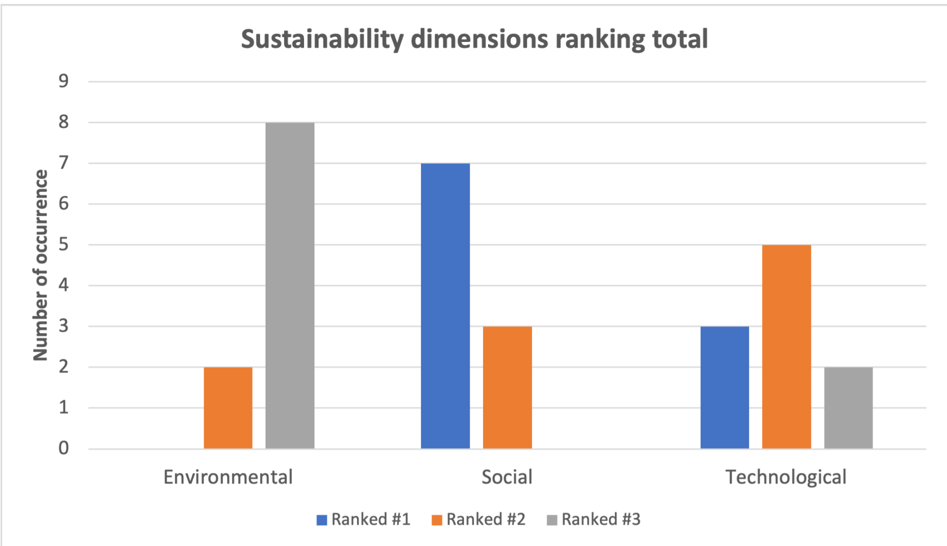

Figure 4.7: DET sustainability dimensional ranking total

4.5. Challenges identified in sustainable DET selection

The final theme emerged from asking interviewees about the challenges they face in selecting DET for sustainability from Q17, Q18, and Q19. Specifically, these questions aim to uncover which challenges were in decision-makers' control and could be addressed such as **working in multidisciplinary teams** versus more systemic issues that require institutional or national level initiatives like tenders in **selection process**.

Theme	Code level 1	Code level 2	Code level 3
SQ3: What challenges do institutions face when incorporating sustainability into their digital education technologies?	Resource	Financial	
		Human resources	
	Selection process	DET market	USA companies
			Company monopoly
			Small DET market
		Inflexible contracts	
		Long process	
		Tool expertise	
		Tool support	
	Service provider	Dependency on DET providers	
		Losing decision-making power	
		Vendor lock in	
	Sustainability dimension	Environmental	Difficult to measure environmental sustainability
			Sustainability is a secondary gain
		Social	Accessibility
			Data security
		Technological	Competing IT systems
			Limited functionality
			Single tool for the entire university
			Unstable or no internet
	Working in multidisciplinary teams	Conflict	Different perspectives
			Fixation on a single tool
		Communication	
		Multidisciplinary collaboration	
		Organizational context	
		Working in silos	
	COVID		

Figure 4.8: Codebook theme 4 - What challenges do institutions face when incorporating sustainability into their digital education technologies?

4.5.1. Resource

The most common challenge DET decision-makers and the IT department face discussed in all ten interviews was the limited **resources** available for actors to choose the best tool option. Specifically, the two main resource constraints were **financial** and **human resources**. While the economic sustainability dimension was explicitly excluded from this research's analysis, it is a realistic and significant factor for decision-makers, often taking up to 40% in criteria weighting. As mentioned in Section 4.4.5, the heavy cost weighting reduces the impact of sustainability criteria influencing the decision during DET evaluation. Therefore, as IRE3 said, reducing the cost weighting and shifting the weights toward sustainability criteria could greatly influence the number of sustainable DETs chosen. In many situations, actors would like to procure a certain tool that met most of their requirements but due to the immense cost, were forced to choose an inferior alternative. This was the case for FIN1's selection of a community communication tool. Both the decision-makers and current users wanted to choose Slack, but in order to comply with the university's data security policies, they would need to purchase the most expensive license. Therefore, the decision-makers decided to select Zulip as their community communication tool because it was significantly cheaper but lacked many of the functionalities users wanted.

The financial cost is considered beyond just purchasing the tool but also taken into consideration in its maintenance and system upkeep, which requires trained experts and a well-staffed team. NL3 highlighted the university's core function is not in tool development but in education. Therefore it is understandable that while there are ”a handful of” IT tool specialists and internal developers to create ”minimal viable products” and adjustments to the infrastructure, broadly speaking the human resources are not sufficient to properly support a full team of developers. This is also a reason why there is an outsourcing trend in universities because service providers are able to fill this research and development niche. Additionally, while IT departments regularly receive tool requests for new DETs, some of which could greatly benefit the existing infrastructure, the department is ”extremely limited when it comes to manpower” to process the requests and has to turn down many proposals. As GER1 stated the biggest challenge they see in sustainable DET selection is the IT department ”cannot be as fast as we want because of the insufficient resource of people and money.”

4.5.2. Selection process

There were several challenges interviewees identified about the selection process and during its various stages that contribute to sustainability. First is during the research and exploration stages concerning the **DET market**, specifically the potential limitation of a **small DET market**. The market size can be restricted by a few factors. First is due to the high number of requirements and kickout criteria that set the hard boundaries of the DETs that could be considered viable candidates. While decision-makers can have some control over which criterion is a kickout criterion, some criteria are regulated by national and EU regulations. For example, the GDPR criterion for privacy is a kickout criterion that could severely shrink the DET market. Five interviewees cited this as a reason why their universities do not consider any DETs from **USA companies** since ”almost all fail to abide by our data security requirements.” This is not to say these decision-makers think GDPR needs to be modified for USA companies, but instead, interviewees believe GDPR is a great regulation and it should push USA companies to modify their products to become GDPR compliant. NL4 has seen a recent shift in some USA DETs that began implementing changes to make products more secure. Additionally, FIN1 has seen the market shrinking due to **company monopoly**. This is due to big corporations, predominantly the Big Tech companies such as Amazon and Google, buying out smaller competitors and startups, thus limiting the choices decision-makers have access to.

During the evaluation stage, decision-makers cited **tool expertise** and **tool support** for DETs to be challenges in choosing more sustainable solutions. As mentioned in Section 4.5.1, financial and human resource constraints limit the number of IT tool specialists at institutions, thus leading universities to be dependent on technical support from service providers. However, external experts often lack the organizational context to provide adequate support and can take longer to respond. Taking these into consideration during the selection process, decision-makers prefer to choose a tool that the IT department has expertise in. Given it takes time and experience to gain expertise in tools, this results in decision-makers choosing older and more mature tools, which are typically less sustainable than their newer counterparts that embody the recent trends of people first, privacy, and data security values. An example is FIN1's selection of Moodle for its LMS which is a two-decade-old tool because its IT tool specialists have extensive experience with the system. While internal FIN1 experts can ”provide support much faster”, the platform has unsustainable elements such as poor user experience and the decision-maker said many people ”hate Moodle”.

Additional challenges highlighted were the **long process** for tool selection and often universities sign **inflexible contracts** which makes it difficult to switch to different tools. FIN2 stated it could ”take years” to procure a tool and it becomes ”very hard to get rid of it.” The long process comes from various stages, predominantly from the research, exploration, and experimentation stages. While it is understandable that decision-makers should do their due diligence and gather enough data to make an informed decision, often the time spent on each iterative stage accumulates and stalls the progress. Furthermore, organizational bureaucracy adds further time. Due to the length of the process, ITA1 explains that is why decision-makers ”want to ensure that the tool we choose can serve us for a long time." However, long contracts make universities less flexible and unable to switch systems if new tools emerge. FIN2 said there are "a lot of small software popping up that people are using and want to use" but due to the contracts universities are locked into, they cannot tender for these tools. A big area of improvement identified by multiple actors including GER1, FIN2, and ITA1 is for universities to be more "agile" and conduct "smaller tenders" so DETs can "come and go" more easily to accommodate for more tool requests and an up-to-date digital infrastructure.

4.5.3. Service provider

Another set of challenges DET decision-makers face in tool selection is with service providers. As mentioned previously in Section 4.5.2, company monopoly, tool expertise, and inflexible contracts create a **dependency on DET providers**. Therefore, if companies make changes to their services, such as stopping support for certain products or raising prices, universities are limited in the actions they can take and often are subject to companies' decisions. These situations result in university actors **losing decision-making power** in the DET selection process. Furthermore, this leads to **vendor lock in** where institutions are forced, either by companies or external circumstances, to continue using a particular service provider's services even if more sustainable and better products are available. Usually, vendor lock ins occur when institutions choose a service provider that is an established corporation like a Big Tech company that offers a bundle of DETs, such as Microsoft Office and Google Workspace, that work well together. However, this walled garden makes it hard to choose alternative DETs in the future because most of the infrastructure is already using a certain system. For example, when choosing a videoconferencing tool, GER1 chose Webex mainly because the rest of the university's communication system is Cisco. Choosing a different system such as Zoom or MS Teams would incur a higher switching cost and having to manage multiple systems in parallel.

4.5.4. Sustainability dimensions

The three sustainability dimensions also contribute to challenges to tool selection. For the **environmental** dimension, the biggest challenge explained in Section 4.4.5 is it is **difficult to measure environmental sustainability** for DET tools. As almost no universities and service providers currently have initiatives to gather these environmental data, environmental metrics are often excluded in selection criteria due to the lack of information available. Therefore, much of the environmental **sustainability is a secondary gain** during DET selection. In other words, the environmental sustainability achieved is a by-product and not a primary goal of the decision-makers. A prominent example is during the **COVID** pandemic, NL3 implemented Remote Labs to deliver education content at home, thus reducing the potential carbon emissions from students' and professors' commute to campus. As stated by NL3, carbon emission savings were not a factor considered when selecting a remote education DET. The decision-makers at the time cared mostly if the tool had the functionality and accessibility to deliver content remotely. It was after implementing Remote Labs that actors realized the environmental benefits of the tool. This is a challenge because environmental sustainability is not actively discussed or incorporated into decision-making, and actors cannot rely on accidental environmental gains to make significant progress.

A major **social** criterion is **data security** and privacy, with nine interviewees citing it as the top selection criterion for the social dimension. However, having strict data security criteria could reduce the DET market available, such as eliminating USA companies for not being GDPR compliant. Sometimes this only leaves one tool that the university must choose, even if the tool is not great functionally or meets other criteria. NL3, FIN2, and IRE3 all agree that data security criteria "limits the pool" of candidates and do not leave many options for decision-makers to choose from. NL3 gave another example that there are instances that tools are not environmentally sustainable or less **accessible** for some users, but the university had to use it because it is the only option and has spent months in the tendering process.

