PROMOTING THE SUSTAINABILITY TRANSITION WITH THE CONTENT AND COMPETENCIES PROVIDED BY TECHNICAL HIGHER EDUCATION

Case: School of Technology at the South-Eastern Finland University of Applied Sciences

Lappeenranta–Lahti University of Technology LUT

Master's Programme in Circular Economy, Master's Thesis

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Liisa Routaharju

Examiners: Professor Risto Soukka

Sanni Väisänen, D.Sc. (Tech.)

ABSTRACT

Lappeenranta–Lahti University of Technology LUT

LUT School of Energy Systems

Environmental Technology

Liisa Routaharju

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Keywords: Sustainable Development, Key Sustainability Competencies, Education for Sustainable Development, Institutions of Higher Education, University of Applied Sciences

Education is at the heart of the changes needed for the socio-technical transition to a sustainable world. Understanding the necessity of change should be coupled with awareness of the root causes of the currently dominant unsustainable development. This research establishes the current situation of how sustainable development contents and Key Sustainability Competencies are manifested in technical higher education curricula as well as educational guidance and teaching activities in a case example organization, the South-Eastern Finland University of Applied Sciences, School of Technology. The research methods include data collection by a literature review, curricula analysis, interviews and a survey. The data is analysed using qualitative content analysis to identify the degree of sustainable development contents and competencies included in curricula and teaching implementation.

The results indicate potential for increasing both sustainable development content and sustainability competencies in technical higher education. Guidance to include these in curricula development and teaching could be more structured. This would allow the staff to identify the tools for integrating sustainable development topics in teaching. More systematic assessment of working life competence needs and helping teaching staff identify field specific examples of sustainable development would ease this integration.

TIIVISTELMÄ

Lappeenrannan–Lahden teknillinen yliopisto LUT

LUT Energiajärjestelmät

Ympäristötekniikka

Liisa Routaharju

Kestävyysmurroksen edistäminen tekniikan alan korkeakoulutuksen tarjoamalla osaamisella.

Tapausesimerkki: Kaakkois-Suomen ammattikorkeakoulun tekniikan koulutusalat

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Koulutuksen vaikuttavuuspotentiaali kestävyysmurroksessa on merkittävä. Koulutus lisää tietoisuutta muutoksen välttämättömyydestä ja ymmärrystä nykyisten kestävyyshaasteiden juurisyistä, edistäen osaamista muutoksen työkalujen käyttöönottamiseksi. Tässä tutkimuksessa selvitetään kestävän kehityksen tietoisuutta ja kestävyyskompetensseja lisäävien sisältöjen ilmenemistä tapausesimerkkinä toimivassa koulutusorganisaatiossa, Kaakkois-Suomen ammattikorkeakoulussa. Tutkimus keskittyy tekniikan alan koulutuksiin.

Tutkimuksessa tunnistettiin kestävän kehityksen sisältöjä ja kestävyyskompetensseja opetuksen ohjauksessa, opetussuunnitelmien sisällöissä ja opetuksen toteutuksessa. Kirjallisuuskatsauksen, opetussuunnitelma-analyysin, henkilöstön haastattelujen ja opiskelijoille suunnatun kyselyn avulla kerätyt tiedot analysoitiin laadullisen sisällönanalyysin keinoin.

Tulosten perusteella kestävän kehityksen tietoisuutta ja kestävyyskompetensseja lisäävän sisällön integroimista opetukseen on mahdollista tehostaa. Ohjauksen kestävyysosaamisen lisäämiseen opetussuunnitelmissa ja opetuksen toteutuksessa tulisi olla aktiivisempaa. Opetushenkilöstölle tulisi myös luoda nykyistä paremmat mahdollisuudet tunnistaa omaan alaansa liittyviä kestävyysosaamisen esimerkkejä. Järjestelmällinen menettely työelämän kestävyysmurrokseen liittyvien osaamistarpeiden kartoittamiseksi voisi edesauttaa niiden integroimista opetukseen.

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ABBREVIATIONS

Arene	The Universities of Applied Sciences Rector's council
BEng	Bachelor of Engineering
CE	Circular Economy
CU	Credit Unit
ESD	Education for Sustainable Development
ESG	The Standards and Guidelines for Quality Assurance in the European Higher Education Area
GP	Finnish Governmental Programme
IHE	Institution of Higher Education
ISO	The International Standardization Organization
Karvi	the Finnish Education Evaluation Centre
KSC	Key Sustainability Competence
LC	Life cycle
LfS	Learning for Sustainability
MEng	Master of Engineering
MLP	Multi-Level Perspective
MoEC	Ministry of Education and Culture
NFSA	The National Forum for Skills Anticipation
OKM	Opetus- ja kulttuuriministeriö (The Finnish Ministry of Education and Culture)
SD	Sustainable Development
SDG	Sustainable Development Goal

UAS	University of Applied Sciences
UN	United Nations
UNESCO	The United Nations Educational, Scientific and Cultural Organization
XAMK	South-Eastern Finland University of Applied Sciences

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1 Introduction

Replacing the current operational models and habits by new ones starts with the understanding of the need for the change and envisioning of the desired outcome of it, not limited by what is seen possible (Meadows, 2014). Once these are clarified and commonly accepted, the instruments for implementing and measurement methodology for assessing the change can be developed, tested, and developed further. Education, in the meaning of disseminating information and increasing knowledge, is at the heart of all these phases: there is no understanding or solving problems without knowledge.

The United Nations Sustainable Development Goals have become a widely recognized symbol of the work towards a more sustainable world, combining the aspects of sustainable development under an umbrella of tangible aims (UN, n.d.). Each of the 17 goals is given targets and indicators have been selected to help measure progress in reaching the set aims. The role of education in understanding the necessity for sustainability and in finding the tools for the sustainability transition is highlighted in goal 4: "Quality Education" (UN, n.d.). As a specification of goal 4, target 4.7 sets an ambitious aim of ensuring availability of knowledge and skills for sustainable development promotion. Reaching these is measured using the extent to which education for sustainable development and global citizenship education are mainstreamed in educational policies, curricula, and teaching (UN, 2022) as one of the indicators. In the beginning of 2022, no results on this target were yet reported in Finland (Statistics Finland, 2022) and according to the Finnish Ministry of Education and Culture (OKM, 2019 and 2020) specific methods for measurement were under development. The results reported globally for the reference year of 2017 were also based on estimations or partial coverage (UNESCO, 2021).

The National Forum for Skills Anticipation (2019, 3) country specific skills forecast for 2035 names digital and technological skills as well as the need to understand aspects of sustainable development as the skill requirement areas with the clearest increase in the future. In addition to understanding the meaning of sustainable development, the competencies required for the large scale behavioral and habitual change to facilitate sustainability transition must also be strengthened (Pacis and VanWynsberghe, 2020, 576). Changing the Dominant Metanarrative of limitless growth to Life-Affirming metaphor (Glasser, 2019, 40) can only succeed

with sufficient knowledge and level of understanding. Higher education, in addition to providing students with high level professional competencies, has a role in finding the scientific and technological solutions that help humanity towards a more sustainable and resilient existence. This role is very strong in technical field higher education.

