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A nexus analysis of future ICT professionals' views on sustainable digital technology development

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Abstract

Purpose – There are increasing expectations for educators to include sustainability as part of higher education Information and Communication Technology (ICT) curricula, but we still lack concrete ways how to integrate it into teaching. To be able to create meaningful learning experiences we need to understand how our students approach sustainability and what they base their thinking on.

Design/methodology/approach – We asked our students to consider technology development linked with the European Green Deal targets in their essays and utilized nexus analysis to focus on discourses in place, interaction order and the historical body revealed in the essays.

Findings – Learning about sustainability could be approached in the ICT courses in a structured way as a question of four intersecting elements: individuals, societal systems, current and emerging technologies, and relevancy of the topic, all of these linked with the agency of ICT professionals.

Originality/value – This study contributes toward sustainable ICT research and design of effective ICT education (1) by providing an understanding of how future ICT professionals approach sustainability and digital technology development, (2) by proposing a way to raise students' consciousness of their own role as future professionals in developing more sustainable digital solutions and (3) generally helping students to see the big picture of sustainability through setting the scene with the wider targets.

Keywords Sustainability, ICT education, Nexus analysis, Systems thinking

Paper type Research paper

1. Introduction

The significance of digital technology in supporting more sustainable ways of living has been increasingly understood (Bibri, 2019; Gholami *et al*., 2016; Watson *et al*., 2021; Ziemba, 2019). Information and Communication Technology (ICT) professionals are in a central role as they can help, e.g. reduce material use through optimization and improving material efficiency, by affecting people's behavior through persuasive system design and enabling collaboration (Corbett, 2013; Dedrick, 2010; Elliot and Webster, 2017). Indeed, reliance on technology and the individual's importance in solving problems have been identified as patterns in sustainability research (El Idrissi and Corbett, 2016). Green initiatives tend to be initiated by individuals, who promote the issue in their organization (Hedman and Henningsson, 2016), and the beliefs, norms, and attitudes of the professionals influence the technologies and practices they create, which impacts sustainability (Bokolo, 2019). ICT professionals' abilities to acquire information and their organizational fields also influence their pro-environmental behavior (Molla *et al*., 2014). These things also apply to our current ICT students who are the future workforce. The education of future professionals is one of the key levers we can affect in universities (Corbett, 2023).

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Previous research on sustainability and ICT education has focused, e.g. on ways to teach sustainability topics (Ciesielska *et al*., 2021; Corbett, 2023; Riekki and Mämmelä, 2021); curricula and teaching practices (Kranz *et al*., 2022; Riekki and Mämmelä, 2021); and how ICTs can support education for sustainable development (Joyce, 2018). However, we lack understanding of how ICT students view sustainable digital technology development and what they base their views on. This is needed to understand what kind of topics, ethical deliberations and practical questions we could integrate into education to support their growth as responsible ICT professionals in sustainability-related issues. For that purpose, we collected 163 student essays on sustainable digital technology development, where students linked their own thoughts on the topic with the European Union (EU) Green Deal, the aim for Europe to be the first climate-neutral continent.

As our research question, we ask: *how do students approach sustainability and digital technology development,* and *what does this imply to ICT education?* We utilized "nexus analysis (NA)" (Scollon and Scollon, 2004) as a theoretical lens to help us see how the students see themselves as future ICT professionals taking part in sustainability efforts, by focusing our attention on their histories, discourses and interaction order between the identified actors. We contribute with our work to research on sustainable digital technology development and use (e.g. Seidel *et al*., 2017; Watson *et al*., 2021), as well as ICT education (e.g. McGibbon and Ophoff, 2018).

2. Related research and theoretical lens

2.1 Sustainability in ICT education

Sustainability is a popular concept, but its definition can be elusive (Watson *et al*., 2021). Sustainability can be defined from two perspectives: protecting ecological processes, and from the social scientific perspective where sustainability is about the relationship between the present and future human welfare (Norton, 1992). The often-cited Brundtland definition is the latter kind: "*meeting the needs of the present without compromising the ability of future generations to meet their own needs*." (United Nations, 1987). Digital technologies' impact on sustainable development has been considered from many perspectives, including ecological, social, cultural and economic (Ziemba, 2019). The discipline agnostic definition of sustainability by Norton (2005) describes how communities choose what indicators are important to them and define sustainability for themselves based on their values. Sustainability is a question of practice and communities that try to secure a future (Norton, 2005, p. 40).

United Nations Sustainable Development Goal 4.7 calls for education systems to integrate learning of knowledge and skills that promote sustainable development (UNESCO, 2016). When searching for research on sustainability education in ICT disciplines, there is surprisingly little to be found. A policy on computing education for sustainability has existed from the year 2008 (Mann *et al*., 2008), but a lack of concrete, recent directions for how to integrate sustainability into curricula has been identified, e.g. in Information Systems (IS) education (Corbett, 2023). In ICT disciplines, an interdisciplinary approach is often proposed for sustainability education (Ciesielska *et al*., 2021; Corbett, 2023; Riekki and Mämmelä, 2021). In practice, it can mean courses that draw from sciences, social sciences and humanities (Mokski *et al*., 2023), relying for example on lectures of experts from different disciplines (Braßler and Sprenger, 2021).