For the **technological** dimension, some common challenges faced are users with **unstable or no internet**, which cause accessibility issues for online learning during COVID, and selected tools having **limited functionality**. Limited functionality could be due to the previously stated small DET market forcing decision-makers to choose an inferior product, or institutions facing vendor lock-ins to simplify the digital infrastructure. However, the latter point to achieve a **single tool for the entire university** can also lead to issues because certain tools may only be useful for specific groups of users, such as a department, but not useful for other groups. In FIN1, the Arts department used Slack for communications and has a dedicated user base. However, the decision-makers made the switch for the entire university to Zulip to save on cost. This was not well received by the Arts department because the users now have to use a different product they are unfamiliar with and lose historical conversations from Slack because the university preferred having only one communication tool. These decisions can cause disturbances and user dissatisfaction, especially if the reason for the switch was not communicated well and if users were not given the chance to provide feedback and input. However, using multiple **competing IT systems** in parallel could also lead to their own issues. GER1 shared there are difficult technical challenges in building the infrastructure between different tools that were not designed to communicate data with each other. These siloed tools increase the strain on the IT department as it requires a limited number of staff to be proficient in maintaining and using more systems to provide support. More tools can also cause poor user experience because people need to have multiple accounts and have to remember which system has access to what content. A major infrastructural project FIN1 underwent was to combine three separate LMS systems (i.e. Noope, Premium, and Moodle) into a single Moodle platform because students and teachers ”had to jump between the different environments and the user experience was not that good.” FIN1 shared that because ”data was not flowing [between] the systems”, students and teachers found it ”frustrating to use multiple systems.” GER1 currently faces a similar challenge. Students in Berlin can take courses from any other Berlin university, but institutions ”have different IT systems” and it is ”a huge challenge to harmonize all of them.”

4.5.5. Working in multidisciplinary teams

From Section 4.1, it was seen that many actors are involved in the selection, maintenance, and operation of DETs and digital infrastructure. This requires **multidisciplinary collaboration** across departments and actor groups. However, many challenges had been observed that create difficulties and **conflicts** when working in large teams with actors from different backgrounds. A common conflict actors face is **different perspectives**. This could be in how weights are distributed, what tools to eliminate, or how important each criterion is. NL2 describes how actors would often approach the selection process already **fixated on a single tool** they plan on selecting for, even before the research stage has started. This poses a challenge as the actor is heavily biased during a supposedly objective selection process. The tool the actor wants may also be ”inaccessible, not fair, or doesn’t meet the privacy policies”.

Another challenge is the lack of effective or frequent **communication** between groups of actors. Especially in a multidisciplinary setting, where **organizational context** is important to share, a lack of communication can lead to teams **working in silos**. NL6 stated the lack of communication was the biggest challenge they consistently have to handle because teams would not understand what or why they are doing which could have been resolved if they had communicated with each other. They found that by setting up clear communication channels and expectations, teams became more effective and efficient.

5 Discussion

This chapter discusses the interpretations and limitations of this research project. Section 5.1 summarizes the key results from the research study. Sections 5.2 to 5.4 expand on interesting findings and touch on the excluded sustainability dimensions (i.e. economical and pedagogical). Next, Section 5.5 examines three common trade-offs between sustainability dimensions that emerged from the analysis. Section 5.6 interprets the predominant sustainability challenges identified in Section 4.5 through induction. Finally, Section 5.7 highlights the limitations of this research.

5.1. Summary of key findings

Based on the previous chapter, the most important findings in this research are as follows:

- The interviews highlighted three key DET selection methods, with the EU-regulated **tender** being the most common method for large-scale infrastructural procurement and often involving all four actors in the selection process.
- The sustainability dimensional ranking and coding analysis suggest that university decision-makers prioritize social and technological sustainability, specifically the **privacy**, **data security**, and **functionality** of DETs over other sustainability criteria.
- The coding analysis identifies environmental sustainability to be underrepresented in DET selection criteria with the main reason being the **lack of available data** and initiatives collecting DET environmental impact metrics.
- The data indicates that decision-makers heavily weigh **economic considerations** (i.e. DET price) over other sustainability considerations.
- The three most common challenges interviewees identified that hinder sustainable DET selection are the limited financial and human **resources**, the insignificant or lack of sustainability criterion **weighting**, and the **long** and **inflexible** tender process.

5.2. Disparity in environmental sustainability importance in research and DET selection practice

As mentioned in Section 4.4.5, the environmental dimension was found to be of lower priority for DET decision-makers compared to the social and technological dimensions. However, this placement contrasts with the research literature found in Chapter 2 where environmental sustainability was the most investigated topic. This section discusses this disparity in the importance of environmental sustainability by reflecting on several factors in the context of the literature review, interview data, and data analysis. Notably, the disparity is more applicable to software environmental impacts (e.g., carbon emissions) than hardware impacts (e.g., e-waste). As interviewees illustrated in Section 4.4.1, there are existing e-waste recycling and disposal programs and hardware selection criteria while there are comparatively fewer policies and criteria for software impacts.

As first discussed in Chapter 4, a key element is the absence of available data on carbon emissions of digital education technologies. There are a number of components contributing to the lack of data. First is the lack of actors, both universities and service providers, collecting carbon emission data. From the literature review, only a few institutions in recent years have begun to measure their carbon emissions in any capacity. From interview conversations, decision-makers shared the scarcity of data from service providers when asked to share their product's environmental impact. Complementing the lack of data collection initiative, the second challenge is the difficulty in accurately measuring the carbon emissions of DETs. Herth and Blok (2022) shared TU Delft's 2018 analysis of the institution's carbon footprint and highlighted the "poor data accuracy" and "high aggregation level" contributed to the study's limitations and encouraged future investigations into more accurate "calculation approaches". Additionally, Herth and Blok claims "real progress regarding these issues only seems possible when suppliers make their product's carbon footprint or material data available". Additionally, during the interview's dimensional ranking exercise, while interviewees mostly ranked the environmental dimension as a low priority, most people shared their personal beliefs that it should be ranked higher, especially given the context of their institution's sustainability goals. Both literature and interviews point toward the responsibility of service providers to collect and share accurate carbon emission data of their products with their clients. With more data available, this may support the inclusion of environmental metrics in DET selection criteria that is largely absent today.

5.3. Disproportionate economic sustainability bias

While the economic dimension was explicitly excluded from this research scope and the interview questions did not include questions regarding economic DET considerations for reasons provided in Section 2.4.3, interviewees consistently brought up the topic of price and cost as a major factor in their decision making. Given that institutions and their IT departments have limited financial resources, it is not difficult to understand why economics plays a big role in procuring tools, often taking up to 40% in criteria weightings. In DET selection, the economic factor is typically calculated as the total cumulative cost throughout the selection process and not just the cost of the tool. Legal costs, tender costs, and experimentation costs are also taken into consideration for the evaluation stage. Therefore, it is informative to highlight the economic dimension and its implications for DET sustainability selection.

Ideas to address the high economic weighting bias were shared in earlier chapters, including shifting a portion of economic weightings toward other sustainability dimensions or being cost agnostic and selecting the best tool regardless of the cost. However, interviewees shared their doubts about how realistic or impactful these solutions would be in practice. Finnish participants agree that the economic weighting should be lowered but doing so requires more university budget allocated towards tool procurement, which they identified as a big hurdle in convincing the institution of such change.

Considering the challenges highlighted in Section 4.5 of resource constraint, a long and inflexible procurement process, and a highly EU-regulated tender, addressing the economic bias is a larger systemic issue where the tendering practice needs to be modified to reduce this bias significantly. Current tenders are time-consuming and restrict a university's ability to be agile to try new DETs and remove outdated tools from its infrastructure. As interviewees explained, this motivates decision-makers to sign long and expensive contracts so as to not consistently be stuck in the tendering process. However, an alternative tender process that focuses on a faster selection timeline with shorter and cheaper contracts may allow decision-makers to become more agile as they are able to essentially experiment with tools with no long-term obligation to remain with a particular product. If the university believes the tool is a good fit, they can choose to renew the contract, perhaps for a longer time period. If not, they can switch to another tool and experiment.

A shorter tender contract shifts the focus from tediously procuring a few expensive long-term tools to flexibly selecting many cheaper short-term tools. The benefit of the latter is the total cost is reduced and decision-makers can focus on maximizing other selection criteria. The option of long-term expensive contracts is still available, but it is no longer the default and is only signed if the university believes it is the best tool for them. Thus, decision-makers can reduce the economic weightings in DET evaluation. Potential trade-off decision-makers should consider when doing shorter tenders is the potential pedagogical impacts and behaviour change pushbacks users may experience if tools are changed too frequently or if a significant minority of users do not want to switch tools. A solution would be to implement a multiple-systems approach and procure a group of tools users can choose to use, such as

MS Teams, Zoom, and Google Meet for videoconferencing and filtering out tools if it sees a decline in users. This way, most users can use a tool they are satisfied with while universities continue to procure DETs on shorter timelines and with lower financial concerns.

However, to achieve this systemic change, the Finnish participants believe it would need to be a collective effort from university and grassroots actors to influence the national and EU actors to modify the regulated tender process. Service providers, especially established Big Tech companies who hold the market monopoly, could be in opposition to this change as a more flexible process will draw a portion of currently contracted universities to competitors and lose profit. However, this could be a net positive for the DET market as it breaks up monopolies and encourages service providers to innovate and improve their products.

5.4. Pedagogical considerations in DET selection

Interviewees also shared two key pedagogical considerations during DET selection. First is the utilization of pilot projects to experiment with new tools in small-scale classroom settings to get user feedback. While pilots are not always included in all DET procurements, those that did provide decision-makers with primary data to inform better if the specific piloted tool is fit for the university. Service providers can work with IT tool specialists to further customize the product before fully integrating the tool with the infrastructure. This leads to the second consideration: change management and user adoption post-selection. Decision-makers need to anticipate how teachers, students, and staff will use and respond to the new tool, and pilot projects are a great way for user participation during the experimentation stage. Dutch and Finnish participants both shared that user participation in pilot projects significantly helped communicate with actors the motivation and reason for selecting a particular DET. Successful pilots with positive responses from users can indicate a higher user adoption, while critical responses can either notify the decision-makers the tool is not a good fit or better inform them of what needs to be changed and adjust their change management strategies.

5.5. Dimensional trade-offs

Beyond the traditional economic trade-off with the social and environmental dimensions, this research has identified additional trade-off relationships in the context of sustainable DET selection. The following will examine three trade-offs between and within sustainable dimensions and their specific criteria decision-makers should consider when choosing new DETs. The criteria will be **bolded** while the sustainability dimension will be enclosed in parenthesis.