The sustainability actions in educational institutions can be divided to two main categories: taking sustainability aspects into consideration in decision making and daily operations (operational sustainability) and the way in which sustainability is incorporated in the provided education (contentual sustainability). Ideally the educational activities at Institutions of Higher Education increase awareness of sustainability and the versatile research and development activities enhancing the Key Sustainability Competencies (KSCs) along with finding innovations that promote the transition. Institutions of Higher Education have a great potential to act as regional sustainability leaders by increasing awareness of sustainable development throughout society not only by the example of operational models, but through the increased skills and competencies graduates bring to working life.

The aim of this research is to establish the current level of how sustainable development contents and Key Sustainability Competencies are included in technical higher education using the UN SDG Target 4.7. indicators as a basis for the research design. The research sets out to describe the path of guidance for Institutions of Higher Education for incorporating education for sustainable development in their educational activities. A case study is used to determine the degree of how sustainable development awareness and key competencies are represented in curricula and manifested in teaching and learning. The research is focused on the technical study programmes of the School of Technology at the South-Eastern Finland University of Applied Sciences (Xamk). The theoretical background consists of an overview of the role of higher education in the socio-technical sustainability transition and a description of the current guidance mechanisms used for steering Finnish Universities of Applied Sciences towards education for sustainable development and provision of Key Sustainability Competencies. The sustainable development contents and competencies in the case example organization are studied by a literature review and a qualitative content analysis of the current study programme curricula, completed by staff interviews and a student survey to reveal the actualization of sustainability aspects of teaching in more detail.

2 The Role of Higher Education in the Sustainability Transition

The ability to learn and pass the learning outcomes forward is one of the features that makes the human species so resilient, even to the changes caused by humans themselves. The Cambridge dictionary definition for education points especially towards learning at an educational institution (Cambridge University Press, 2022) and very commonly the word education refers to formal education: teaching at educational institutions and completion of degrees based on set requirements. Education is one of the cornerstones of the human socio-technical development as it enhances innovation, sparks insights, and enables advanced problem solving. Unfortunately, the past socio-technical development has led to the current imbalance between the planetary boundaries (Rockstöm et al, 2009, 472) and the human quest for continually increased systemic efficiency (Martin, 2019). Major sustainability challenges caused by this imbalance can be categorized to environmental, socio-cultural, and economic challenges, although the complexity and interconnected nature of the planetary system and the human society also means these challenges are strongly interlinked (Raeworth, 2017, 32).

The importance of education in providing the necessities for well-being for the current and future generations was established even before the concept of sustainable development, as the "Recommendation concerning Education for International Understanding, Co-operation and Peace and Education relating to Human Rights and Fundamental Freedoms" was completed already in 1974 (UNESCO, 1974). Education is also one of the fundamental human rights (UN, 1948) and as such plays a key role in increasing awareness of sustainability challenges and the need to address them, as well as finding new scientific and technological solutions to help humanity towards a more resilient life. The UN sustainable development goals (UN, n.d.) have helped make the complexity of both sustainability challenges and the means for addressing them more tangible. A multitude of effort is put into finding the path to a sustainable world. Addressing the current sustainability challenges can only succeed via systemic changes in the structures that have generated and maintain these challenges. Geels (2002, 1257) calls these necessary systemic changes "socio-technical transitions", which very aptly describes the multidisciplinary nature of the required alterations. A transition of this magnitude and versatility cannot take place without a large-scale habit change (Pacis and VanWynsberghe, 2020, 576) simultaneously on several fronts. Formation and

maintenance of sustainability agency call for individual growth through understanding and a mind-set change (Koistinen, 2019, 87). Geels (2011, 25) points out that the changes made to enhance sustainability transitions offer very few direct benefits, increasing the importance of understanding their necessity and development of agency even further.

Education is, quite justifiably, seen as one of the enablers of the sustainability transition as promoter of understanding and competencies, which in turn promote agency. Figure 1 illustrates how the elements of educational design and guidance together with monitoring performance ideally result in the outcome of behavioral change with some examples of theoretical frameworks used to contextualize them in this research.

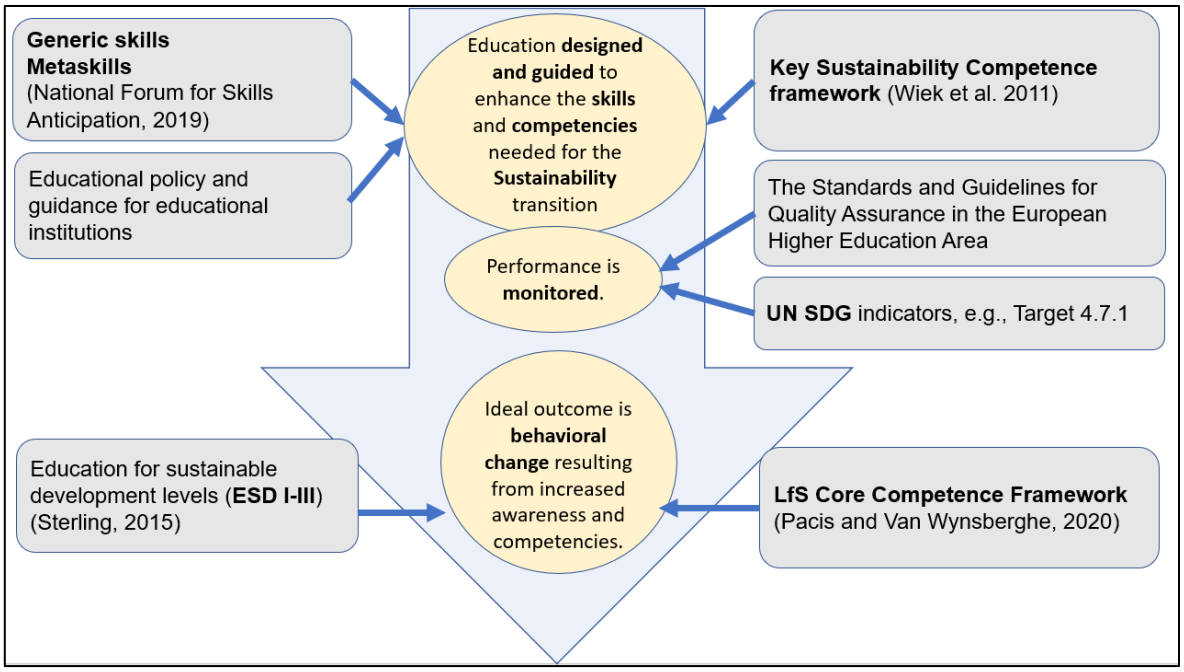

Figure 1. The Theoretical Frameworks Used to Contextualize the Role of Education in the Sustainability Transition in this Research (ESG, 2015; NFSA, 2019; Pacis and VanWynsberge, 2020; Sterling, 2015, 98; UN, n.d. and Wiek et al., 2011, 207)

The UN SDG indicators have been critiqued as incomplete in their ability to provide information on how well the key sustainability competences are enhanced in education (da Silva, 2020; Helin, 2021; GAML, 2017; Mochizuki and Fadeeva, 2010). The Key Sustainability Competence and the Learning for Sustainability Core Competence frameworks are briefly

described in this chapter to bring more conceptual basis for the utilized measurement methodology. These help bind the future skillset requirements identified by the National Forum for Skills Anticipation (2019, 3) to the importance of measuring how well education is able to provide the required skills and competencies.