From the ICT field's perspective, there are arguments that core sustainability concepts and other knowledge linked with making sustainable choices in software development should be an integral part of education (Heldal *et al*., 2023), and curricula include sustainable development approaches (Topi *et al*., 2017). Corbett (2023) provides experiences of how to integrate sustainability into curricula and suggests a framework adapted from Warren *et al*. (2014) with futures-, values-, systems- and strategic thinking to understand and analyze the complex and broad topic and to come up with potential solutions. These ways of thinking can be encouraged through reflection tasks and an interdisciplinary approach to enable viewing facts from different perspectives; localization of problems can help students feel connected to the issues (Corbett, 2023). Real-life problems as examples seem to help students to better understand and propose solutions to those (Caetano and Felgueiras, 2020). Corbett (2023)

found students comfortable with socio-technical and systems thinking, but challenged in considering the technical, people and environment together (Corbett, 2023). Although being introduced to Green ICT can provide students with normative and interpersonal competence, and the competence to anticipate the future (McGibbon and Ophoff, 2018), students may find it difficult to imagine different possible futures and impacts of technology (Corbett, 2023). Thus, when educators try to support students to develop responsible ways of working, there is a need to find ways to make it visible to the students that they need to understand the causes and effects of their own actions (Caetano and Felgueiras, 2019).

The need to understand sustainability as a systemic issue has been recognized (e.g. Norton, 2005; Eriksson *et al*., 2020; Corbett, 2023; Riekki and Mämmelä, 2021). Systems thinking can be encouraged by situating sustainability issues within the topics studied, linking them with students' future professions (Eriksson *et al*., 2020). One way to make this visible to the students is to use the recent developments in machine learning and artificial intelligence (AI) and related requirements for infrastructure as an example of systemic issues in the sustainability of ICT education. The variety of generative AI tools utilizing, e.g. large language models have challenged educators to ponder how to use the tools in the best way to support learning (Gimpel *et al*., 2023; Shah, 2023). They have also set expectations for effective novel tools and systems supporting organizations and businesses as well as raised worries for the future of work – what is going to happen to workers and work practice when AI can be increasingly used for doing routine tasks (Anthony *et al*., 2023; Jain and Ranjan 2020). This concerns also ICT professionals, as we know that, e.g. programming tasks can be increasingly given for AI tools to do (Ebert and Louridas, 2023). The new data-intensive systems, however, set a need for infrastructure support (van der Vlist *et al*., 2024), i.e. strong electronic infrastructure for Internet connectivity, where fiber optic cabling and well-working telecommunications network are, on the one hand, an essential requirement for the systems to work but on the other hand they are also one more challenge for digital divide – countries with more advanced infrastructure have a head start in utilizing and benefiting from these new systems. Strong infrastructure also allows geolocation agnostic (ICT) education in the form of, e.g. video lectures and sharing of other learning material (Membrillo-Hernández *et al*., 2023), which is once again both a chance for more effective and equal education also in countries where the educational network does not cover the whole country. However, all these are also a systemic question of social sustainability: how equal world we are able to create globally – do these advancements offer new chances for less advanced countries to prosper or do they widen the existing digital divides (cf. Law *et al*., 2023)?

Another way to address sustainability from a systemic perspective is to discuss with students what type of actors or stakeholders are relevant to sustainability questions. This can be done by taking into use existing systemic models, such as the quadruple helix model (Carayannis and Campbell, 2010), which argues that central stakeholders in sustainable technology development and use are in the subsystems of academia, industry, politics and civil society, nature encompassing all of those. This model guides us to examine what is happening in the different subsystems and between them. This requires understanding of the world as a collection of interacting, interlinked systems, which can be challenging for the learners to grasp because it demands a more complex way of knowing – not only understanding of systems but systems of systems (cf. Kegan, 1998). All this calls for careful pedagogical planning.

2.2 Nexus analysis as a theoretical lens

Constructive-developmental theory offers us a valid reason to consider our students' existing *ways of knowing*. It distinguishes between informational and transformational learning. In transformational learning, it is central to recognize that students have a past that affects their learning and that for adult students their relationship history and personal views on the subject are significant (Kegan, 2018). We utilize NA to understand our students' ways of knowing and

consider how they take on board the systemic framework we offer them to discuss sustainable digital technology development. More individual- and group-level work on sustainable ICT research has been called for (Sedera *et al*., 2017), and NA is well suited for looking at the group of students.

Scollon and Scollon (2004, p. 9) describe NA as an ethnographic methodological strategy, which involves both discourse analysis and motive analysis, asking what is said, how, and why. NA was developed for addressing complex social situations (Scollon and de Saint-Georges, 2013). Actions are seen as social, with reference to an individual's social networks that might influence the action (Scollon and Scollon, 2004, pp. 11–12, 141), and carried out using mediational means, such as language and writing. In NA, social action is constituted in the nexus, or intersection, of three "aggregates of discourse": discourses in place, interaction order and historical body (Scollon and Scollon, 2004, p. 19).

NA guided us to examine the social action of "higher education students making sense of sustainable digital technology development" as tied to the social and historical context and the relationships among actors. Historical body (Nishida, 1958) refers to the life experiences and bodily memories of individuals, and it is closely tied with participants' concrete embodied actions (Scollon and Scollon, 2004, p. 13) and related to the concept of "habitus" (Bourdieu, 1990). In this study, historical body may show, e.g. students' experiences of their own education, or habits at home. Interaction order describes the different roles and role expectations, the social arrangement among people (Scollon and Scollon, 2004, p. 13). It comes from Goffman (1955, 1983), who noted that people behave differently depending on who they are accompanied by. In our study, students' behavior in discussing sustainability and technology may differ when discussing with friends compared to writing an essay for their studies. We may also find students describing different social situations where they were affected by other people when it comes to sustainable practices. Discourses in place include various types of discourses, circulating at different speeds; slower discourses could be the aging of the built environment, and faster discourses the conversations among friends (Scollon and Scollon, 2004, p. 14). The concept of discourses in place also emphasizes the social space which people have become accustomed to (Blommaert and Huang, 2009).