First, the trade-off between **cost-effectiveness** (economic) and **longevity** (technological) is a recurring theme decision-makers have to balance. While cheaper solutions may initially seem attractive, this could lead universities to vendor lock-ins and thus hinder the institution's ability to adapt and grow its digital infrastructure over time. Long tendering contracts and outsourcing to service provider monopolies discourage institutions from experimenting with alternative tools and decrease the university's decision-making power. For example, if an institution already purchased Google Workspace tools, it seems logical to choose the cheaper Google Meets option as a videoconferencing platform since it easily integrates with existing infrastructure without fully reviewing the implications of being locked into purchasing Google products in the future. Thus, the institution can become dependent on the service provider and find it difficult to switch to new DETs.

Second, the **functionality** (technological) of a DET can come into conflict with a tool's **data security** and **privacy** (social). This is exemplified by many USA companies' DETs that interviewees have highlighted often have great functionality but poor data security and do not comply with GDPR. While some of these companies have begun to adjust their products so they can expand to the European market, other service providers have not yet done this, thus limiting the options European universities can choose from. In addition to complying with GDPR, DETs such as personalized learning platforms utilize user data to customize the learning experience, which raises concerns regarding data security and privacy. This prompts a trade-off between the benefits of personalized education and safeguarding sensitive information.

Third, when deciding between **in-house development** and **outsourcing** (technological), the **environmental impact** (environmental) of the choice should be taken into consideration. Depending on the situation, outsourcing to a service provider such as Microsoft which has dedicated efficient servers could lead to an overall lower environmental impact as the institution does not need to build its own local servers. However, in cases shared by FIN1 and ITA1, where the building's heat can be repurposed to run local servers built out of outdated electronics, choosing an in-house option can be viable. By keeping the option to reuse existing resources, universities could start creating circular systems to repurpose waste and improve environmental sustainability.

5.6. Interpreting sustainable DET selection challenges

This section explores the three key sustainability challenges in an inductive manner: limited financial and human resources, lack of sustainability criterion weighting, and the long and inflexible tender process. The aim is to characterize the nature of each challenge and assign appropriate actors as problem owners so as to better address them. Each challenge will be examined to determine whether it is a technical or institutional problem or both.

The limited resources institutions face when selecting and processing DET tools is predominantly an institutional challenge the Head of IT encounters. As the budget for the IT department is determined by committees over which the Head of IT has some but not full control, they have to navigate the institutional politics to acquire money for what they estimate to be necessary in the coming budget cycle. The amount allocated scopes the number of DETs decision-makers can procure while also managing the rest of the department's activities. Hiring and maintaining staff, such as IT tool specialists, are also influenced by the budget. Therefore, to address the limited resource challenge, the Head of IT needs to work with their team and their superiors to gain more resources such as by demonstrating the value added by conducting pilot projects for new tools or working with service providers to tailor for the institution's specific needs. Additionally, the Head of IT could reevaluate the university's current infrastructure stack and remove redundant, outdated, and rarely used tools and staff to free up more resources and keep the department lean.

As discussed in Section 4.5, the lack of sustainability criterion weightings in the decision-making process stems from an overemphasis on cost as well as difficulties in translating sustainability into measurable criteria. The focus on cost can be attributed to an institutional challenge where a systemic change in decision-makers' mindset in choosing DETs needs to be made. While it is realistic that the budget places a constraint on how much the university can spend on tools, shifting the focus from short-term economic gains to developing sustainable infrastructure in the long term can influence the cost versus sustainability weighting. Incorporating sustainability criteria can highlight potential vendor lock-ins, data incompatibilities, and switching costs that would have been overshadowed if cost was the main selection criterion. Education associations and the Head of IT should be the leaders in shifting decision-makers' mindsets as they are in a position to set selection criteria. On the other hand, some sustainability dimensions, prominently the environmental dimension, are technical challenges are it is difficult to formulate them as metrics since the data are absent. Expanding on Section 4.5.4, service providers should develop initiatives to measure their product's environmental impacts and provide the data to decision-makers. Without the data on the tool's environmental footprints, decision-makers would not be able to include relevant metrics even if they want to. At the same time, universities should follow the example of TU Delft by implementing similar environmental impact tracking programs to generate internal environmental data.

Universities' experience with the long and inflexible tender process is an institutional challenge as it is regulated by the EU with strict guidelines. As many major tenders could be up to a length of 10 years, decision-makers are careful in selecting and negotiating the contract, which naturally extends the process. While there are situations in which long contracts are needed to ensure stable access to tools, the utilization of cheaper and shorter-term contracts could be used more to allow for more experimentation and testing of new DETs before committing to a longer contract. The Head of IT can push for this practice at their institution and connect IT tool specialists with service providers for DET pilots. Regarding the strict tendering process set by the EU, which could be further expanded on by the country and institution, university actors and education associations could campaign for more freedom in setting selection criteria and how tenders are conducted. Given that education associations set the tendering frameworks universities use, they have the expertise to champion how a more flexible process may look like.

5.7. Limitations

As with any research investigation, the results and implications of this study have to be considered within the context of the research limitations. The following discusses this study's limitations and addresses why the results are nonetheless valid.

First, 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 due to the limit of the author's network and responses to interview requests. Furthermore, there was an insufficient number of interviewees per country for the results to be representative of the country's universities. Many countries also only had one interview, such as Germany and Italy. Therefore, the results should not be generalized or interpreted as accurately representing the diverse views each country's institutions hold for DET selection. However, a few national trends could be gleaned from the interviews. For example, Dutch participants all worked in some capacity with the education association SURF for tendering or pilot projects. However, this study's goal was to gain a high-level view of the EU university's DET selection process and not compare the country's or university's specific processes. Additionally, given many selection aspects are regulated on a social or EU level, such as tenders, broader trends and results can provide actors with useful insights. For example, the results section shared many common challenges different decision-makers make and sustainability priorities.

Second, given the scope and timeline of this study, only university decision-makers were interviewed. However, this provided a limited perspective on the selection process and interviewing additional actors, such as service providers, would present a more holistic view. It was considered during the initial interview process if education associations should be interviewed, especially since Dutch and Irish participants worked with SURF and HEAnet, respectively. However, due to the aforementioned limitations and research scope, a decision was made to not interview SURF and other education associations and solely focus on interviewing the university decision-maker persona.

Third, only three of the five identified sustainability dimensions were taken into account for this study. Therefore, the results from this study should be interpreted with the three chosen sustainability with the provided definitions and the assumptions to exclude certain dimensions in mind. As demonstrated in earlier sections, while the environmental, social, and technological play a significant role in DET decision-making, the pedagogical and especially the economic dimensions are important factors too. As stated in Chapter 2, the primary motivation to remove the financial considerations in this study is its heavy weighting overshadowing other sustainability criteria. Excluding the economic dimension allowed this research to shine a light on the understudied sustainability dimensions but should be examined under the impression that the real-world DET selection landscape considers additional sustainability dimensions not part of this research's investigation.

Fourth, due to the subjective nature of the chosen coding methodology, the codes generated and the degree of analysis were influenced by the author's own biases and understanding of the subject. While the author has taken steps such as consulting existing literature in aiding the generation and categorization of codes, biases are still present in the analysis, and therefore the results may reflect these biases.

6 Conclusion

The digitalization trend of digital infrastructure has significantly transformed the landscape of European higher education institutions. However, amidst this rapid transition, there is a pressing concern regarding how the concept of sustainability is being taken into consideration in the selection of digital education technologies. The lack of clarity and standardized guidelines in this area is evident, leading to a significant knowledge gap in how decision-makers can choose more sustainable tools while balancing stakeholder requirements. Furthermore, the field of sustainable DET selection is under-researched, exacerbating the problem. As a consequence, there is a critical need to bridge this knowledge gap to effectively evaluate and improve the sustainability of EU university digital infrastructure.

This paper addressed these issues through a grounded theory approach. First, the sustainable dimensions for DETs were created. Second, interviews were conducted with EU university DET decision-makers in parallel with open and axial coding analysis to determine qualitatively the extent to which sustainability is considered in DET selection. Finally, barriers and challenges for university decision-makers to incorporate sustainability in their DET selection are identified.

6.1. Answering the research questions

The following section revisits and addresses the research questions posed in Chapter 1 while also explaining the significant contributions that this research has made to the field. The sub-research questions will be discussed first and concluded by answering the main research question.

6.1.1. SQ1: What dimensions of sustainability should be considered in the context of digital education technologies?

The review of the existing academic literature identified five sustainability dimensions applicable to the selection of DETs. The pedagogical and economic dimensions were excluded from the final set due to the former being more relevant in the post-selection stage and the latter being too heavily biased in the current selection criteria, thus overshadowing other dimensions. Thus, the environmental, social, and technological dimensions comprised the pillars to evaluate a DET's sustainability further in this study. Using the three dimensions, a definition for sustainable DETs is defined as *any digital education technologies that promote or incorporate environmental, social, and technological sustainability in its design, development, use, and disposal*. This thesis fills the knowledge gap by defining what a sustainable digital education technology is, compiling siloed DET sustainability studies into a holistic state-of-the-art review, and providing three sustainability dimensions for decision-makers and researchers to study DETs.

6.1.2. SQ2: How are sustainability dimensions taken into account by decision-makers in the selection of digital education technologies?

Interviews with university decision-makers revealed that sustainability plays a relatively insignificant role in current DET selection processes, especially in comparison with other factors such as price. During the tendering process, the criteria weighting for sustainability factors total to around 5% while price weighs around 40%, suggesting that decision-makers value the economic factor much more than a tool's sustainability. The coding analysis found components of social and technological sustainability, specifically a DET's privacy, data security, and functionality are regularly evaluated during selection while environmental sustainability is largely unaccounted for. This disparity is attributed to the kick-out criteria generated from the former two dimensions that set the DET selection boundaries, such as mandatory GDPR compliance. In addition to the environmental dimension lacking kickout criteria requirements, the large absence of DET-related environmental data (e.g. carbon emissions) from service providers and institutions makes it difficult for decision-makers to measure and compare DET alternatives along the environmental dimensions. These compounding factors are reflected in the interviewee's sustainability dimensional ranking, with social being the top priority, then technological, and finally environmental, which are consistent with the extent each dimension is currently used in DET selection. These novel results are the first of their kind in qualitatively illustrating university DET decision-makers' selection framework and the role sustainability dimensions play in current selection processes.

6.1.3. SQ3: What challenges do institutions face when incorporating sustainability into their digital education technologies?

Interviews further illustrated common challenges decision-makers face in sustainable DET selection. Through coding analysis, the three most ubiquitous challenges actors face across institutions and countries are limited financial and human resources, the insignificant or lack of sustainability criterion weighting, and the long and inflexible tender process. These barriers in conjunction with the experience of vendor lock-ins, service provider monopolies, and small DET markets reduce an institution's ability to make agile and appropriate DET selections that increase sustainability and user satisfaction. By demonstrating the biggest challenges decision-makers face are shared by other university actors, this thesis contributes to identifying areas of improvement these actors can organize themselves to tackle systemically. Additionally, potential solutions including shifting criteria weightings from economic to other sustainability dimensions and introducing a shorter and cheaper tendering process were suggested that actors can explore.