2.1 The Three Stages of Education for Sustainable Development from The Multi-Level Perspective Viewpoint

Education is incremental for promoting the effectiveness of any sustainability instrument through developing engagement and agency of stakeholders (Sterling, 2015, 90). Ideally higher education equips students with the competences to help them become future sustainability change agents and leaders (Pacis and VanWynsberghe, 2020, 586). At the core of these key competences are systems-thinking, anticipatory, normative, strategic, and interpersonal competencies as well as the ability for integrative problem solving (Wiek et al. 2011, 212).

At the core of educational activities are the identified aims for them: the demand for the set of skills, competencies and awareness build by education. This demand is influenced by the regional labor market (i.e. the need for educated workforce) as well as megatrends influencing the types of generic skills employers look for when recruiting. The pressure for knowledge of sustainable development is likely to increase in the future (NFSA, 2019, 3). This pressure sends signals to the policymakers also. On the other hand, individual educational institutions, or even individual teachers or students may have a personal motivation to incorporate certain competencies and areas of awareness in teaching, which initiates a larger demand throughout societal layers. Furthermore, it is becoming clearer that addressing environmental challenges is insufficient, when the actual challenge is societal (van deer Leeuw, 2018, 1590).

In the multi-level perspective (MLP) for socio-technical transitions described by Geels (2002, 2005 and 2011) education in the role of innovation promoter has a clear significance and the lack of the necessary skills is identified as an element blocking or slowing the transition. The MLP differentiates three levels, 1) niche, 2) regime and 3) landscape levels, of coordination and structuration provided for socio-technical innovations (Geels, 2005, 682), each influencing and being influenced by the transition in a nested hierarchy. Education is

more than the research network (Geels, 2002, 1260) provided by Institutions of Higher Education and in terms of the techno-scientific knowledge the role of education is undisputed. Knowledge is also one of the elements of socio-technical system innovations (Geels, 2005, 683), so Institutions of Higher Education and the results of their work have an influence on niche, regime and landscape levels.

The socio-technical landscape is influenced by the imposed policies, as examples the international educational policies by, e.g. United Nations, and the United Nations Educational, Scientific and Cultural Organization (UNESCO), and the European Union. These policies, be they legislative or voluntary, are generally brought to national guidance through the relevant ministries and, if necessary, incorporated in the national legislative framework. In addition to the policy guidance, various actors of the landscape level are able to influence the sociotechnical change via financing instruments. In terms of educational institutions, funding for research and development or educational activities is a powerful guidance tool (Korhonen-Kurki et al., 2020). Education for Sustainable Development (ESD) is a term used to describe a set of educational and related activities that seek to facilitate the transition to more sustainable societies. UNESCO (2012, 33) calls attention to all aspects of education, from planning, policy development and implementation to financing, teaching and learning from a society to individual levels being addressed to facilitate more efficient ESD and "a more sustainable future".

Sterling (2015, 98) named three stages of education for sustainability. In the first stage (ESD I) the education focuses on learning about sustainable development and change from an informational perspective. This "first order learning" is not likely to motivate long lasting behavioral change especially because the benefits of the change are not direct (Geels, 2011, 25). The second stage (ESD II) typically generates deeper affective learning and sense of engagement through expansion of thinking and reflection of values. The third level (ESD III) is most likely to achieve the mindset change towards a more holistic view on sustainability, since it involves engagement and empowerment achieved through critical reflection. (Sterling, 2015, 98.)

ESD in the MLP framework, and from the viewpoint of the stages of ESD described by Sterling (2015), reveals education as a force both driven and sculptured by the sustainability transition on one hand and enabling, even reinforcing it on the other. Education is the elemental tool for the deeper understanding of the urgency and necessity of the sustainability

transition as well as the enabler of building the competencies necessary for developing this understanding further into empowered action. On the landscape level this is revealed by the policy guidance for incorporating ESD in the educational system simultaneously to setting operational requirements for the incorporation of sustainability driven decisions in the daily activities of educational institutions. Ideally this guidance provides educational institutions with the tools to educate future sustainability leaders that see sustainable decisions in daily activities as the operational model they have grown accustomed to during their studies. Both of these views, the sustainability driven decisions in the operations of the institution ("operational sustainability") and the educational, competence building view on sustainability ("contentual sustainability"), should be looked at in the sustainability considerations of educational institutions as they are likely to influence the educational environments provided as well as the content and quality of teaching.

2.2 Sustainability Competence Frameworks

Education aims to increase the competencies of those being educated, thus increasing the overall competence of society. Competences consist of knowledge, skills and attitudes that together allow the competent individual to perform successfully (Wiek et al., 2011, 204). Rieckmann (2012, 129) includes aspects of personal motivation, cognitive, affective and volitional elements in characterization of competencies. Glasser (2019, 40) titles the current unsustainable way of life the "Dominant Metanarrative", that should be replaced by a "Life-Affirming Metanarrative". Breaking the Dominant Metanarrative calls for learning and understanding the state of the planet. This, in turn, takes thorough understanding of the planetary systems along with their complex and interconnected functions (Rockström et al., 2009; Meadows, 2014), as well as the ability to innovate and find ways for the Life Affirming Metanarrative represented, e.g., by setting limits to exploitation and seeking conservation and regeneration of resources, and a commitment to common good (Glasser, 2019, 42).

Wiek et al. (2011, 207) have identified the key competencies aiding the ability to understand systems and the root causes of the disruptions caused in them. Ideally enhancing these Key Sustainability Competencies (KSCs) will also enhance the sustainability transition. UNESCO, (n.d.) names "*critical thinking, imagining future scenarios and making decisions in a collaborative way*" as the competencies education for sustainability should enhance.

The KSC framework (Wiek et al., 2011) includes competencies such as *systems-thinking*, *anticipatory*, *normative*, *strategic*, *and interpersonal skills* that can be combined to *integrative problem-solving competencies*. These demonstrate some similarities to the skills named by the National Forum for Skills Anticipation (2019, 3) as the metaskills (*problem solving skills*, *self-regulation*, *the ability to learn*, *development and management of personal competence*, and *information evaluation skills*) that are increasingly important in future working life. The KSCs (Wiek et al., 2011, 213) and the work of, e.g., Glasser (2018) were used as a basis for the Learning for Sustainability (LfS) Core Competence Framework described at the University of British Columbia by Pacis and Van Wynsberghe (2020, 583). The LfS core competence framework is described on three levels build up from values and commitments to knowledge and understanding and finally reaching the top of social skills and agency (Pacis and VanWynsberghe, 2020, 583) representing a similar contextualization as the ESD levels described by Sterling (2015). The key features of these frameworks are listed in Table 1.

Table 1. Connections in the ESD and the LfS Core Competence Framework (Sterling, 2015, 98 and Pacis and VanWynsberghe, 2020, 583).

ESD	LfS CCF
ESD I: **CONTENTS** SD subject matter, such as ecological, economic and socio-cultural challenges or how they are addressed.	**VALUES AND COMMITMENTS** Common good, affinity of life. Care for self and others.
ESD II: **UNDERSTANDING** Critical reflection regarding SD subject matter, expansion of thinking towards systemic understanding. Engagement.	**KNOWLEDGE AND UNDERSTANDING** Systems thinking and future thinking. Awareness of the state of the planet.
ESD III: **EMPOWERMENT** Capacity building, holistic content view, creative engagement.	**SOCIAL SKILLS AND AGENCY** Modeling of sustainable behavior Implementing change. Wise, compassionate decision making

The levels of both ESD framework (Sterling, 2015, 98) and the LfS framework (Pacis and VanWynsberghe, 2020, 583) are reflected in the recommendation for shared competences of Universities of Applied Sciences published by the UAS rectors' council Arene. The

competence recommendations are categorized under six focus areas "*learning to learn*", "*operating in a workplace*", "*ethics*", "*sustainable development*", "*internationality and multiculturalism*" and "*proactive development*" (Arene, 2022, 5). The recommendation sets an expectation that a graduating Bachelor's degree student: "is familiar with the principles of sustainable development, promotes their implementation and acts responsibly as a professional and a member of society." and a graduating Master's degree student: "develops and manages sustainable and responsible operating methods in their work and promotes sustainable change in their work community and society" (Arene, 2022, 7), but as of yet no information is available on how these recommendations are to be implemented at Universities of Applied Sciences.