3. Research methods

To explore students' views, we constructed an essay task in the academic year of 2021–2022 for a course titled "Technology innovation and business" where value (worth, benefit) is a central concept discussed with students and sustainable development and use of digital technologies is one module in the course. The 183 students were told their choice to give consent to use their essay as anonymous research data (consent from 89% = 163 student essays) was entirely voluntary and would not affect their grades.

This course is mandatory in our Finnish university for first-year bachelor students in a study program, which is a mix of IS, human-computer interaction, and software engineering. The course is also available to anyone enrolled in the university or through an open university. Because of this, the participants' backgrounds vary. Although we did not ask the students to disclose personal information, we know that most are aged 20–30, and most lived in city of Oulu area. While most were enrolled in some ICT study programs, there were also students from production economy (2), economics (2), mathematics (1) and a former biology student who switched over to our study program. Nationalities were not visible in the essays, but everyone mastered Finnish at a university level, which indicates a high level of integration into Finnish society. Based on the essays, some were working in the ICT industry, and most had some work experience in various fields.

We introduced sustainability with a holistic approach in a lecture, to provide a comprehensive understanding of the various dimensions related to sustainability and digital technology development (cf. Corbett, 2023). This lecture was based on ICT/IS literature, introducing technical, social, economic and political perspectives (Ketter *et al*., 2016), and

how Green ICT can support sustainable goals in organizations through the implementation of IS, processes, software and technologies (Corbett, 2013; Seidel *et al*., 2013; Ziemba, 2019). We discussed how sustainable development is linked with innovations (Hanelt *et al*., 2017; Melville, 2010) that are envisioned to support sustainability through digital solutions. This was exemplified by discussions about data supporting the sustainable development of society through business development (Hugo *et al*., 2022) and big data as a path to digital transformation and sustainable societies, where interaction between different actors is the path to value creation, knowledge and innovations (Pappas *et al*., 2018). We also discussed how the development can be problematic, considering, e.g. ethical issues with consumer data related to privacy, surveillance, data security and confidentiality, as well as ownership and even pollution as a by-product (Martin, 2015; Sohaib and Olszak, 2021).

"Green" is among the most popular key terms in IS research on sustainability (El-Rayes *et al*., 2022). We asked our students to consider technological innovations in light of the European Green Deal and its benefits (European Commission, 2019). The Green Deal program aims for sustainable development and neutral climate change and highlights opportunities to enable connected economic regions. The European Union (EU) lists eight essential targets for the following years: Fresh air, clean water, healthy soil and biodiversity; Energy efficiency by repairing buildings; Healthy and reasonable food prices; Increasing public transportation solutions; Clean energy and high-end clean technology innovations; Long-lasting products that can be repaired, recycled, and re-used; Future jobs and education for the transition period; and Competitiveness and survival of global industries (European Commission, 2019).

The students' task was to focus on and envision the future through software innovations and how those might help (or not) with the EU's targets. We asked the students to (1) choose at least three of the targets mentioned above, (2) consider what role technological innovations can have for those targets, and who they affect, (3) write about problems they would like to solve, how they would approach it, and what value they hope the solution might produce and for whom, and (4) what kind of business could this result in, and would it be sustainable (in the business sense). The average essay length was 765 words, in Finnish.

In analyzing the results, we quantified which of the eight Green Deal targets were chosen by the students and listed stakeholders identified in the essays. Next, we utilized NA (Scollon and Scollon, 2004) to explore our findings in depth. We looked for the students' historical bodies: what problems the students would want to solve, what personal histories they bring up, and what technologies they discuss. For interaction order, we looked for which actors the students mentioned, who they thought could make a difference and how. Regarding discourses in place, we looked for emerging discourses on sustainability and technology development and where they seemed to stem from. These findings were compiled into an Excel worksheet, and shaped and negotiated among the authors throughout the writing process. In the following section, we discuss the results along these key concepts of NA.

4. Findings

First, the students were asked to pick three Green Deal targets to discuss. Long-lasting products was the most popular category, but rather than software, the essays focused more on physical devices. The next one was increasing public transportation solutions, involving software and systems as knowledge support. Clean energy was discussed in terms of its production, but also of companies choosing those options and offering products that can utilize clean energy, such as electric cars. Fresh air was discussed in terms of reducing harm by producing technological products. The target of future jobs and education gained some ideas for software that could help offer people options that suit their skill profile, whereas platforms for anyone to offer education and technologies such as virtual reality were envisioned for training purposes. Education was seen as an opportunity for European export along with new innovations, but there were also critical views of innovations removing low-income jobs.

For food, students envisioned technological solutions in the production, and the energy efficiency of buildings was thought to improve through smart technologies. New innovations and investments in them were suggested as solutions to competitiveness and survival of industries.

Next, we explore our findings that indicate the complex relations between historical bodies, discourses in place, and interaction order in the sustainable development of digital technology. The students did not always discuss their background explicitly, but we could draw some insights from between the lines.

4.1 Impact of historical body

Aspects of the students' historical bodies were visible in discussions about lived experiences, living in a certain place, studying and working life. Students indicated reasons for *favoring certain essay topics* due to their relevance, *"I chose these benefits because I think they affect students' lives the most.*" (E63) Everyday experiences with consumer electronics showed when students assessed electronics sustainability. Purchasing a mobile phone is an experience shared by students and many different brand names were discussed (Nokia, Swappie, Apple, Siemens and Fairphone). Long-lasting products were discussed most, and the ethics of profiting from repair services and replacement parts. Many mentioned seeing ads for those across social media. Similarly, students' familiarity with public transportation showed in the discussions on transportation and electric cars, which were seen as important future development areas, together with energy solutions. Clean energy and its high-end innovation were a familiar topic, "*constantly present in media*" (E91). The battery industry was reviewed critically due to battery's limited lifespan, which makes devices obsolete in students' lived experiences.