6.1.4. Main RQ

The main research question this thesis investigated was **How are European higher education institutions incorporating sustainability into selecting digital education technologies?** Using the DET sustainability dimensions, it was found that through interviewing university decision-makers that sustainability currently plays a minor role in DET selection processes, with economic factors dominating the decision-making process. The study highlighted the need for greater consideration of environmental sustainability and the challenges posed by the lack of relevant data and criteria weighting. Additionally, the research illustrated 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. Overall, this thesis contributes essential insights into the current state of sustainability integration in European higher education institutions' DET selection processes, offering valuable guidelines for decision-makers and researchers to improve the overall sustainability of digital education technologies.

6.2. Implications & recommendations

The findings from this research have important implications for each actor, both for their individual interests and the broader DET selection process. This section summarizes these implications and provides recommendations for relevant actors. First, the prioritization of social and technological dimensions indicates to the Head of IT and education associations, who are the main actors in the criteria setting stage, that more emphasis should be given to the environmental dimension. Additionally, actors should discuss how environmental impact metrics can be better collected and implement initiatives to fill this knowledge gap. These two actors may look to collaborate with other actors, such as service providers, to measure environmental impact.

Second, the coding analysis supports the interests of the Head of IT and IT tool specialists to develop a ”safe and functional university digital infrastructure”. As privacy, data security, and functionality are the most frequently quoted codes, this demonstrates to service providers the current sustainability focus of university actors. To achieve their own interests of increasing their company's profitability and market dominance, service providers can modify their products according to these criteria. Additionally, they may approach universities with pilot project proposals to gain better access to users and address specific institutional needs. More co-development projects can lead to tailored and more frequent tool support which helps universities achieve their interest of providing ”support to staff, teachers, and students in using DETs”. Conversely, the Head of IT can incentivize more bottom-up DET development and encourage teachers and students to explore or develop new tools which can lead to more pilots and co-development initiatives.

Third, the results show the prominence of tenders in DET selection. While the process is regulated by the EU and individual actors have limited influence, it demonstrates to actors that collective action is needed to make the systemic change to improve the sustainability of the tendering process. Education associations stand at the intersection of the actor network as a collection of multidisciplinary institutional actors and are positioned well to organize such efforts. Additionally, education associations should provide more streamlined services to expedite and simplify the selection process. For example, joint procurement services and model contracts are offered by SURF to support participating Dutch university members in tendering and can be adopted by other education associations (SURF, 2023b, 2023c).

Furthermore, general recommendations can be made to university actors who are not part of the actor groups above, such as teachers, students, and administrators, who could also assist in the sustainability transformation of their institution's DET infrastructure. These actors are encouraged to submit tool requestions and experiment with new DETs, which can lead to more grassroots-driven DET selection. Universities can transition to renewable energy sources such as wind and solar to reduce the carbon footprint associated with DET operations and implement responsible e-waste management practices to increase environmental sustainability. Procurement departments can also prioritize suppliers that adhere to sustainable practices in their manufacturing, disposal, and recycling to acquire more sustainable products. Lastly, universities can support research and innovation in sustainable DETs and collaborate with experts in fields such as green computing and e-learning to develop sustainable solutions.

6.3. Future work

As mentioned in Section 5.7. there are several limitations in the approach of this research. Future work can build on this study by incorporating the economic and pedagogical dimensions, as they were demonstrated to play a role in the selection process. Additional sustainability dimensions not discussed in the report should also be studied as they may prove to be of relevance.

The results of this thesis were limited to the university decision-makers, therefore expanding the interviewee scope to include additional actors such as service providers, education associations, and tendering regulators can provide a more holistic view of the selection process. Interviewing non-decision-makers like teachers and students can be beneficial to incorporate the voices of end-users, especially as they play a non-insignificant role in pilot projects and tool experimentation. Collecting data beyond northwestern Europe will address the shortcomings of this study. Future research could also choose to more scope down and deeply investigate sustainable DET selection between institutions within a country and explore in more detail the local actors and policies.

While this study did not focus on creating a sustainability selection process for decision-makers, this could be another future investigation as it is largely absent today. A more sustainable selection criteria and weighting can also be a follow-up research direction as the outcome can provide a practical resource to be used by decision-makers. Furthermore, a standardized selection process could be developed to create an accessible best-practice framework which can be a helpful guideline for actors who don't know where to start for sustainable digital education technologies selection.

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A

Appendix A: Interview protocol

All interviews follow a similar protocol to ensure standard process procedures. The candidates are provided with a *Participant Information* document outlining the research objectives and interview details and are required to sign a *consent form* before the interview can take place. Both documents are attached below. Each interview is conducted on MS Teams, recorded for audio and video, and transcriptions are automatically generated and manually edited for accuracy. The consent forms, interview notes, transcriptions, and candidates' personal information are all stored on secure TU Delft OneDrive, adhering to TU Delft's Human Research Ethics Committee requirements for data security. Due to confidentiality agreements, candidates' personal information and complete interview transcripts are not published to protect their privacy. Table A.1 lists the total number of interviews conducted including the candidate persona, date, and interview ID.

Table A.1: Interview details

ID	Persona	Meeting date	Used in analysis
NL1	Dutch subject expert	April 26, 2023	No
GER1	German decision maker	April 28, 2023	Yes
NL2	Dutch decision maker	May 2, 2023	Yes
NL3	Dutch decision maker	May 3, 2023	Yes
NL4	Dutch decision maker	May 4, 2023	Yes
FIN1	Finnish decision maker	May 8, 2023	Yes
NL5	Dutch subject expert	May 9, 2023	No
FIN2	Finnish decision maker	May 17, 2023	Yes
IRE1	Irish subject expert	May 22, 2023	No
ITA1	Italian decision maker	May 23, 2023	Yes
IRE2	Irish decision maker	May 24, 2023	Yes
NL6	Dutch decision maker	May 24, 2023	Yes
IRE3	Irish decision maker	May 25, 2023	Yes

The interview questions are listed below in the order in which they are typically asked and broken down into 6 groups. Given that the interviews were conducted in a semi-structured manner, the question order was shuffled in response to the conversation. Furthermore, by taking into account the time constraint along with the interviewee's expertise, responsibilities, and answers, some questions were skipped. For example, based on the candidate's top-ranking sustainability dimension from Q5, only questions related to that dimension are asked from the *SDET dimensions* question group. The required questions that are asked in each interview are marked with an *.

Introduction & context setting

1. How would you describe your role/position at your institution? What are your main responsibilities? *

2. How do you define digital education technology?
3. What criteria do you consider when selecting DET for your university? *

Sustainability & DETs

4. How do you define sustainable digital education technology?
5. 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 (below). How would you rank these dimensions in terms of importance when selecting DETs for your institution? Please explain your choice. *

Sustainable DET dimensions

6. Environmental: How do you consider the environmental impact (eg. carbon emissions, e-waste) of DETs when making decisions on their selection at your university?
7. Social: How do you ensure that the selected DETs are accessible and inclusive for all learners, including those with diverse backgrounds and abilities?
8. Social: Do you have in mind an occasion that a DET you choose ended up exclusion some teachers/learnings (eg. accessibility issues).
9. Technological: How do you ensure that the DET is easy to maintain or lasts a long time?
10. Technological: What technological considerations do you have when considering a solution over another? (eg. RAM, outsource, fix it in-house).
11. Technological: How do you evaluate the simplicity, openness, and ownership of a DET?

Selecting DETs

12. How are the sustainability dimensions incorporated into the DET selection process? *
13. When was the last time you saw one of these dimensions considered in your university’s DET decision-making process? *
14. Were the dimensions framed as matters of ”sustainability”, or how were they framed?
15. What strategies do you use to ensure that the selected DET aligns with your university’s sustainability goals and objectives (eg. reduce carbon footprint, increase accessibility, easy to use)?
16. Can you walk me through your institution’s process for selecting a new DET?

Challenges & struggles

17. Tell me about the hardest challenge you’ve faced with respect to selecting DET for sustainability. *
18. How did you solve the challenge? *
19. What trade-offs between the dimensions have you seen when making a tool selection?

Wrap-up & organizational change

20. 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? *
21. What was the last time you saw some form of data gathered by your organization on the sustainability of DET?
22. Is there anything you wanted to mention that we didn’t cover today? *
23. Is there anyone involved in DET selection you would recommend I speak with? Either within or outside your institution. *

Participant Briefing Document

You are being invited to participate in a research study titled *Building a Sustainable Future of Education: An Investigation into the Sustainability of Digital Education Technologies in European Higher Education Institutions*. This study is being done by Morris Huang from the Faculty of Technology, Policy and Management at TU Delft as part of his Master's thesis project.

The overall vision for this thesis is to help European universities create a more sustainable education system through the incorporation of sustainable digital education technologies (DETs). The purpose of this study is to gain a better understanding of how institutions select their DETs and the extent to which sustainability dimensions factor into their decision-making process.

The research will be carried out as an audio and video recorded interview conducted in English through an online MS Teams meeting and will take approximately 1 hour to complete. The answers you provide will be used for the master thesis, scientific publications, and presentations. We will be asking you questions regarding what type of DETs your institution uses, how were those DETs selected, to what extent sustainability dimensions were considered during DET selection, and how sustainability dimensions may be incorporated into institutions to increase the sustainability of its DETs.

As with any online activity, the risk of a breach is always possible. To the best of our ability, your answers in this study will remain confidential. We will minimize any risks by making sure that the data from the interview will be completely anonymized – the audio and video recordings and transcript will be stored confidentially at TU Delft for up to 2 years. We will not ask you for any personal information during the interview, and any personal information you provide during the interview will not be included in the interview summary which will be part of the thesis report appendix. This personal information will not be shared publicly. The anonymized answers you provide will be made publicly available with the associated scientific publication. Furthermore, the data will be stored only in a secured TU Delft server.

Your participation in this study is entirely voluntary and you may revoke my consent at any time in the future, without giving reasons. In such a case, all data that has been gathered up to that point will be deleted and destroyed. To revoke your consent, you may contact the responsible organizational unit. Also, you are free to omit any questions.

If you have any questions about the project or have any concerns, please contact Morris Huang (M.C.H.Huang@student.tudelft.nl).

Participant Signed Consent Form

Project: Building a Sustainable Future of Education: An Investigation into the Sustainability of Digital Education Technologies in European Higher Education Institutions.