2.3 Sustainability Competencies in Technical Higher Education

According to the National classification of education (Statistics Finland, 2016), engineering and engineering trades, manufacturing and processing and architecture and construction are classified as technical education. Skills and competencies typically associated to these fields include, at the very least, problem solving competencies. Professionals working in technical fields, particularly those with higher education, are expected to deliver technological solutions to the sustainability challenges and measure the effectiveness of these solutions.

The Finnish education system relies on age-appropriate levels of education beginning at the early childhood education and care and building up through the basic education to upper secondary education and offering further opportunities for vocational education and higher education. Each level and educational institution have their specialization in the overall educational system as guided by the Ministry of Education and Culture (MoEC). Higher education in Finland is given by universities and universities of applied sciences. Institutions for Higher Education provide education based on scientific research (universities) and working life needs (universities of applied sciences). (OKM, 2021a.)

Institutions for Higher Education should facilitate the development of the identified key competencies, and many have adopted Education for Sustainable Development policies and committed to action to promote sustainability as an elemental part of their operations (Rieckmann, 2012, 129). Challenges of staff and student mobilization and inclusion of sustainability in research and teaching activities still prevail (Rieckmann, 2012, 129), even if

research (e.g., Alm et al., 2021, Pálsdóttir and Jóhannsdóttir, 2021) indicates an increase in the use of the key competence frameworks as a basis for higher education design. One clear obstacle is the complexity and multidisciplinary nature of sustainability. Willamo et al. (2018, 2) suggest a comprehensive approach framework of generalism, holism and holarchism to help address this issue. Generalism would help approach the challenges from the multiple viewpoints that mere understanding them requires, and holism and holarchism would allow for approaching the topics as entities and as the units the entities are made up from simultaneously (Willamo et al., 2018, 2).

Systems-thinking as a Key Sustainability Competence represents the ability for holistic thinking and identification of interconnections between system components that can be used to analyse features of complex systems (Wiek et al., 2011, 207). Many technical professions rely on the ability to comprehend such complexities and the cause-effect relations of the topic under study. Technical professions are also typically very future oriented and constantly seeking to come up with new innovative technological solutions, so it can be argued that anticipatory competences, as defined by Wiek et al. (2011, 207), are an integrative part of technical higher education. Technical fields are often regarded to focus on the "hard" content so normative knowledge of ethics, socio-ecological integrity and equity (Wiek et al., 2011, 209), may not be among the first topics of expected content in technical field education. Interpersonal competencies, such as negotiating, communicating and collaborating (Wiek et al., 2011, 211), are emphasized throughout the educational path, so they are likely to be manifested in technical field higher education also. Strategic competencies that rely on much the same abilities as systems-thinking allow understanding of, e.g., systemic inertia, barriers and path decencies (Wiek et al., 2011, 211) that are often present in assessment of technical solution feasibility.

3 Sustainable Development Work at Finnish Universities of Applied Sciences

Education for Sustainable Development (ESD) calls for identifying the type of education that is likely to promote and advance social, economic and ecological sustainability. Realization of sustainability and action towards sustainable development in IHEs include the sustainability driven decisions in daily activities (e.g. infrastructure management, procurement and work related travel) and the promotion of sustainability competences and awareness on sustainability for the students.

Awareness of the urgent need for sustainable lifestyles and knowledge of the aspects of sustainable development alone may not provide sufficient boost for the sustainability transition. These needs are reflected in the UN Sustainable Development Goals and specified into targets and related indicators seeking to ensure a wide scale understanding of sustainability and educational activities throughout the World are restructured to better facilitate reaching these aims. A clear commitment to ESD and incorporation of aspects of sustainability in decision making can be found in guiding documentation for educational institutions. This chapter describes the guidance for Universities of Applied Sciences in incorporating aspects of sustainable development in their operations and in the educational activities with some examples of the methods they use for implementation of the set sustainable development aims.

3.1 Sustainable Development Guidance Mechanisms for Finnish Universities of Applied Sciences

For ensuring freedom and impartiality of science Institutions of Higher Education have a highly autonomous status to make decisions about their administrative, research and development and educational activities, as described in the University of Applied Sciences Act (Ammattikorkeakoululaki 932/2014) and the Universities Act (Yliopistolaki 558/2009). Figure 2 illustrates some of the factors influencing the sustainable development work at Finnish Universities of Applied Sciences.

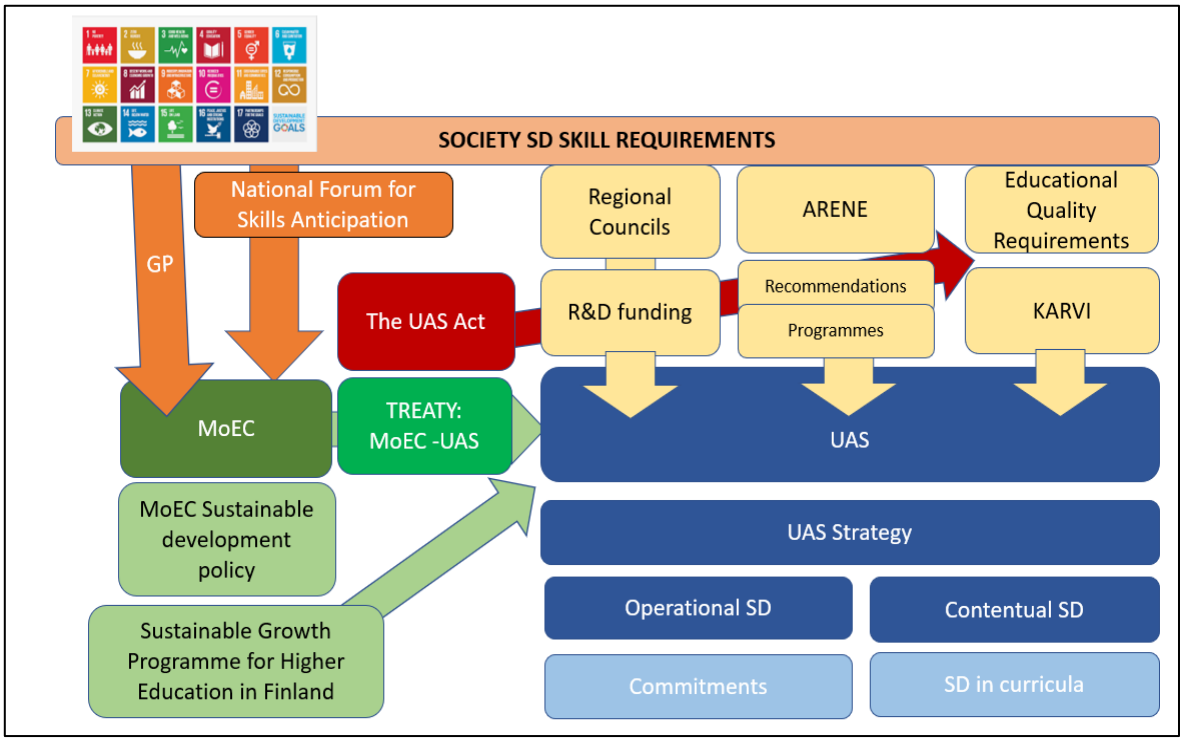

Figure 2. Some factors influencing the sustainable development work at Finnish UASs. Abbreviations used: GP: Governmental Programme, MoEC: Ministry of Education and Culture, SD: Sustainable Development, UAS: University of Applied Sciences (Arene, 2021; ESG, 2015; Etelä-Savon maakuntaliitto, 2021; FEEC, n.d.; Kymenlaakson liitto, 2021; OKM, n.d., 2020a and 2020b; UN, n.d.; VN, 2019)