A shared factor for the students is the *experience of entering student life*. In Finland, this often means moving out of the childhood home, making one's own decisions and forming own habits. Here, the EU's Green Deal targets seem to affect many aspects of student everyday life, for example by having to figure out their finances, food and recycling. "*The third, 'healthy and reasonably priced food' is central to consumers, particularly student and others living with a low income*." (E90) Some entered student life from work, and as a result they had evaluated benefits of sustainable choices, "*When I switched from work to student life, I noticed that green choices create immediate value on the individual level*." (E22) The students' historical body also involves their *interests and habits.* Many mentioned an interest in ICT, knowledge of computers, and being accustomed to using applications and digital services. However, students had outdated knowledge of existing solutions, such as transportation applications, food delivery, and food spoilage prevention solutions, which were visible in their ideas of sustainable solutions.

One's *home* (country, city, or house) has an impact on views of sustainability and technology development. The students' historical bodies were similar in that most of them were currently living in the same city. This "home" seemed to affect students' views as they reflected on those from the society they live in. For instance, education was highly valued, and it was generally agreed that it should be free of charge, "*people must be offered access to free education*" (E13). On the societal scale, many students discussed freedom of speech and decisions as basic rights, a value basis in their thinking. Most students disclosed where they came from, which included cities and smaller towns, and this had implications on what sustainable choices can be made, e.g. in transportation, "*public transport does not yet work well enough in sparsely populated areas for people to want or be able to give up their own car*" (E137). Students described the disadvantages of living in different areas when it comes to public services, including long distances, prices and ease of use, and how this reality was linked to making sustainable choices. Perhaps due to their lived experiences, students had varied understandings of what "public services" meant.

Students who had *work* experience had more to say about sustainability actions and costs. This experience was mainly from ICT-related fields but also from retail, banking and

construction, where work involved recycling procedures and waste management *"I've seen how much the waste varies and how much is wasted" (E93).* This awareness was reflected in students' personal recycling habits and how they support companies or products that are making their businesses more sustainable. The students' positions in a company or organization provided some with experience in training other people, making visible the challenges of changing one's work environment. One of the risks in the development of technology-enabled automation was seen in challenges to re-educate people used to operative or mechanical work to knowledge work. In these ways, work-life has provided students with more perspectives on the impacts of sustainability and technology development.

4.2 Discourses on sustainability

Students' general *sustainability discourse* revolved around the environment and nature, with harmful behavior described as irrational. According to them, recycling, reusing and saving natural resources ought to be integrated into everyday life. Sustainability was also cynically recognized as a trend, "*Sustainable software development is a key part of a company's strategy for software business, because it is at the top of trends, and we know trends sell well."* (E68) In this way, students also considered the motivations behind the discourse. The students considered the nature of trends and emphasized influencing behavior and creating change, seeing a need to engage in the discourse and encourage everyone to choose the "green" option. Overall, there was a great willingness to strive for the EU's sustainable goals and create digital solutions for those; thus, software development was seen as potentially supporting green change. However, there were critical voices too, one of which stated, "*I think they are extremely hypocritical in the EU*" (E13), as they saw the current problems as stemming from technology development and the EU being superficially sustainable, with a vast lobbying machine ensuring profits for the rich. This critical view acknowledged inequalities that may stem from sustainability efforts.

Most students came from an ICT faculty, and their essays reflected this background in their vision of *technology as a solution for sustainability*, "*The materials and technologies developed as a result of research and development by industrial enterprises are the key." (E129)* Innovation was constructed as a way to provide better, more sustainable options that solve current problems. While 74% of the students thought the role of technology would be significant in sustainable change, almost 20% thought that it would not, and 6% thought technology does not play any kind of part. Most students saw links between technology, business, innovation and sustainability, "*When technology develops, making products can also become cheaper. Cheaper products mean more demand, which increases competition, which increases solutions.*" (E10) In this way, business was painted as a key in technology development in both positive and negative ways. Data is a central theme in contemporary ICT development, and the students recognized this: "*data is the key for monitoring and guiding development.*" (E34) It was envisioned to help sustainability in optimization, in informing people, and through the new ways of handling the data, but the question of how far our privacy is compromised in the name of development was left open. In this way, students recognized both the pros and cons of solutions.

Innovations were described as important and necessary for sustainability, but *students were also critical of the innovation speak.* AI is an example of an innovation that was thought to have great potential in decision-making and data analysis, but it was also linked to discourses of ethics and harm caused by carelessness where people's data have been compromised, "*privacy problems from handling large amounts of data, such as unintended deanonymization have been in media a lot." (E156)* There were statements that innovations must abide by societal rules: "*sustainable development needs sustainable principles and legislation*." (E35) Behind such assessments were various reasons. The focus on new innovations was thought to divert our attention away from creating longer-lasting products, and those were considered unprofitable for companies. Students also recognized a rush to utilize new innovations, and

some called for focusing on the necessity of the novelties and ensuring the quality and readiness of new solutions, "*Technological innovations mostly support sustainability goals, but it is important to carefully design the innovations before their large-scale adoption.*" (E39) Another problem was recognized in the scalability and usability of innovations. For instance, public transportation was one of the most popular topics for sustainable development, yet many refused to decrease private driving due to a lack of options in their area.