PLEASE TICK THE APPROPRIATE BOXES	Yes
A: GENERAL AGREEMENT – RESEARCH GOALS, PARTICPANT TASKS AND VOLUNTARY PARTICIPATION	
1. I have read and understood the study information from the **Participant Information** document, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐
2. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	☐
3. I understand that taking part in the study involves: • An approximately 1-hour online interview on MS Teams that will be recorded for both video and audio. • A transcription of the recording into text. • The answers you provide will be used for the master thesis, scientific publications, and presentations. • The recording and transcripts will be stored in secured TU Delft storage solutions, and all of your data will be deleted and destroyed if you choose to withdraw from the study. • Asking you questions including what type of digital education technologies (DETs) your institution uses, how were those DETs selected, to what extent sustainability dimensions were considered during DET selection, and how sustainability dimensions may be incorporated into institutions to increase the sustainability of its DETs.	☐
4. I understand that the study will end on approximately mid-August, 2023, and the personal data will be preserved for up to 2 years.	☐
B: POTENTIAL RISKS OF PARTICIPATING (INCLUDING DATA PROTECTION)	
5. I understand that taking part in the study involves collecting specific personally identifiable information (PII) including my **name** and **email** and associated personally identifiable research data (PIRD) including **audio** and **video** with the potential risk of my identity being revealed.	☐
6. I understand that the following steps will be taken to minimise the threat of a data breach, and protect my identity in the event of such a breach: • My personal data (ie. name and email) will only be accessible to the principal investigator (Morris Huang) and the primary supervisor (Özge Okur) and will not be shared. • Transcribed interview notes will be shared only anonymously. • All recordings and transcribed notes will be stored on secured TU Delft storage solutions.	☐
7. I understand that personal information collected about me that can identify me, such as **name** and **email**, will not be shared beyond the study team.	☐
8. I understand that the personal data I provide will be destroyed after 2 years.	☐
C: RESEARCH PUBLICATION, DISSEMINATION AND APPLICATION	
9. I understand that after the research study the interview summary will be used for the Master's thesis report, scientific publications, and presentations.	☐
10. I agree that my responses, views or other input can be quoted anonymously in research outputs.	☐
D: (LONGTERM) DATA STORAGE, ACCESS AND REUSE	
11. I give permission for the audio and video recordings and transcripts to be archived in TU Delft repository for up to 2 years so it can be used for future research and learning.	☐

Signatures

__________________________ _________________________ ________

Name of participant [printed] Signature Date

Study contact details for further information:

Principal investigator: Morris Huang, M.C.H.Huang@student.tudelft.nl

Primary supervisor: Özge Okur, O.Okur-1@tudelft.nl

B

Appendix B: Coding analysis

A grounded theory approach was selected for the coding analysis of the interview transcripts using the process described in Section 3.3.2. After each interview, memos and notes were recorded to capture key ideas immediately after the conversation. Next, open coding is done to generate new codes and apply relevant codes to quoted texts in the transcript. As new codes could emerge from the open coding of later transcripts, it is an iterative exercise to revisit previously coded transcripts and retroactively apply relevant new codes. For this study, 182 codes (Figure B.1) were generated from the open coding step.

Challenge	Unstable service	Digitalization	Selection process	Data management	Examination
Accessibility	User experience	Innovation	Checklist	Functionality	Feedback Fruits
Adoption	User familiarity	IT technician training	Contract negotiation	In-house development	Generative AI
American companies	Vendor lock in	Multidisciplinary collaboration	Create tendering selection criteria	Integrability	Google
Change management	Working in silos	Multiple systems	Iterative process	Local server	Google Analytics
Communication	Education	Operations	Kickout criteria	Longevity	Google Meet
Company monopoly	Blended university	Policy	Procurement framework	Maturity	Hotspots
Competing IT systems	Flexibility	Private institutions	Research DET market	Open source	Labster
Conflict of interest	Hybrid education	Re-evaluating tools for sustainability	Selection criteria	Outsourcing	Learning management system
COVID	Online education	Strategy	Tool request	Ownership	Mentimeter
Data security	Open education	Structure	Tool selection	SaaS license	Microsoft
Dependency on DET providers	Personalization	Student support	Trade-offs	Simple	Miro Board
Different perspectives	Environmental	Sustainability awareness	Weighting	Storage	MOOCs
Difficult to measure environmental sustainability	Carbon emission	Sustainability goals	Social	Technological development	Moodle
Digital divide	E-waste	Teacher training	Accessibility	Theory	MS Teams
Financial	Photovolatics	Willingness to change	Autonomy	Early and late majority	Noope
Fixation on a single tool	Power consumption	Pilot	Fairness	Innovators	Panopto
Higher bandwidth	Recycling	BOOST!	Flexibility	Rogers curve	Premium
Human resources	Repurposing heat for HVAC	Demonstrating value	Freedom of choice	Tool	Proctoring
Limited functionality	Sustainability is a secondary gain	Pilot projects	Inclusion	Amazon	Sakai
Long process	Goal	Scaling pilots	People first	AWS	Slack
Organizational context	Faster selection process	Startups	Privacy	Azure	Translation
Politics	Flexible tool selection	Validation	Public values	Big Blue Button	Turnitin
Pushback	HEAnet	Regulation	Universal design	Blackboard	Video
Single tool for the entire university	Organizational	Building	SURF	Blog	Videoconferencing
Small DET market	Administration	Cloud Act	Technological	Canvas	Virtual reality
Tool expertise	Bottom-up development	GDPR	Centralized system	ChatGPT	Webex
Tool silos	Core competence	Inclusion	Cloud center	Community	Wordpress
Tool support	Culture	Storage	Co-develop tools	Discord	YouTube
Unstable or no internet	Decision-making power	Tender	Customization	E-chalkboard	Zoom
				Email	Zulip

Figure B.1: Open codes

After open coding, axial coding was conducted to organize the codes into higher-level themes while removing redundant or irrelevant codes. A code is deemed redundant if it shares a similar definition with another code, in which case one of the codes will be merged with another code. For example, *tender* and *procurement* both refer to the acquisition process for an institution to purchase a new DET and therefore the two were merged. A code is deemed irrelevant if the code has very few quotations or is later decided to be out of the scope of the research. For example, while *building regulations* is tangentially related to environmental sustainability, it only had 2 quotes and is not relevant to the selection of DET and is therefore removed during axial coding. After merging and removing open codes, the total number of codes was reduced to 97. Codes that fall within a similar category are grouped under a higher-level code. Higher-level codes can also be further aggregated into subsequent higher-level codes. For this study, the coding levels are three levels deep, with level 1 being the highest level and level 3 being the lowest level. The lower the code level, the more detailed the code is in answering the research question. For example, *Pilot projects* and *Scaling pilots* level 3 codes both fall under the level 2 code of *Pilot*, which itself is under the level 1 code of *Enhancing existing systems*. All level 1 codes are grouped under one of the four identified themes for this research, which emerged from the axial coding analysis: **Digital education technologies**, **DET Selection**, **SQ2: How are sustainability dimensions taken into account in the selection of digital education technologies?**, and **SQ3: What challenges do institutions face when incorporating sustainability into their digital education technologies?** These themes were discussed in detail in Chapter 4. A codebook was created to organize the axial codes with their respective coding levels, definition, the circumstance when the code is applied, a quote from transcripts, and the total number of quotations. The codebook is attached below and can also be accessed using this link: https://bit.ly/3P7EF8e.

Themes	Code level 1	Code level 2	Code level 3	Definition of the code	Description on when the code is applicable	Coded text example (with source)	Number of quotations
Digital education technologies	Enhancing existing systems	Co-development with service providers	Co-develop tools	The university, often the IT tool specialists, working together with service providers, pilots, or teachers to co-develop DETs. The outcome could be to expand the tool functionality, get data on user experience, or customize the product for the institution's specific needs.	Statement includes university staff working with external actors to co-develop a DET together.	[FIN1] We still have some people in-house who are quite good at coding and developing code. Their main job is not doing that, but they still will work with the consultant developers.	13
			Demonstrating value	Taking the outcomes and learnings from co-development and demonstrating the value of the DET to new users or decision makers to help with user adoption or DET selection.	Statement indicates presenting the value of DETs to decision makers or users.	[NL6] So for us, we needed to evaluate and research the added value of the tool so we be evidence informed and provide teachers with that kind of information	4
			Startups	Young and/or less developed service providers.	Statement includes the word "startup".	[NL6] In our selection with the tools, we worked closely with the IT department to figure out what requirements they have. But we also worked with a lot of startups.	4
			Validation	Use data collected from pilots or user feedback to confirm with initial hypothesis to help make more informed selection.	Statement includes validating previous hypothesis with newly collected data.	[NL6] But you do some test and figure out if it is user friendly and is it really answering the needs of teachers.	2
		Pilot	Pilot projects	Small scale innovative projects testing new DETs to get preliminary data on the tool.	Statement includes the word "pilot" or the concept of doing small scale test projects.	[NL2] So testing of tooling in small groups, getting consent from people, students and teachers to use things iteratively until we decide it fits the goals, the principles and we can implement it university wide.	28
			Scaling pilots	Growing successful pilot projects to a larger scale.	Statement mentions growing or upscaling an existing pilot project.	[NL3] There are quite a lot of these pilots that we probably can upscale. So our views not only for the faculty that it's been made in, but also for other faculties. So right now I'm in the stage of looking at all these pilots and say and talking with program director education and asking them, "so what is it for you and your faculty?"	4
		Innovation		Doing something new that is different from the status quo.	Statement includes the word "innovation" or the concept of doing something different from the status quo.	[NL6] So we needed to know what teachers want to do and which tools, because right from the get go we focused on educational tools teachers wanted to use to innovate their education.	24
	Tools	Cloud computing server	AWS	AWS (Amazon Web Services) is a cloud computing platform that offers a wide range of scalable services.	Statement includes the word "AWS" or "Amazon Web Service".	[IRE2] We have multiple data centers on premise and our security, our identity platforms, multi factor authentication, single sign on, all Amazon Web Service, Microsoft Azure.	1
			Azure	Azure is Microsoft's cloud computing platform that provides various services and solutions for businesses.	Statement includes the word "Azure".	[FIN1] We run things in Azure, but we are quite picky about what we run. For example in Azure, we don't run everything in there because we prefer some of it to be in our own servers because we want the data to be in our hands and not in Azure, even if we do have quite good contracts with Microsoft. So for this we are quite picky in the way we choose where we run things, even to the point that it makes life a bit difficult sometimes.	3
		Community	Discord	Discord is a communication platform primarily used by gamers and communities for voice, video, and text chats.	Statement includes the word "Discord".	[GER1] We also run Discord.	1
			Slack	Slack is a collaboration tool that enables team communication and file sharing in a chat-based environment.	Statement includes the word "Slack".	[FIN1] Slack was the other option, which is of course a big market based software and it's actually quite easy to use and it looks good and the Arts department love Slack. The computer science department not show much, but they would still use sometimes.	3
			Zulip	Zulip is a group chat application that organizes conversations into threads for efficient communication.	Statement includes the word "Zulip".	[FIN1] But this was a market based decision where we looked at Slack and its license prices, but in order to offer our users a service that is data secure or safe, we would actually need to buy the most expensive licenses that they offer and that will cost the university a lot of money. Because of the cost, we decided to use Zulip chat.	4
		Generative AI	ChatGPT	ChatGPT is an AI language model developed by OpenAI, capable of generating human-like text responses.	Statement includes the word "ChatGPT".	[NL2] ChatGPT just happens to be the most keyword one right now, and we're also implementing updated policies around analytics in general and our policy development comes out of these pilots.	2
		Learning management system	Blackboard	Blackboard is a learning management system commonly used by educational institutions for online courses.	Statement includes the word "Blackboard".	[GER1] We have a centralized system based on Blackboard.	4
			Canvas	Canvas is an online learning management system that facilitates course management, communication, and grading.	Statement includes the word "Canvas".	[IRE3] Our main platform is Canvas and it is heavily used by all academics and have many things built off of that.	4
			Moodle	Moodle is an open-source learning management system used to create and deliver online courses.	Statement includes the word "Moodle".	[FIN2] As opposed to My Courses and Moodle, which is built in-house so our team can provide support much faster and we can go quite deep to see what's the actual problem is and solve it with the teachers.	15
			Noope	Noope is a learning management system developed internally by the Helsinki University of Technology.	Statement includes the word "Noope".	[FIN1] Technical University was using Noope, which was a service that they will developed themselves.	1
			Premium	Premium is a Finnish learning management system.	Statement includes the word "Premium".	[FIN1] For example Canvas's user experience is much better than Moodle and Premium, a Finnish system, they have much better API support, but Moodle has all of them.	1
			Sakai	Sakai is an open-source learning management system designed for educational institutions and collaboration.	Statement includes the word "Sakai".	[GER1] Sakai is completely open source and you can modify or attach whatever you like.	11
		Video	Panopto	Panopto is a video platform used for recording, managing, and sharing video content, particularly for educational purposes.	Statement includes the word "Panopto".	[IRE3] We use Panopto for lecture recording.	1
			YouTube	YouTube is a video-sharing platform where users can upload, view, and share videos.	Statement includes the word "YouTube".	[GER1] Should we place everything on YouTube? Oh no, we have some videos we do not want to the public to see it because for example, we have medicine, veterinary medicine and you don't want to see the public what they do to animals, but they have to do this for teaching surgery and all this stuff. So This is why we have our own server.	2
		Videoconferencing	Big Blue Button	Big Blue Button is an open-source web conferencing system that provides real-time audio, video, and collaboration features.	Statement includes the word "Big Blue Button".	[NL6] Oh yeah, that's the entire discussion on public value we're having now. So we have experimented, for example Big Blue Button, but then we also as a university like SaaS solutions. We're always looking for Saas.	3
			Google Meet	Google Meet is a video conferencing platform developed by Google, allowing users to host and join online meetings.	Statement includes the word "Google Meet".	[ITA1] There were other services like Google Meet or MS Teams. MS Teams have been on the market for some time, but at the start of the pandemic it was not very useful.	3
			MS Teams	MS Teams (Microsoft Teams) is a collaborative communication platform that integrates chat, video meetings, and file sharing.	Statement includes the word "MS Teams".	[GER1] But we also have the teams running MS Teams licenses but not for all the students because we could do this, but then again we have to discuss the data privacy, etcetera.	6
			Webex	Webex is a web conferencing and collaboration platform that offers online meetings, webinars, and file sharing.	Statement includes the word "Webex" or "Cisco" since Cisco is the company that owns Webex.	[GER1] I'd say most of the video conferences are run by Cisco, SO this is the what we call the leading system.	4
			Zoom	Zoom is a popular video conferencing platform that provides online meetings, webinars, and screen sharing.	Statement includes the word "Zoom".	[NL4] So at some point we phase out Zoom and people were not entirely happy, but then MS Teams improved so much in functionality and ease of use that people didn't care anymore, and they understood why we had to get rid of Zoom.	11