The Ministry of Education and Culture steers IHE activities by allocating funding based on the funding model and by the agreements negotiated with each IHE every four years. (OKM, n.d). The agreement covers the main objectives (e.g., on completed degrees) and the profile of the IHE in question, as well as the expected reporting of reaching the set objectives. In addition to the agreement negotiations and funding, "steering by information" is used to guide IHEs (OKM, n.d.). The Ministry of Education and Culture Sustainable Development Policy (OKM, 2020a) recognizes both the SDGs set in the Agenda 2030 and the sustainability objectives of the Finnish Governmental Programme (VN, 2019) as the basis for the steering IHEs towards sustainable development. The Ministry has identified the role of Institutions of Higher Education in the overall societal transition towards sustainability in, e.g. the "Roadmap for Research, Development and Innovation" (OKM, 2020b) and the "Sustainable Growth Programme for Higher Education in Finland" (OKM, 2021b) that were initiated by

the current Government Programme (VN, 2019) emphasizing the need for high-quality competence in renewal of society and enhancement of sustainable growth. The Ministry uses sustainable development indicators for the sector for monitoring progress (OKM, 2019). These include the indicators decided for monitoring progress towards SDG 4 (Quality education) with its targets, but it should be noted that the overall sustainability transition should not be diminished to monitoring only one goal, especially since the activity under study, education for sustainability, has such overall influence on the entire socio-technical system. Four indicators designed to measure target 4.7 were listed on the Statistics Finland Sustainable Development Indicators database, but no results on it have been reported yet (Statistics Finland, 2022).

The quality of education in Institutions of Higher Education is monitored (Ammattikorkeakoululaki 932/2014, Yliopistolaki 558/2009) in the context of the European Standards and Guidelines for Quality Assurance in the European Higher Education Area (ESG, 2015) and regularly audited by the Finnish Education Evaluation Centre Karvi (FEEC, n.d.). In addition to the educational objectives, Universities of Applied Sciences have strong roles in regional development (Ammattikorkeakoululaki 932/2014 §6). IHEs are generally seen to have high importance in regional development (Väisänen et al., 2015, 34). This importance can be a driver for the regional sustainability transition, particularly as most Regional Councils allocate funds to research and development projects and have also seen the importance of incorporating sustainability aspects in these projects. As an example the South Savo and Kymenlaako Regional Councils allocate funding for R&D projects in accordance with the Regional Strategies (Etelä-Savon maakuntaliitto, 2021; Kymenlaakson liitto, 2021).

The UAS Rectors Council Arene has also taken a leading role in promoting sustainable development at Finnish UASs. Sustainable development is given as one of the competence areas in the recommendation on the shared competencies of UASs (Arene, 2022, 5). The “Sustainable, responsible and carbon-neutral universities of applied sciences” programme contains sustainability and responsibility commitments for education, research and development as well as management and personnel skills (Arene, 2020, 3). In terms of operational sustainability, one of the current foci is climate impacts. Carbon neutrality or negativity are very timely topics for any organization and the Universities of Applied Science have a commonly agreed commitment to becoming carbon neutral by 2030 (Arene, 2020, 3). To turn this aim into action, the UASs have adopted a carbon calculator (Arene, 2021) taking into

account greenhouse gas emissions from traveling, infrastructure and procurement. Many UASs have not contented to these commitments but have set more ambitious aims.

3.2 Sustainable Development as a Strategic Goal at Finnish UASs

As legal entities, each UAS has an appointed board of directors (The UAS Act 932/2014), with the tasks described in the Limited Liability Companies Act (624/2006). Often a CEO is also appointed. UASs decide on their curricula for the scope of their educational responsibilities, as stipulated in the authorization to provide education by the Government (the UAS Act 932/2014 § 7, 14). All of the 22 UASs operating under the MoEC (OKM, n.d.a) demonstrate commitment to sustainable development in their strategies, but there is variation in the implementation as seen in Table 2. It should be noted that the Table only represents a brief review of the information provided on the UAS websites, so the presented information should be seen as some examples, not a thorough representation of the situation.

Table 2. Some examples of SD implementation in Finnish UASs as presented on their websites and strategies

	Examples of implementation	**Information sources**
Centria	information not available	Centria (n.d.a and n.d.b)
Diak	University of Fair Trade Carbon footprint reduction Responsible employer	Diak (n.d.a and n.d.b)
Haaga-Helia	Principles for Responsible Management Education FIBS ry's diversity charter WWF Green Office, ISO 14001(Vierumäki)	Haaga-Helia (n.d.a and n.d.b)
Humak	information not available	Humak (n.d.a and n.d.b)
Hamk (Häme UAS)	Sustainability perspective in thesis Operational sustainability	Hamk (n.d.a and n.d.b)
Jamk (Jyväskylä UAS)	information not available	Jamk (n.d.a and n.d.b)
Xamk (South-Eastern Finland UAS)	Global Compact WWF Green Office Carbon neutrality target 2030 Swan label	Xamk (n.d.a and n.d.b)
Kamk (Kajaani UAS)	information not available	Kamk (2020 and n.d.)
Karelia	Carbon neutrality target 2028 ISO 14001 used as basis for EMS	Karelia (2022a and 2022b)

LAB	UN Global Compact Societal Commitment 2050 Systematic reporting from 2022	LAB (n.d.a and n.d.b.)
Lapin amk (Lapland UAS)	Commitment to Bio and Circular Economy Promotion	Lapland UAS (n.d.a and n.d.b.)
Laurea	SD themes incorporated in all curricula Operational sustainability promoted	Laurea (2019 and n.d.)
Metropolia	SD teams, integration in education and assessment Supporting Immigrants in HE SDG analysis tool SD Roadmap	Metropolia (2020a and 2020b)
Oamk (Oulu UAS)	SD action plan SR reporting Commitment to carbon neutrality Sustainable procurement	Oamk (n.d.a and n.d.b.)
Samk (Satakunta UAS)	Environmental policy Satakunta climate partnership	Samk (n.d.a and n.d.b.)
Savonia	Great Place to Work -certificate	Savonia (2022 and n.d.)
Seamk (Seinäjoki UAS)	Commitment to carbon neutrality by 2030 SD working group	Seamk (2019 and n.d.)
Tamk (Tampere UAS)	SD working group Fair trade universities Climate partnership Times HE Impact Ranking SDG Accord Climate Leadership Coalition the UN SD Solutions Network Nordic Sustainable Campus Network	Tamk (n.d.a and n.d.b.)
Turku amk (Turku UAS)	Commitment to be carbon neutral 2035 Fairtrade university	Turku amk (n.d.a and n.d.b)
Vamk (Vaasa UAS)	SD working group, Commitment to carbon neutrality 2030 SD and responsibility programme	Vamk (2022a and 2022b)
Arcada	Ecological handprint ESD WWF Green Office SD in curricula	Arcada (n.d.a. and n.d.b.)
Novia	SD linked to all course work SD measured in staff and student surveys	Novia (2020 and n.d.)