We can see suggestions of the influence of daily study environment in the essays, as students with a background in economics focused on the markets, industrial students discussed areas of production and students with a background in biology highlighted each person's responsibility. The ICT students have some technical understanding of how companies can make a difference through IS, data and devices. In these responses, we can see how the student's educational backgrounds and the discourses from those contexts guide their focus toward different parts of the social system.

Students with work experience had noticed how government and other actors support and demand actions for sustainability goals, "*Then comes the EU, which tells the company's management that you must do this.*" (E164) Students' experiences in decision-making roles seemed to affect how they assess sustainability initiatives. Discourses in management seemed to involve *sustainability as a question of costs and expenses* and in this sense, the disadvantages of sustainability were recognized. Quick and unplanned change was not supported, and companies outsourcing the problem had been noted; "*They concluded that such changes in the company would cost them 100 million euros. Then they came up with it: outsource the manufacture of the company's products, even to China.*" *(E164)*

The students described digitalization as a great shift in people's lives that should be viewed broadly, "*digitalization is seen narrowly, primarily as social media, forgetting about technology and other dimensions of digitalization." (E45)* Such statements imply the students have noted and are *critical of narrow views on how digitalization affects sustainability* in discourse. Evidence of digitalization trends was seen in behavior change (e.g. time spent online) at work, and in everyday life. Many thought that the coronavirus disease 2019 (COVID-19) pandemic, which reduced driving, travel and consumption, led people to increase their use of digital solutions and work at home, which was estimated to have a long-term impact on a more sustainable society. Working from home was also considered beneficial and less stressful by some, "*As someone slightly on the autism spectrum, I couldn't imagine working in a shop or healthcare because I would meet too many people and it is stressful*" (E108).

Students identified and mentioned sustainability discourses they had come across in media, including themes such as data or wind power. European democratic values and culture were also visible in the discourses, for example in how freedom of choice and rights were emphasized in students' essays: "*In principle, responsible choices are individual's own choices . . .*" (E38) Students discussed how individuals could have their own opinions, choices and actions, but also how people in Finland tend to follow the rules blindly, which was seen as a benefit for the environment, and a potential detriment as change will not happen unless it is "in the rules" and thus a norm. Here, *sustainability* is then *a matter of regulation and norms*: although individuals have rights, society has some control over people, and individuals may follow the rules rather than make decisions for themselves. Mostly laws were deemed necessary to guide companies' conduct rather than the citizens, "*To reach the goals we also need laws that guide technology development.*" (E53) This speaks to a level of trust in the impact laws can have in guiding societal change.

Many discussed how modern European society follows capitalist ideologies to the detriment of sustainability. "*In a capitalist society like this, words like 'long-term' seem to be swear words in many big businesses.*" *(E74)* Here, *sustainability* was seen as *hindered by the economic system*. Mega brands were seen as thriving, but they were seen to chase only profits, downgrading the quality and sustainability of markets. That reflects consumption habits, which were strongly emphasized in the essays. Old traditions in consumption were seen as changing and new trends as modifying markets with constantly innovative digital products. In

contrast to previous thoughts on individual agency, some students placed responsibility on the companies' shoulders, "*I think it is mainly on the companies to create better alternatives for the consumer, rather than the consumer demanding change from existing businesses." (E75)* The belief was that local trends, markets and people should be respected in development.

4.3 Interaction order: identified actors and their impact

Students' thoughts on the actors who can affect the sustainable development of digital technology fall into five categories: *the Public System, the EU, Companies and Individuals*. Students generally believed that the responsibility does not lie with the average consumer but with the larger societal structures and organizations.

Our students positioned *the public system* as a core "actor" for a sustainable society, capable of supporting sustainable solutions through infrastructure, including energy-efficient buildings and garbage recycling. They recognized that many necessary technologies and solutions already exist and now it is a matter of people choosing them. Developed public services were seen as one way to encourage individuals in sustainable change by providing better, cheaper, and user-friendly solutions. In the public sector, collaboration was highlighted, and a few mentioned universities and research as central to innovations. The impact of the public system was also recognized in its capacity to affect peoples' choices through regulation and education. The public system's role in education is in digitalization and enabling lifelong learning. New technologies and automation were seen to reduce jobs, and result in a need for re-education, "*Automation will affect low level education the most, those that are easiest to replace with automation. This will create inequality and widen the income gap even more*." (E1) For the EU goal of future jobs and education for transition period, students' values were aligned with free education for future jobs, but they were divided on whether this responsibility should be on the public, the companies or the individual.

The students thought that the *EU* should aim for member countries and companies to adhere to supporting a transformation toward the Green Deal targets through regulations and laws. Collective climate politics was seen to standardize methods and actions, resulting in new policies, supporting collaboration, and spreading skills and education. Students thought controlling market regulation and standardization were a requirement to reach the targets. Thus, the students constructed the interaction order as one where the EU needs to oversee others, particularly companies.

Companies were recognized as key actors in the interaction order, as enablers of others' sustainability and as central in creating new innovations for everyone. The industry's competitiveness in the market was discussed in most essays as important. The companies were thought of as (1) *manufacturers* that utilize energy and raw materials, or (2) *provider organizations*, which teach and market products and services.

From the manufacturing point of view, students strongly highlighted businesses as influencers but also questioned their intentions, "*Technology companies' problem with long-lasting products is that their sales will decrease. (. . .) Now new innovations have been used to the detriment of this goal." (E64).* They thought that a direct way to affect consumption is to improve product lifecycles, by finding sustainable solutions in every step from product manufacturing to the use and recycling of the product, "*If a functioning older device does not get updates, people will buy new devices even if the previous ones still work."* (E53) The reasoning for making products last longer and creating opportunities to fix old ones was the possibility to reduce purchasing frequency and in the long-term decrease the negative impacts of manufacturing. For example, the concept of a modular and easily fixable phone was mentioned often. Another change students wanted to see from industry was energy solutions. Students thought that following one's carbon footprint is a trend and businesses that assimilate this as a key element in their businesses will gain loyal customers. However, not all companies were estimated to be ready to change or have the funds to do so.