Themes	Code level 1	Code level 2	Code level 3	Definition of the code	Description on when the code is applicable	Coded text example (with source)	Number of quotations
		Virtual reality	Labster	Labster is a virtual laboratory platform that offers interactive and simulated lab experiments for educational purposes.	Statement includes the word "Labster".	[IRE3] A recent example is our virtual reality tool we purchased from Labster, so that was about two or three years ago. You can pick up your beaker and you can pour your chemical into it and you can do safety training. And this was when the university was closed during COVID and this was the only way we could still deliver laboratory sessions to students. That was very useful and we've kept it going.	2
		Multiple systems		Using multiple DET products that serve similar purposes (e.g. using Zoom, MS Teams, and Google Meet for videoconferencing) at the same time.	Statement indicates the parallel usage of multiple DETs for a similar function.	[GER1] This is why we always say we do not have the 100% solution. We try to make 80% happy and then there will be exceptions. This is a university. We are not a company, so that's different. And so we have to be open to a new products and new ideas.	11
DET Selection	Selection criteria	Regulation	GDPR	The General Data Protection Regulation (GDPR) is an EU law designed to safeguard the privacy and personal data of individuals by setting strict standards for data collection, processing, and storage. It aims to give individuals greater control over their data and impose hefty penalties on organizations that fail to comply.	Statement includes the word "GDPR" or selection criteria includes aspects of GDPR.	[GER1] So we are quite strict in the European Union when it comes to private data. So the GDPR is quite strict here.	20
		Criteria creation		New criteria for DET selection is created.	Statement mentions a new selection criterion.	[NL2] Actually that's how we created the principles. By doing these pilots and informing ourselves on how we create generalized principles that are strict for the scale up.	28
		Existing criteria		Existing criteria used by the institution for DET selection.	Statement mentions an existing selection criterion.	[NL2] There's always criteria that comes down from the board and that is financially viable.	63
		Kickout criteria		Criteria for DET selection that is a hard requirement that if not met, the DET is disqualified and removed as a possible candidate.	Statement mentions a kickout criterion or concept of a hard requirement.	[NL4] It's what we call a knock out criterium. Any tool that doesn't comply with GDPR, we are not interested in, period.	18
		Weighting		The weight given to each criterion during a DET selection. The specific criteria and weights may differ between each procurement, but generally there is a common weight range a criterion is allocated.	Statement mentions the weights used in DET selection.	[IRE2] These are the requirements we are looking for in a new tool and we can give different weightings for this. Normally it is something like 30% or 40% goes to the qualitative.	9
	Selection framework	Education association	HEAnet	Ireland's National Education and Research Network (HEAnet) that provides high-speed internet connectivity and ICT shared services to all levels of the Irish education sector.	Statement includes the word "HEAnet" or mentions aspects of HEAnet.	[IRE2] When we are doing procurement, we're obliged to utilize frameworks from the Office of Government Procurement or HEAnet.	3
			SURF	SURF is a cooperative association of Dutch educational and research institutions in which the members work together to acquire or develop the best possible digital services.	Statement includes the word "SURF" or mentions aspects of SURF.	[NL2] So we then join something with SURF or with some of our colleagues at other universities to scale it up and decide what will work, either through the purchase through SURF or we tender ourselves.	4
	Selection process	Iterative process		The selection process is often iterative, with decision makers repeating steps to improve their decision with each cycle. For example, performing DET market research multiple times.	Statement includes the concept of iteration on the selection process.	[NL3] So it's a continuous development of exploring the needs, implementing, changing. It can be a long process, and it took us 5 to 8 years to get these basic infrastructures in order with a governance on that with people who prioritize on it, with sounding boards that prioritize on that, program directors in IT.	2
		Research DET market		Investigate to gain an understanding of the university's DET needs/requirements, available products/services on the market, and technological capabilites. Typically done early in the selection process.	Statement mentions investigation or research into the DET market.	[IRE2] Well, I can speak in general I suppose. The first thing we normally is we educate ourselves in terms of what's available out in the market and figure out what do we really need and what's the capability out there. We do this sometimes informally ourselves by inviting vendors in to talk to us about some of their products. Sometimes we might go through a more formal process and it could be an expression of interest and you want to talk to us about the technologies and we create a shortlist from that. So the first part is understanding the market and understanding our requirements.	1
		Trade-offs		The balancing of selection criteria to select for the most optimal DET. This can include the trade-offs between the three sustainability dimensions for the thesis (i.e. environmental, social, technological).	Statement includes the word "trade-off" or includes the concept of balancing/sacrificing performance on certain criteria for another.	[FIN1] So this becomes very expensive when we are tendering because it goes over €50,000 in three or four years. So we either have to choose between very cheap options that are functionally not that good or we have to develop something on our own or we have to find a solution that's so different in functionality but much more secure.	12
		Methods	Bottom-up development	Non decision makers (e.g. professors) experimenting with new DETs without first submitting a formal request to decision makers (e.g. Head of IT), which later organically grew in users and adoption, leading to a formalization of the DET at the university.	Instance when a selection process is initiated by a non-decision maker without a submitting a formal request to a decision maker(e.g. professor).	[NL4] On the other end we have professors that encounter tools that they find interesting as well, and then it's brought together and a couple of them are selected to try and practice. So it's a bottom up organic process that's used to select which pilot is started next.	14
			Tender	Tender is the formal process universities are required by the EU to follow if the contract exceeds a legal threshold value whereby the institution announces that they want to purchase a certain service from a DET supplier. The university selects the supplier that best matches their needs and award them a contract.	Statement includes the word "tender" or the instance when a selection process is initiated by a formal tender.	[NL3] So what we do is tendering because that's obligatory for every university in the Netherlands and Europe, so that's not a big surprise there.	43
			Tool request	Actors submitting a formal request to decision makers for a specific DET they want to use. This typically results in the decision maker directing them to existing DETs the university have access to or submitting a formal tender for large contracts.	Instance when a selection process is initatived by a non-decision maker who put a formal request to a decision maker.	[ITA1] The delegates of the Director of Education usually collect a lot of these feedback and requests from professors and teachers, which then they process through their channel. So that's where a lot of these new tool selection process start.	2
	Tool selection			A new DET tool is selected.	Statement includes when a tool was was selected.	[GER1] Well, as I mentioned, the video conferencing system was chosen because there was a time pressure within a few weeks, we had to change from university with 32,000 students that work on the campus, within 3-4 weeks. Shift over to university that is completely online and immediately we had the discussion.	29
	Environmental	Environmental impact	Carbon emission	The carbon emission environmental impact generated from DET usage.	Statement includes the word "carbon emission" or relates to carbon emissions.	[GER1] We want to be carbon neutral in let's say 2030. So complete carbon neutral as university.	28
			E-waste	The e-waste environmental impact generated from DET usage.	Statement includes the word "e-waste" or includes the materialistic environmental impact from e-wastes.	[FIN2] For example, we are recycling computers and laptops. At the university, you can get a new or recycled laptop. I think this service is less than a year old.	8
		Recycling	Recycling e-waste	Recycling the materials of e-waste for other usage or repurposing/reusing old electronics that are still functional.	Statement includes the act of recycling or reusing e-waste.	[ITA1] Regarding electronic waste, we also try, when possible, to reuse all the systems. I don't think there's a specific strategy on reducing e-waste.	4
			Repurposing heat for HVAC	Repurposing the heat generated from running local data servers to run the Heating, Ventilation, and Air Conditioning (HVAC) systems at the university, thus reducing overall energy consumption.	Statement includes the act of recycling heat for HVAC.	[FIN1] know for example that for our new data centers, they are taking the heat from the server and use it for heating our rooms and heating other parts of the university buildings, so we don't have to use heating from other sources.	3
			Accessibility	Ensuring equal access and usability of DETs for all individuals, including those with disabilities or diverse learning needs.	Statement includes the word or concept of "access" or "accessibility".	[ITA1] The issues of accessibility and digital divide that are important because especially during COVID, we discovered that some students weren't even able to attend lectures in real time because bad or no internet connection. For example, during the lockdown, we needed to connect from home. And even though there is a lot of investment, we still have problem of digital divide of people accessing the network.	25