Student views on sustainability have been studied, as an example, at Jyväskylä University of Applied Sciences (Jamk) focusing on ecological sustainability (Alppisara and Knuuttila, 2020). Based on the results, Jamk students feel ecological sustainability is important, which might very well reflect the opinions of UAS students more generally, as implied also by Cebrian and Junyent (2015) and Drayson et al. (2014). Knuuttila (2021) have listed action to help UASs towards implementation of SD throughout their organizations. Commitment to the programs and initiatives listed in Table 2 is likely to enhance the systematic

sustainability performance of UASs in practice and some demonstrated implementing the strategic goals in curricula and teaching activities also. A more thorough analysis would be needed to fully understand how these commitments are reflected in students' competencies. Ideally, the increased competence and skillset offered to working life nurture the skills, attitudes and competencies required for a true sustainability transition. Measuring KSCs and knowledge of SD throughout the UAS field would make for an interesting further study.

4 Sustainable Development Work at at the South-Eastern Finland University of Applied Sciences School of Technology

Ideally higher education serves the society by providing students with the professional competencies and abilities required by different organizations for their operations. The UAS Act (932/2014) names providing education based on the working life requirements on expertise one of the main missions for these Institutions of Higher Education. Technical higher education is seen as elemental for building the sector specific competencies for the green transition (Wikman et al., 2022), so the expertise achieved by technical education enhance the sustainability transition both via increasing the professional competencies required to enable the technical development necessary, but also by imbedding sustainable development awareness and the key competencies in the set of professional skills provided.

The South-Eastern Finland University of Applied Sciences (Xamk) operates on four campuses in Kotka, Kouvola, Mikkeli and Savonlinna (Xamk, n.d.). The three focus areas, wellbeing, technology and creative industries, are reflected in the organizational structure of educational activities into schools of wellbeing, business and culture and technology. Xamk School of Technology is organized into departments of Information Technology, Logistics and Marine Technology, Forestry and Environmental Engineering, Construction and Energy Engineering and Electrical Engineering, Building Services and Material Technology, each lead by a Director of Education. The degrees offered in these five departments are mainly technical degrees (Bachelor or Master of Engineering) with some exceptions. Some degrees are offered in English and there is active cooperation with several other Institutions of Higher Education both nationally and internationally. (Xamk, n.d.c.)

Incorporating sustainability into the educational activities of the technical degree programmes is guided through the overall guidance from the Ministry of Education and Culture, influenced by the international and national policy guidance, the treaty between Xamk and the MoEC as well as financial steering of Xamk. Sustainable development is mentioned as one of the basis for operations (OKM, 2020c) in the 2021-2024 treaty and similarly to several other UASs, Xamk is committed to the UAS carbon neutrality target of 2030 and demonstrates operational sustainability action via, e.g. the Green Office system and the UN Global Compact Sustainability Initiative (Xamk, n.d.a and n.d.b.). In addition to action aimed to

ensure sustainability in the UAS operational activities, the Personnel- and educational plan includes a mention on increasing staff skills on responsibility (Xamk, 2021b).

Contentual sustainability of any educational institution is achieved through increasing the sustainability competencies of students as part of their education with the expectation that they will make use of their skills for the good of their employers and this way benefit the society as a whole (Figure 3). Building Key Sustainability Competencies (KSC) and increasing awareness of the aspects of sustainability can be achieved by integrating these in teaching activities. To ensure this, these topics should exist in each degree programme curricula as learning objectives, and both the students and the teaching staff should have the motivation to include these in educational activity implementation.

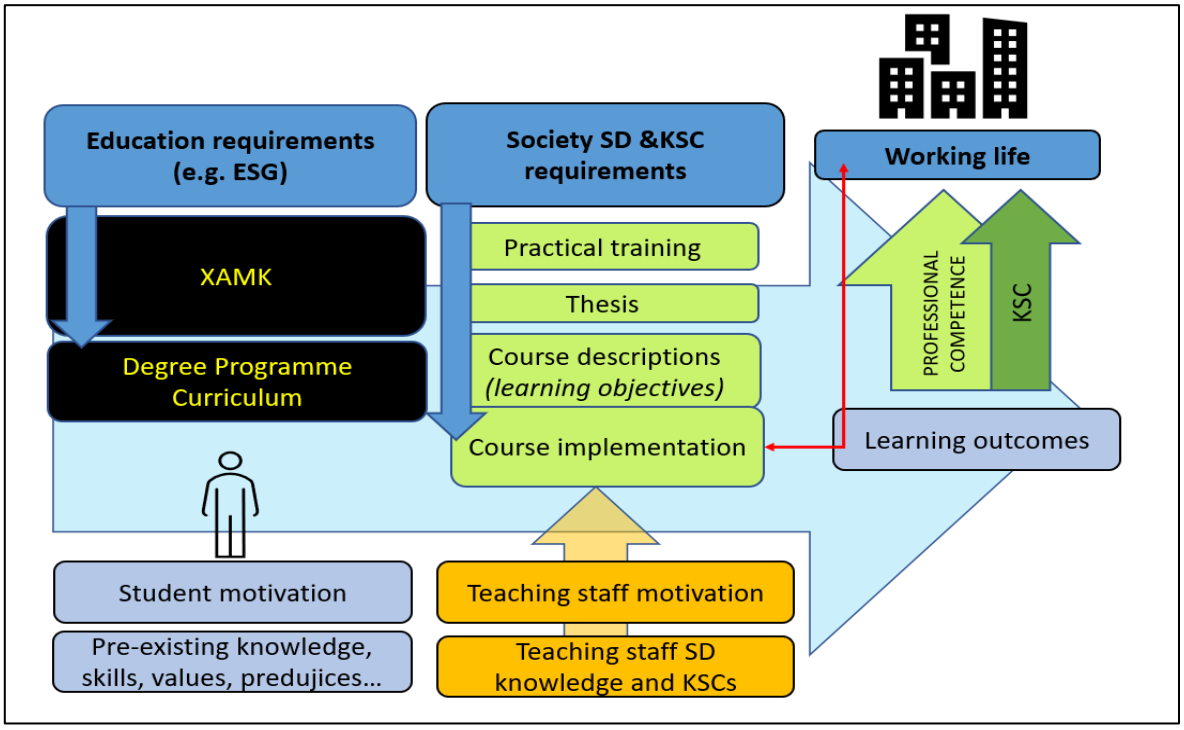

Figure 3. Promoting sustainability competences and awareness of sustainable development in society via higher education. Abbreviations used: SD: sustainable development, KSCs: Key Sustainability Competencies, ESG: The Standards and Guidelines for Quality Assurance in the European Higher Education Area (Xamk, n.d. and 2021a, UAS Act 932/2014)

Each Institution for Higher Education has a procedure for establishing their degree programme curricula taking into account the given requirements as well as expectations for the educational content (Wikman et al, 2022; NFSA, 2019). Each degree programme curriculum consists of a verified set of the degree structure and the descriptions of study modules made up of individual courses set on the European Qualification Network and Finnish National Framework for Qualifications and Other Competence Modules -frameworks and rely on the ESG principles (Xamk, 2021a). At Xamk any updates to existing curricula, as well as any suggestions for new degree programmes, are evaluated by the Pedagogical Management Team to ensure compliance with these criteria and approved by the Vice Rector. (Xamk, 2021a.)