From the provider perspective, students recognized that ecological marketing has been a trend for decades, but they called for more detailed information about product origins and

companies' sustainable actions. After companies provided detailed information on their sustainability changes and actions, students said that they are willing to change their behavior, indicating an interaction order where companies must show that their conduct is acceptable, and other people will follow. The students noted that companies need continuous consumer feedback, to stay on top of trends, but companies were also positioned as teachers of better solutions. This teaching was thought to happen through marketing, and the companies were recognized to have a great influence in guiding the markets, "*Marketing could require some teaching of customers . . . informing of the ease of service and environmental impacts, and these factors should be understood as core factors in new marketing.*" (E41) The students believed that companies could make a difference if sustainability influencing is a strong and convincing part of their operations, "*it is partly the responsibility of companies to direct consumers' attention to sustainable products*" (E157). Moreover, some thought companies ought to offer free transitioning training for citizens in the changing job market.

Ninety students believed that consumption habits of *individuals* play a major role in achieving sustainability goals, and that controlled change through informing people and improving awareness is the way to achieve the EU's targets. They thought citizens have power in numbers, through consumption habits that can affect larger organizations, "*social pressure is pushing companies to invest in this" (E157).* The students thought that megatrends are challenging companies to make changes in their production to maintain popularity because future customers are challenging this arrangement where companies lead people. Overall, students thought that marketing has changed their thinking toward nature and sustainable solutions, as a trend or as part of the ideology. "*As sustainability is a growing value in the world, I believe it will be enough to change people's and organizations' thinking*." (E64) Some compared the current situation to the past, when people had fewer options to choose from, but also recognized that opportunities to change people's habits are limited by the cost of those sustainable choices, exemplified in high organic food prices. Students who emphasized equality as an important value saw controlled change as important, as everyone cannot afford or accept all the changes made in the name of sustainability. According to our students, essential factors for sustainable future environments and markets were the pricing of the products, re-use-based development and technology development including interaction with consumers to improve the products and services. Although individuals were seen as a powerful group when united, it was strongly expressed in the essays that responsibility lies elsewhere, in the larger organizations and social systems.

Naturally, the *students' own future* was on their minds. Thus, when considering their position in sustainable development, a hope for work opportunities arose in the essays, "*A promise of future jobs and education for them are interesting for a young student.*" (E131) In the essays, we can see a will to be a part of the change for the better, to be an active part of creating new and better technology for everyone. Those who focused less on technology emphasized moral choices and values, affecting consumer behavior, providing jobs, and technology that is accessible to everyone. The students structured their roles based on what they are studying, "*On my part as an IS student, I would like to influence and solve problems on the technology development and production side, because I trust my education to prepare me for those tasks.*" (E151) IS students emphasized technology as a solution, "*Of course as a student and worker in this field I see technology as an automatic solution.*" (E93) Meanwhile an economics and a production economy students highlighted business solutions, "*Particularly as a production economics student I would imagine the solution to come from business planning on my part.*" (E150).

5. Discussion

This study contributes toward sustainable ICT research and design of effective ICT education, motivated by our interest in understanding what students should learn as future ICT professionals who will work in a world where sustainable solutions are of central interest. ICT

professionals' attitudes toward the environment have been explored (e.g. Bokolo, 2019), as well as European's attitudes toward the environment and technology (Duda, 2022). While these provide some insights, they did not provide us in-depth, qualitative understanding that we were looking for. With a better understanding of how our students view sustainable digital technology development and what they base their views on, we can reflect on how to develop their education. Thus, we asked our students to choose EU targets to discuss in the context of technology development, particularly software innovations, for us to understand *how students approach sustainability and digital technology development and what this implies to ICT education?* We identified four central themes visible in the students' answers, and we discussed those next.

5.1 It is easier to focus on issues that are relevant to one's own life

Our data revealed that students actively engaged in discussions relevant to their lives, driven by their historical bodies in the form of interest in ICT and a belief in technological solutions for sustainability. They use digital services and show awareness as conscious consumers. Corbett (2023) suggests that localizing problems helps students connect with the issue, and our students draw on personal experiences. Transitioning to student life prompted active consideration of sustainability, influenced by workplace culture and responsibilities. This demonstrates evolving thinking across life stages and contexts. The significance of one's home, whether house, city or country, was evident in discussions on people's rights and the scalability of sustainable innovation, particularly in less populated areas. Public transportation emerged as a concrete and popular example, reflecting varied experiences between cities and rural areas.

Discourses in place stem from students' everyday lives, including university and work, but also the larger society and media. The smaller circles of discourse can involve recycling practices at the workplace, and the larger ones can involve the capitalist economic system and its effects on sustainability. We found the students affected by discourses in their education in how they approached the question, and students in ICT were inclined to emphasize the socio-technical aspects (similarly as in Corbett, 2023). At work, they noted the EU's influence; it is an example of institutional pressure, which has been found to impact IT professional's views (Bokolo, 2019). Investing in Green ICT may be driven by cost reduction, but our students saw sustainable options as more expensive. They also pondered individual rights, the role of laws in achieving sustainability goals, and the inclination of people in Finland to abide by laws. The importance of local culture in pursuing sustainable change was emphasized. These findings, supported by Corbett (2023), suggest the value of selecting familiar and relevant topics for discussing sustainability with students, enhancing their understanding and relevance of sustainable choices. Drawing from students' current experiences as higher education students as well as their future profession (Anthony *et al*., 2023; Ebert and Louridas, 2023; Jain and Ranjan 2020) can be an effective way to make them visible, e.g. the significance and systemic nature of infrastructure in sustainability efforts (van der Vlist *et al*., 2024).