Themes	Code level 1	Code level 2	Code level 3	Definition of the code	Description on when the code is applicable	Coded text example (with source)	Number of quotations
SQ2: How are sustainability dimensions taken into account in the selection of digital education technologies?	Social	People first	Fairness	Ensuring equitable opportunities, resources, and treatment for all users, regardless of their background, socioeconomic status, or personal circumstances.	Statement includes the word or concept of "fairness".	[NL2] The second thing then is our strategic goals around a blended university and that means very active learning on site with more online components that are inclusive, fair, accessible.	5
			Inclusion	Creating an environment where all individuals, regardless of their diverse identities or backgrounds, feel welcomed, respected, and have equitable access to DET.	Statement includes the word or concept of "inclusion".	[ITA1] We always favoured the possibility to record lectures and providing offline access to data and recordings to make education more inclusive. Because you can access the content even if you have problems connecting to the platform or students are at work. So I think the social dimension is very much present.	25
			Privacy	Safeguarding individuals' personal information and data within DET, ensuring compliance with privacy laws and regulations and providing transparency and control over data collection and usage.	Statement includes the word or concept of "privacy".	[IRE3] We're moving away from Google Analytics and we've used Google Analytics for years. We're moving to a cookieless platform because we have concerns about privacy.	35
		Autonomy		Providing the institution and users with the freedom and control to make choices regarding which DET they can select and use.	Statement includes the word or concept of "autonomy".	[NL6] We've found one of the strong correlations is between autonomy, or at least the feeling of autonomy, and the willingness to change.	10
	Technological	Data	Cloud center	A remote infrastructure that provides scalable computing resources, storage, and applications accessible over the internet, enabling efficient and flexible delivery of educational services and reducing the reliance on local hardware and infrastructure.	Statement includes the word "cloud center" and storing data in the cloud.	[NL2] think we're not sustainable yet because we're storing way too much data and running way too many servers to store it, whether it's locally or through our cloud provider vendors.	16
			Data management	Involves the processes, policies, and technologies implemented to collect, organize, store, secure, and analyze educational data, ensuring its accuracy, accessibility, and appropriate usage to support decision-making, personalization, and continuous improvement in teaching and learning.	Statement includes the act of managing data.	[FIN2] Also quite quickly, students began to say that from their point of view, it was impossible to use the different tools and platforms because every teacher uses different tools and they have might have five courses running at the same time, so they would have a like a huge scale of different tools to work with, and information wasn't collected in the one place, so it was kind of problematic for them to so yeah.	20
			Data storage	The means and systems used to store and retain educational data, including student records, course materials, and analytics, ensuring their availability, durability, and security, whether through local servers, cloud-based storage solutions, or other storage infrastructure.	Statement includes the storage of data.	[NL2] So there is a sustainability element of security and privacy, but also storage, and we talk a lot about what what we need to archive, what we're legally responsible to archive and store and what we don't need.	9
			Local server	A physical computer or network of computers that stores and manages educational data and applications within the local premises of an educational institution, allowing for greater control over data privacy, security, and network performance.	Statement involves the university using local servers.	[ITA1] We've decided to keep the most vital devices, typically the GPUs that very powerful computational PCs on our local centres.	18
		Openness	Open source	Software or technologies that have their source code freely available for viewing, modification, and redistribution, enabling collaboration, customization, and innovation within educational contexts, fostering transparency, flexibility, and community-driven development.	Statement includes the word "open source" or the usage of open source DETs.	[FIN1] During the project for My Courses, we did look into other LMS, both open source and also market based solutions, but at the time that we created My Courses, they weren't that many market driven software that that did this many things or had even remotely as well or as good or as varied services as Moodle.	26
		Ownership	In-house development	The creation and customization of educational software, applications, or systems by an insitution's internal team or developers, providing control, customization, and tailored solutions to meet specific educational needs or requirements.	Statement involves the institution's usage of in-house development or discussing the topic of in-house development for DETs.	[FIN1] There's a couple of reasons why we chose Moodle. One of them is that it's open source. It's quite easy for us to develop it ourselves or change things like the UI or theme or add things into it and develop plugins for it.	26
			Outsourcing	Delegating specific technological functions or services to external vendors or partners, such as infrastructure management, software development, or technical support, allowing educational institutions to leverage external expertise, reduce costs, and focus on core educational activities.	Statement involves the university outsourcing its digital infrastructure.	[NL2] We have a mix at the moment, but there's a give and take to that because then we give up some of what we think should be stored and not to the vendors and outsourcing some of the development to them.	40
			SaaS license	Software as a Service (SaaS) license allows educational institutions to access and use software applications hosted by a provider over the internet, typically on a subscription basis, enabling convenient and cost-effective access to a wide range of educational tools and resources without the need for local installation or maintenance.	Statement includes the word "SaaS" or the usage of SaaS products.	[NL6] So but now, with the discussion on public values, we'r looking at open source solutions. So we use a SaaS version or we going to build the tool ourselves with open source materials which requires extra labor and money.	6
		Simplicity	Adoption	The process of embracing and implementing DETs within an institution and encompasses planning, training, infrastructure setup, user acceptance, and integration to enhance teaching, learning, and administrative processes.	Statement includes the word or concept of "adoption" in the context of adopting new DETs.	[GER1] So to avoid this, in the process at least we try to be as transparent as possible. So that also the acceptance is high for this software so.	8
			Easy to use	The design and functionality of DETs that prioritize simplicity, intuitiveness, and user-friendliness, enabling users to easily navigate, interact with, and effectively utilize the technology for learning and instructional purposes.	Statement involves the ease of use of DETs from the user's perspective.	[NL3] So in terms of a technology's simplicity, we let the teachers and students decide there. They gave us opinions back.	2
			Integrability	The ability of DETs to easily connect, exchange data, and work together with existing DETs in the university's infrastructure and promotes interoperability, data sharing, and a more integrated educational ecosystem.	Statement involves the integrability of new DETs with existing DET systems.	[ITA1] Sometimes we tend to favour services that are easy to integrate with our existing services like Microsoft and Google.	6
			User experience	The overall experience and satisfaction of users when interacting with educational technologies, encompassing ease of use, accessibility, responsiveness, aesthetics, and the overall quality of the user interface and interaction design.	Statement involves the word or concept of "user experience".	[NL3] But you do some test and figure out if it is user friendly and is it really answering the needs of teachers.	12
		Customization		The ability to adapt and tailor DETs to meet specific needs and preferences of institutions and users, allowing for personalized experiences, content, settings, or features that align with diverse educational contexts or individual requirements.	Statement involves the word or concept of "customization" in the context of DETs.	[NL6] We prefer to have a tool that allows use to customize and build on it so we have some autonomy and ownership over it.	2
		Functionality		The range and performance of features, tools, or capabilities offered by DETs, ensuring their ability to effectively support teaching, learning, assessment, collaboration, communication, content delivery, or administrative tasks, and meet the requirements of decision makers.	Statement involves the word or concept of "functionality" or DETs.	[NL4] And then depending on the tool, let's say learning management, there's functionality of course, which is important.	19
		Longevity		The lifespan, sustainability, and durability of DETs. This considers factors such as continuous updates, compatibility with evolving standards or infrastructure, adaptability to changing educational needs, support for future advancements, and the ability to provide reliable services over an extended period.	Statement involves the concept of longevity of DET systems and digital infrastructure.	[NL2] And so we'll look at 10 years forward if we think that tool can to say in a 10 year trajectory with the parent principles in place, so accessibility, inclusiveness, proper data management in our sustainable goals.	10
		Maturity		The level of stability, refinement, and reliability of DETs and considers factors such as development stage, time in the market, user feedback, adoption rates, proven effectiveness, and the presence of robust support, documentation, or best practices, indicating a well-established and mature technology ecosystem.	Statement involves the concept of a DET's maturity.	[ITA1] Typically we look at the maturity of the technology. For videoconferencing during the start of COVID, Zoom was one of the few offers that were on the market today. Now there's a lot more alternatives. But at that time it was the only one that allowed users to have some control on the interaction between the teacher and the student.	4
	Institutional sustainability initiatives	Re-evaluating tools for sustainability		Universities periodically re-evaluating their existing DET tools to check if the tool is the a product that still fulfills their needs and sustainability requirements. Many universities did DET re-evaluation after the COVID-19 pandemic as many tools were quickly introduced to move to online eduation without the usual rigourous evaluation.	Statement involves institutions re-evaluating existing DETs for sustainability.	[NL4] We already started the process to seriously evaluate all the tools in terms of functionality, privacy, security and other factors. We've been phasing out the most egregious offenders in the past couple of years already.	3
		Sustainability awareness		Increasing the level of understanding and consciousness among students, faculty, and staff regarding sustainability issues and practices. This can be done through marketing campaigns, initiatives, or course content.	Statement includes raising sustainability awareness within the institution.	[NL2] That's a hard one, but I think it is about awareness of the things that we're facing as a, not just Leiden but as a society. The things we're facing and more awareness of that within the organization.	2