The teaching staff orientation towards sustainability plays an important role in the extent to which such topics are included in educational activities. Teaching staff is consulted in writing the course descriptions and they have the opportunity to suggest changes to existing curricula. Teaching activities are organized based on course teaching plans that are made by each course teacher and give more detailed information on the contents and structure of the course in question. Teaching planning is done annually on a fixed schedule (Xamk, 2021a). Naturally the teaching plan and its implementation are based on the course description included in the relevant degree programme curriculum; however, cooperation with working life partners and Xamk Research and Development Projects are often integrated in course contents. The occurrence of sustainable development in curricula has recently been studied in hospitality management (Komonen and Tuikkanen, 2021) and social services and healthcare (Eklöf and Laanterä, 2021) and based on the results the aspects of sustainable development are well demonstrated in the evaluated curricula. Similar studies have not yet been conducted for the School of Technology at Xamk.

Higher Education students already have a pre-existing set of skills and knowledge when they enter the educational institution. Their personal values and motivation influence their learning outcome, so the ability of an Institution of Higher Education to enhance societal sustainability transition is not solely dependent on their own activities. Ideally the elements of a degree programme enhance student motivation to improve sustainability competencies and increase their knowledge on the aspects of sustainability allowing them to achieve the empowerment and engagement of the highest degree of ESD. (Sterling, 2015, 98.)

5 Materials and Methods

This research focused on the operations that allow the case example educational organization to enhance sustainability transition by determining the current level of sustainability contents and identifying improvement potential. The research consisted of identifying elements of contentual sustainability in the policy guidance, curricula and educational contents that promote sustainability transition by providing students with the required key competencies and knowledge on sustainable development. The UN SDG target 4.7. indicators 4.7.1a-c (Statistics Finland, 2022) were used to lay a base for the research phases, which are presented in Figure 4. These indicators are designed to measure, e.g., the degree of mainstreaming sustainable development contents in educational policy, curricula, teacher education and student assessment (Statistics Finland, 2022). The stages of Education for Sustainable Development (Sterling, 2015, 98) and the Learning for Sustainability Core Competence Framework (Pacis and VanWynsberghe, 2020, 583) were used to aid in the identification of contentual sustainability and competence areas as examples. The theoretical background presented in previous chapters laid the base for the research by establishing the overall role of higher education in the sustainability transition.

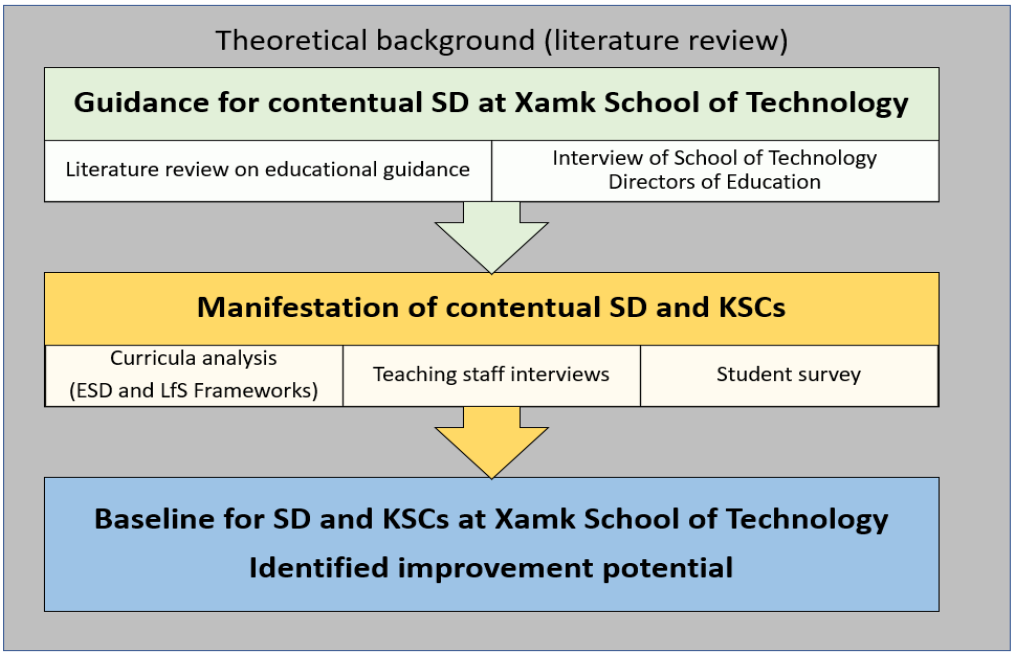

Figure 4. The research phases

The guidance for including sustainable development contents in educational activities and the degree in which it is demonstrated in educational policy were studied by a literature review and a staff interview. The manifestation of sustainable development in curricula was examined by an analysis of the selected degree programme curricula of the case organization Xamk School of Technology. The curricula analysis was completed by studying the process of how these trickle into teaching activities, including the elements of staff skills and student assessment, using staff interviews and a student survey as data collection methods. All phases were carried out iteratively. The methodology used in each research phase is explained in more detail in this chapter.

5.1 Sustainable Development in Educational Guidance

The guidance to incorporate sustainable development contents and key competencies in degree programme curricula and teaching was studied via a literature review on the provided guidance focusing on the case example organization, and by a thematic group interview of the Directors of Education of the five departments of the School of Technology presented in chapter 4. A semi-structured group interview was seen to be likely to reveal aspects that individual interviews might not (Eskola and Suoranta, 2014). The interview focused on three separate themes (Table 3) and the interviewees were invited to elaborate on these themes using guiding questions as basis for the conversation. The interview was initiated by a brief introduction to the topic to explain the wider context of the interview themes and aims. This background included a reference to the UN SDG 4 and the indicators set for target 4.7. as well as the Ministry of Education and Culture commitment to promoting sustainable development but did not give a specific definition for sustainable development so avoid directing the conversation.

The guiding questions listed in Table 3 were designed to help the interviewees to identify examples of sustainable development as well as the competencies students in their departments should gain or improve during their studies. Staff competencies and awareness in SD topics were included in the guiding questions in order to establish the degree and type of guidance for integrating SD content in teaching and curricula development.

Table 3. The group interview themes.

Theme	Guiding questions
Sustainable development in the department study field	• What types of skills are, in your opinion, essential for future working life on this field? • What concrete example would indicate the importance of SD in the study programmes of the department and the filed in general? • Are department teachers advised to take into account SD in their work? • Do teachers bring up initiatives for incorporating SD in their work?
Department staff skills and awareness on sustainable development	• Is awareness or SD skills taken into account in recruiting? • Are teachers encouraged to increase their own SD awareness or skills? • How would you evaluate the teaching staff SD skills and awareness (scale 1-5)?
Incorporating sustainable development in study programme planning	• Have study programmes been updated in your department and if so, has SD been discussed as a potential theme to incorporate in study programme planning? • What, in your opinion, would be the best way to incorporate SD in teaching?