5.2 Technology solutionism with care and consideration

Green IS research identifies modernity patterns, including reliance on technology (El Idrissi and Corbett, 2016). Our students viewed technology positively for solving sustainability issues but emphasized the need for careful consideration due to concerns about fast-paced, impulsive changes. This reflects an awareness of the complexity of technology's impact. Earlier research (Duda, 2022) notes Europeans' skepticism about significant improvements from modern technologies. Students envisioned meaningful future technologies in ICT, with electric and self-driving vehicles and AI topping the list. They recognized data's centrality in technology development, aligning with previous studies (Hugo *et al*., 2022; Pappas *et al*., 2018). Privacy risks associated with data were acknowledged, but concerns about surveillance, ownership, and pollution were not raised (Amin *et al*., 2020; Martin, 2015;

Sohaib and Olszak, 2021) by the students. While technological solutionism is inherent for ICT professionals, encouraging an understanding of linked risks alongside the potential for solving sustainability issues would help students grasp their role as responsible ICT professionals.

Our students advocated for a broad consideration of digitalization, recognizing its positive impact on life, such as enabling remote work and reducing travel and social interactions. While they acknowledged digital solutions influencing how people spend their time and recalled online content related to sustainability, they didn't explicitly connect the two in their essays. However, previous research (Seyfi *et al*., 2022) indicates that digital media can influence Gen Z consumerism. Despite sustainability issues feeling distant from students' usual study topics, connecting them to future professions is crucial (Eriksson *et al*., 2020). In line with this, we inquired about the problems students aspire to solve.

Students predominantly discussed long-lasting products, public transportation and clean energy, relating them to their life situations. However, there was limited exploration of digitalization, software and IS, possibly due to their early stage of education and limited knowledge of these technologies. Addressing this gap, there's a need for students to gain a better understanding of current and emerging technologies in their field to assess their impact on sustainability. To enhance awareness and learning, providing more information on existing solutions or incorporating market research for students to compare their ideas with existing options could be beneficial.

5.3 Lack of deeper understanding of societal systems as a whole and technology's role in them

Interaction order focuses our attention on the actors and power dynamics identified by the students. Notably, the public system, companies and the EU emerged as pivotal for sustainable technology development. The public system's role was emphasized as empowering people through education and digital solutions but not necessarily innovation. Structural changes were deemed more crucial in the industry, with the public sector tasked with encouraging adoption and supporting positive change through legislation. The meaning of the public sector seemed vague to some students, potentially impacting their responses. The EU was discussed separately and was acknowledged for ensuring common goals among companies and countries through laws and competition control. This was mostly described in positive tones. Companies were portrayed as market-driven entities pursuing profits, aligning with the growth goal pattern in Green IS research (El Idrissi and Corbett, 2016). However, they were also depicted as solution providers and educators. The importance of customer engagement highlighted a commitment to user-centered design principles among our students. In a distinct discussion, industry production and factories were explored in terms of products, energy and raw material utilization, and pollution creation.

Generally, our students appeared to lack a clear understanding or interest in discussing the interlinked nature of different societal systems and the significance of these linkages when making sustainable choices; what is sustainable from a business perspective may differ from that of the public system. Considering systems thinking (cf. Corbett, 2023, etc.), it can be challenging without knowledge of the systems, their structures and existing technological solutions, as many parts may be hidden from citizens' view. We recommend focusing on a manageable-sized whole, which can be meaningfully discussed in the task, perhaps starting with a smart home or a smart campus ecosystem, and building from there. Developing strategic thinking, as outlined by Corbett (2023), involves designing and implementing plans to achieve objectives or visions. Linked with that, understanding the surrounding world, and learning systemic thinking and future speculation approaches can prove beneficial in professional life.

5.4 Agency as an ICT professional

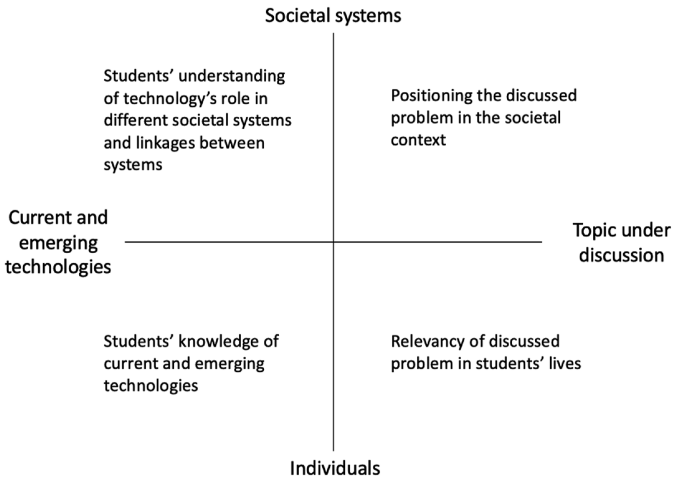
While patterns of modernity in Green IS research highlight the individual's importance in problem-solving (El Idrissi and Corbett, 2016), our students seemed to hold an opposing view.