Themes	Code level 1	Code level 2	Code level 3	Definition of the code	Description on when the code is applicable	Coded text example (with source)	Number of quotations
		Sustainability goals		Universities objectives that encompass specific targets and initiatives to promote sustainable practices, reduce environmental impact, foster social responsibility, and contribute to the long-term well-being of the campus and surrounding community.	Statement includes the sustainability goals of the institutions.	[NL3] So it's how can you influence factors that differs, but if it comes to the bottom line, we want to have tools as environmentally friendly as possible. That's the policy.	8
SQ3: What challenges do institutions face when incorporating sustainability into their digital education technologies?	Resource	Financial		The constraints and considerations related to budgeting, funding, and cost-effectiveness when choosing DETs. Includes the availability of funds, potential implementation costs, ongoing maintenance expenses, and the need to allocate resources efficiently to maximize the value and impact of the chosen technologies.	Statement includes the word "price" or that financial barrier is a main contributer to DET selection..	[FIN1] So this becomes very expensive when we are tendering because it goes over €50,000 in three or four years. So we either have to choose between very cheap options that are functionally not that good or we have to develop something on our own or we have to find a solution that's so different in functionality but much more secure.	40
		Human resources		The availability of skilled personnel, training, and expertise required to implement, integrate, and effectively use DETs in universities. Considers factors such as the need for technical support, teacher training, and the ability to address any potential resistance or reluctance to change among staff or educators.	Statement includes the word "manpower" or that human resources is a main contributer to DET selection..	[GER1] What is the hardest issue is that colleagues come up with many, many new ideas. Can't we do this? Can't we do that? We are extremely limited when it comes to manpower. So we have to say no to many, many good ideas.	21
	Selection process	DET market	USA companies	The trend of EU universities not being able to use DETs from USA companies because most do not meet the GDPR or related privacy/secuirty kickout criteria although they may meet the functionality needs. This limits the DET market EU universities can choose from.	Statement includes the word "Amercian companies" or "USA companies" or how a significant amount of DETs from the USA do not meet the privacy and security requirements of EU tenders.	[NL3] For example, we cannot look to the American market that much because so many tools don't meet our basic requirements for the European market. And this tremendously diminishes our selection options. I think that the biggest challenge is that we are not aware of this small view on the markets in Europe .	6
			Company monopoly	Situations where a single company or a small number of dominant vendors have significant control over the market, often by buying out smaller competitors. This limits competition, innovation, and pricing options, and increasing the risk of dependence on a single provider.	Statement describes the monopoly of large corporations in the DET market.	[FIN1] This is getting more difficult as the big companies are buying more and more smaller providers.	1
			Small DET market	Limited availability or variety of DET options which may pose challenges in finding suitable solutions that meet the specific needs, requirements, or preferences of institutions.	Statement describes the small size of DET market.	[IRE2] In the past, we would've liked this to be a hard requirement for tools but there just wasn't products out there with the option.	15
		Inflexible contracts		Limitations or restrictions imposed by contractual agreements with service providers which may hinder the ability of institutions to adapt, scale, or modify the chosen technologies according to changing needs, emerging trends, or evolving pedagogical approaches, leading to difficulties in aligning the technology with the institution's goals or strategies.	Statement describes the inflexibility of DET contracts.	[FIN2] Being more agile and flexible and having the ability to maybe drop or switch out to a different tool as opposed to having to be locked into this contract with a company for a long period of time.	4
		Long process		The time-consuming nature of tendering, evaluating, and selecting DETs.	Statement describes the tendering process as long or slow.	[FIN2] The process to set select the right tool and implement it is very slow.	10
		Tool expertise		The knowledge, skills, and expertise of the IT department, specifically IT tool specialist actors that may be critical in the decision of DETs.	Statement describes the tool expertise of decision makers, especially of IT tool specialists.	[GER1] Quite often unfortunately, we have to buy software from a company. Although the software is not as good as something we could imagine because of this problem of people, people acknowledge and support, that's a big problem.	5
		Tool support		The availability of technical support of the IT department which is crucial for user addressing issues, resolving technical difficulties, and implementation of new DETs.	Statement describes the lack of support for DETs.	[NL6] So we are in constant conversation with the IT department to understand how to get to a steady state with a new tool for IT to integrate the new tool into the university and handle the technological support, licensing, and infrastructure	7
	Service provider	Dependency on DET providers		The potential risks associated with relying heavily on service providers for critical DET infrastructure which may result in reduced control, limited flexibility, or increased vulnerability to disruptions if the offerings, pricing, or service quality no longer align with the institution's needs or expectations.	Statement describes the dependency of institutions and decision makers on service providers.	[FIN2] If the tool is outsourced, then we have to send information to the company and wait for support.	6
		Losing decision-making power		The adoption of DETs from service providers diminishes the autonomy, agency, or decision-making authority of institutions, potentially leading to reduced control over curriculum design, pedagogical approaches, data ownership, or strategic directions.	Statement describes a trend in losing decision-making power by institutions when selecting for DETs.	[IRE3] You definitely feel, perhaps a perceived lack of a loss of control.	3
		Vendor lock in		The risk of becoming tightly bound to a particular DET service provider, making it difficult to transition to alternative solutions due to factors such as data migration challenges, contractual limitations, or the substantial investments already made in the existing technology infrastructure.	Statement includes the word "vendor lock in" or describes a situation where an institution experienced vendor lock in.	[GER1] But the problem is this type of vendor lock in you sometimes run into because our telephone system, the classical is Cisco, many of our systems are Cisco, the video conferencing system is Cisco. many	8
	Sustainability dimension	Environmental	Difficult to measure environmental sustainability	The difficulty in assessing or quantifying the ecological impact associated with DETs considering factors such as device usage, data storage, electronic waste, or the environmental practices of technology vendors, which can pose challenges in making informed decisions or evaluating the environmental footprint of the chosen DET.	Statement describing the difficulty in measuring environmental sustainability.	[GER1] It's not that we really calculate the carbon dioxide footprint for all tools or operating systems, which is quite complicated.	13
			Sustainability is a secondary gain	Sustainability, especially environmental sustainability, is not the primary objective or a project. But through the project's progression to achieve their main goal (e.g. better functionality), they achieve some environmental sustainability gain as well.	Statement includes the secondary environmental sustainability gains from DET initiatives.	[NL3] The environmental gain was not the initial goal of the people who made the system. But what we tested the pilot, we saw there were some environmental gains.	4
		Social	Accessibility	Ensuring equal access and usability of DETs for all individuals, including those with disabilities or diverse learning needs.	Statement includes the challenge of achieving DET accessbility for users.	[GER1] During COVID, 1/3 up to 1/2 of the students lost in terms of, black hole. We don't know where the students are and they lost because some students, they need regular contact.	7
			Data security	Safeguarding sensitive or personal information, ensuring compliance with data protection regulations, and implementing robust security measures to protect educational data.	Statement includes the challenge of data security.	[NL4] We already started the process to seriously evaluate all the tools in terms of functionality, privacy, security and other factors. We've been phasing out the most egregious offenders in the past couple of years already.	39
		Technological	Competing IT systems	Situations where multiple existing or legacy DETs are already in use within an institution, posing challenges in terms of integration, data sharing, or compatibility with new DETs.	Statement includes the challenge of managing or combining competing IT systems.	[GER1] In Berlin, all the students can take classes from all of the universities. There are no limits, no borders, no nothing. But we all have different IT systems, so it's a huge challenge to harmonize all of them.	11
			Limited functionality	DETs may lack specific functionalities desired by the institution, potentially hindering their ability to meet specific pedagogical, administrative, or organizational requirements.	Statement includes the challenge of limited DET functionality.	[ITA1] There were other services like Google Meet or MS Teams. MS Teams have been on the market for some time, but at the start of the pandemic it was not very useful.	2
			Single tool for the entire university	The potential limitations of adopting a one-size-fits-all approach, where a single DET is expected to fulfill the diverse needs of various departments.	Statement includes the challenge of aiming to use a single tool for the whole institutions for particular DET functions.	[FIN2] technological dimension because this one tool is mostly only used for this department, but not the rest of the university, so functionally it's not very good.	2
			Unstable or no internet	Situations where institutions and learners may face limitations in terms of network infrastructure, connectivity, or bandwidth, making it challenging to leverage online or cloud-based DETs effectively.	Statement describes the challenge of limited or no internet access.	[ITA1] The issues of accessibility and digital divide that are important because especially during COVID, we discovered that some students weren't even able to attend lectures in real time because of bad or no internet connection. For example, during the lockdown, we needed to connect from home. And even though there is a lot of investment, we still have problem of digital divide of people accessing the network.	2
		Conflict	Different perspectives	The diverse opinions of various stakeholders which may lead to conflicting priorities, requirements, or decision criteria during the selection process.	Statement includes the challenge of managing different perspectives of various decision makers.	[NL6] So we need to involve them from the get a go and that was quite a struggle at the beginning actually because we spoke different languages and sometimes we used the same words for different things or different words for the same things, and it was quite a journey to get to the point that n realized that we were both working on the same thing but from a different perspective. So that really was very fruitful from the beginning. Difficult but fruitful to work together.	8

Themes	Code level 1	Code level 2	Code level 3	Definition of the code	Description on when the code is applicable	Coded text example (with source)	Number of quotations
			Fixation on a single tool	Situations where an institution or decision maker excessively focus on a specific DET and overlooking alternative solutions that may better meet their specific needs.	Statement includes the challenge of decision makers who are fixated on choosing a particular tool without real considerations for other viable DETs candidates.	[NL2] Ah, definitely. We have people that are have one tool in mind, despite the fact they may not even go in the principled order we use.	8
	Working in multidisciplinary teams	Communication		The need for effective and transparent communication among decision makers to ensure clear articulation of requirements, expectations, constraints, and objectives to select the best DET solution.	Statement includes the challenge of limited or ineffective communication between different decision makers or team members during the DET selection process.	[NL6] So we are in constant conversation with the IT department to understand how to get to a steady state with a new tool for IT to integrate the new tool into the university and handle the technological support, licensing, and infrastructure	9
		Multidisciplinary collaboration		The need for collaboration between various departments and decision makers to ensure a holistic and comprehensive approach to DET selection.	Statement includes the challenge of collaborating between disciplines.	[NL6] So the program's staff were initially mostly from educational science and we were always looking at the pedagogy, and not so much at the tooling or the technology. So we thought from the start, we need to involve the IT department in this process because they have a lot of rules and procedures and checklists on educational technology.	21
		Organizational context		The unique characteristics, culture, structure, or specific requirements of the institution which must be taken into account during the selection process and usage of DET to ensure that the chosen DET align with and support the institution's goals, values, or operational realities.	Statement includes the challenge of explaining or training actors, in particular those outside of the institution, on the organizational context.	[FIN1] People outside the institution do not have the experience and context on how our university does things and why the things are done the way they are. This is a really big issue because I could take months to understand why this data is going going to be used like this or why this data can't be used in here	4
		Working in silos		Situations where different departments or decision makers operate independently or lack sufficient collaboration during the DET selection process, potentially resulting in fragmented approaches, duplication of efforts, or suboptimal outcomes.	Statement includes the challenge of actors or teams working in silos.	[NL6] But our teams also work in silos. So you have cross silos in order to get things done. There are also silos within silos, and often on that level they that don't know why they're doing the things they're doing.	8
	COVID			Specific challenges and considerations brought about by the COVID-19 pandemic, such as the sudden shift to remote or hybrid learning, increased reliance on online platforms and tools, and ensuring equity and accessibility in remote learning environments.	Statement includes the word "COVID" or "pandemic" or describes the challenges caused by COVID.	[ITA1] Typically we look at the maturity of the technology. For videoconferencing during the start of COVID, Zoom was one of the few offers that were on the market today. Now there's a lot more alternatives. But at that time it was the only one that allowed users to have some control on the interaction between the teacher and the student.	21