They emphasized larger organizations and social systems in their essays. Based on the essays, the individuals' positions appear conflicted – they are constrained by the cost and availability of sustainable options, posing a challenge to social sustainability. However, individuals also have power in numbers, and this suggests that making sustainable choices collectively can influence change in larger organizations. When it comes to these students themselves, they took a different perspective, seeing ICT professionals as having the agency to impact sustainability through their work, by the development of new and improved solutions. A previous study aligns with this, finding that Green IS initiatives often stem from bottom-up processes initiated by individuals promoting the issue within their organizations (Hedman and Henningsson, 2016). Many of our students expressed a desire to play such an active role. To nurture this emerging agency as ICT professionals, fostering discussions on the active roles they can take in supporting the development and use of sustainable solutions, providing examples of those, and critically reflecting on the practical implications of an active role, along with the necessary support and structures, could be beneficial.

6. Conclusion

Given our findings discussed above, it appears that ICT students would benefit from a more structured approach to sustainability within their studies. We propose framing sustainability in ICT courses as a question of four intersecting elements: individuals, societal systems, current and emerging technologies, and the relevancy of the topic under discussion, all of these linked with the agency of ICT professionals (Figure 1).

By gaining a deeper understanding of how students make sense of sustainable digital technology development and the foundations of their views, we can reflect on the desired learning outcomes in ICT education. Approaching sustainability as a future-oriented (Norton, 2005) and systemic issue, the suggestion to incorporate futures-, values-, systems-, and strategic thinking in sustainability education (Corbett, 2023; Warren *et al.*, 2014) appears relevant. Our data provide insights into each of these aspects, guiding the development of a more comprehensive and forward-looking approach to sustainability in ICT education.



Source(s): Figure created by authors

Figure 1. Positioning sustainability as a question of intersecting elements, linked with the agency of ICT professionals

Thinking about the future can be challenging, as highlighted by Corbett (2023), we think it requires some tools. Considering that our visions of the future often rely on trajectories rooted in the present, we acknowledge the limitations in placing such a task for young bachelor students. Speculative design and design fiction could help explore the different facets of sustainability in technology development and use. Akin to how science fiction novels can inspire new thoughts about the world we live in, "*thinking with monsters*" (Hovorka and Peter, 2018) or other speculative ways of engaging with the future (Hovorka and Peter, 2021a, b) might serve as an engaging way for students to explore and articulate values associated with technology development and sustainability. Creating scenarios where the world is just different enough due to emerging technologies or their usage, maintaining recognizability but introducing discomfort with something being a little off, could be an effective method. Students can be presented with these scenarios for discussion, or they could be tasked with developing such scenarios themselves. As Corbett (2023) notes, students may have deeply embedded values, and fostering dialogue among students with diverse perspectives can unveil these underlying values. Encouraging critical discussions from different viewpoints would enrich the conversation among students, providing a more holistic understanding of the complex relationship between technology and sustainability.

Our course did not focus solely on sustainability except for one lecture, reading materials, and task intended for this theme; the rest of the course revolved around software business, innovation and value creation. The students displayed an interest in sustainability goals and discussed the EU goals mostly in positive tones. We think it worthwhile to consider how such a complex issue as sustainability can be meaningfully integrated into ICT education. Notably, a study found that students introduced to Green IS gained normative and interpersonal competence, as well as skills to anticipate the future and assess current and future systems (McGibbon and Ophoff, 2018). Our results complement these findings by providing insights on how students tackle the topic of sustainable technology development and where they draw their knowledge from. We know ICT professionals' beliefs, norms and attitudes impact the implementation of green practices (Bokolo, 2019). NA focused our attention on how students discuss sustainability, what experiences and knowledge they base their views on, and how they position themselves and other actors in the broader picture. When prompting students to envision how they would contribute to the EU targets, we found a lack of knowledge regarding existing solutions, and challenges in focusing on software innovations, as students drew on what they knew. While other courses within the curriculum may touch upon sustainability issues within the context of their respective subjects, our findings illuminate the perspectives our students will bring into the ICT workforce without further education on sustainability. Knowledge about what the ICT field can contribute to sustainable development or how it may inadvertently cause harm should be an integral part of the curriculum. We believe it would be beneficial to explore the discourses students have encountered on the topic, understand their personal experiences, and examine their perceptions of society in terms of who holds the capacity to make a meaningful difference.

As to the limitations of this study, we have a good amount of data from our students, but the cultural context affects the results. The students were asked to discuss the EU Green Deal, which already sets the focus and perspective, and they then reflected on what they know from their own lives and cultural contexts. A similar work in a different cultural context could provide different insights. The study participants are also relatively young, which may affect the findings. The study was conducted before the large language models and other new uses of AI came into wider use, possibly influencing the choice of topics in the essays. Moreover, due to the data being gathered in a university course, it is natural for students not to disclose very personal information as they communicate in a way they have been taught to in an academic context, and they may attempt to please the teachers to gain good scores. This can mean that some relevant information is left out. Despite this, we found the students confident in expressing opinions. Taking the study outside of the university context could bring more varied insights. Although we know that most of these students came from our bachelor's study program, and we can see students mention their own field of study in many essays, we cannot

check how many students came from our own study program. However, all of them chose to enroll in this course of technology innovation and business.

We propose the approach presented in this paper to be used in other courses to raise students' consciousness of their own role as future professionals in the ICT field in developing more sustainable digital solutions and generally helping them to see the big picture of sustainability through setting the scene with the wider targets, such as the European Green Deal, and then asking the students to prioritize the targets and to consider concrete actions of ICT professionals for making the targets come true. Research of students as future professionals could benefit from considering how the future is explored, how the systemic nature of sustainability is considered, and whether utilizing NA (Scollon and Scollon, 2004) as a theoretical lens could help find new ways to construct educational approaches.

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