Data gathered in the interview was analyzed using qualitative content analysis (Puusa and Juuti, 2020). The interview themes were used as basis of data grouping and reduction to allow for more detailed analysis of the meanings represented. These were then listed and discussed together with the findings of the later phases of the research.

5.2 Sustainable Development and Sustainability Competencies in Technical Degree Curricula at Xamk

Xamk degree regulation (2022) identifies Bachelor of Engineering and Master of Engineering as technical field degrees offered by Xamk, so the evaluated curricula were narrowed to cover the study programmes resulting in these degrees (Table 4). Double degree programmes and study programmes not leading to a complete degree were excluded, as were study programmes in marine technology, as their curricula contains several elements required by legislation and are thus structurally quite different from a typical engineering degree. The degree programmes included in the analyses were grouped by the department and by the degree programme level and language.

Table 4. The degree programmes included in the scope of the study. The English translation of Finnish degree programme names are presented in parentheses.

Finnish degree programmes (BEng, 240 CU)	**Finnish degree programmes (MEng, 60 CU)**	**English degree programmes (MEng/BEng, 60/240CU)**
Department of Information Technology (currently 385 students)		
Kyberturvallisuus (*Cybersecurity)*	Kyberturvallisuus (*Cybersecurity)*	Information Technology
Ohjelmistotekniikka (*Software Engineering)*		
Peliohjelmointi (*Game programming*		
Tieto- ja viestintätekniikka (*Information technology*)		
Department of Logistics and Marine Technology (currently 153 students)		
Logistiikka (*Logistics*)	Logistiikka (*Logistics*)	
Department of Forestry and Environmental Engineering (currently 338 students)		
Ympäristöteknologia (*Environmental technology)*	Ympäristöteknologia (*Environmental technology)*	Environmental Engineering
Department of Construction and Energy Engineering (currently 623 students)		
Energiatekniikka *(Energy engineering)*	Projekti – ja myyntijohtaminen *(Project and sales management)*	
Rakennustekniikka *(Construction engineering*)		
Robotiikka ja tekoäly *(Robotics and Artificial Intelligence)*		
Teollinen puurakentaminen *(Industrial Wood Construction)*		
Department of Electrical Engineering, Building Services and Material Technology (currently 646 students)		
Biotuotetekniikka *(Bioproduct technology)*	Talotekniikka *(Building services engineering)*	
Sähkö- ja automaatiotekniikka *(Electrical and automation engineering)*		
Talotekniikka *(Building services engineering)*		
13 degree programmes in total	5 degree programmes in total	2 degree programmes in total

The selected degree programme curricula was mapped to identify the courses to include in the analysis. This was narrowed to cover curricula for students who have begun their studies between 2018-2021, as these students were expected not to have graduated at the time of the research and were not in the very beginning of their studies either. In total 20 different degree programmes (15 Bachelor level and 5 Master level) were included in the analyses. According to Xamk Peppi (2022), there are currently 2145 students enrolled in these degree programmes.

Bachelor' degree programme of 240 credit units (CU) of the European Credit Transfer System (ECTS) consist of core competence courses and supplementary competence courses along with a practical training and thesis. As part of the supplementary competence courses, students are able to select optional study courses based on their personal preferences. These may be selected from the courses offered by Xamk, but also from the UAS joint portal (Campusonline, 2022). For Master level engineering studies, 60 CU, students generally have 4-5 core competence courses, and the remaining optional courses are selected from Xamk Master School. The analysis was therefore narrowed only to include core competence courses, and for Bachelor's degrees further narrowed to only include professional competence courses, excluding language studies, mathematics, physics and other generic topics (Xamk, 2021a). A total of 572 individual course descriptions were included in the analyses. The analyses only covered course descriptions, so an interesting topic for a future study would be to establish how sustainable development is demonstrated as part of students' practical training periods or theses.

Qualitative content analysis, as described e.g. by Puusa and Juuti (2020) was used to identify sustainable development and sustainability competence contents from the analyzed course descriptions. Key phrases (Table 5) selected based on the stages of Education for Sustainable Development (Sterling, 2015, 98) and the Learning for Sustainability Core Competence Framework (Pacis and VanWynsberghe, 2020, 583) were used to aid in the identification of relevant contents. The key phrase listing was iteratively completed during the analysis. In absence of an artificial intelligence tool, such as the one used by Metropolia UAS (2021), the study programme curricula were analyzed manually. This allowed identification of relevant contents, even when it was not expressed using specific terminology, by analyzing the contentual meanings of the text. The Pappas et al. (2013) application of the Bloom's taxonomy of educational objectives, excluding technical sustainability, was used to help categorize the findings into social and cultural, economic and environmental or overall sustainability aspects and the KSC categories used by Wiek et al. (2011, 213) aided categorization of the identified sustainability competencies, although the competence listing was iteratively modified to cover problem solving, strategic thinking, systems-thinking and interpersonal skills, excluding normative and anticipatory competencies, since these proved particularly difficult to identify from course descriptions. Due to the large variation in describing the evaluation criteria in the course descriptions the evaluation part was excluded to avoid potential biases caused by this variation.

Table 5. Key phrase matrix based on the ESD and the LfS Core Competence Framework (Sterling, 2015, 98; Pacis and VanWynsberghe, 2020, 583).

ESD	LfS CCF	SD Phrases used to aid analysis
ESD I CONTENTS: SD subject matter, such as ecological, economic and socio-cultural challenges or how they are addressed.	**VALUES AND COMMITMENTS:** Common good, affinity of life. Care for self and others.	**LEVEL 1: AWARENESS** Environmental, social and cultural or economic awareness/impacts/risks, safety, security, health, energy efficiency, resource efficiency
ESD II UNDERSTANDING: Critical reflection regarding SD subject matter, expansion of thinking towards systemic understanding. Engagement.	**KNOWLEDGE AND UNDERSTANDING:** Systems thinking and future thinking. Awareness of the state of the planet.	**LEVEL 2: UNDERSTANDING** Economic and political instruments/decision making Responsibility Circular economy Life cycle thinking
ESD III EMPOWERMENT: Capacity building, holistic content view, creative engagement.	**SOCIAL SKILLS AND AGENCY:** Modeling of sustainable behavior Implementing change. Wise, compassionate decision making	**LEVEL 3: EMPOWERMENT** Sustainability, Leadership for global citizenship and SD

The identified sustainable development of sustainability competence contents for each study programme were listed and coded to be able to identify the degree programme curriculum they appeared in. The qualitative content analysis consisted of steps of grouping the listed content according to the aspect of sustainable development or the key competence they represented while excluding irrelevant findings, such as the iteratively excluded evaluation criteria, and reducing the data to a listing of relevant key expressions. This allowed for presentation of the number of occurrences in relation to the number of analysed courses for each study programme curricula as well as further analysis of the types of contents found. Courses with the highest numbers of related content occurrences were used to identify teaching staff to be invited to be interviewed in the next research phase, since it was seen most likely teachers of such courses would have insights on including sustainability topics in teaching.

5.3 Sustainable Development Actualization in Teaching and Learning

According to Koskinen et al. (2005), interviews allow gathering data on the meanings and interpretations people have on the studied phenomenon. Lecturer interviews were used to gather data about how sustainable development topics and competencies are taken into account in formulation of teaching plans and actualized in teaching, how teacher education facilitated teaching related topics and how teachers are guided to incorporate sustainable development and sustainability competencies in their teaching. The interviewees were selected from those lecturers appointed to teach courses with content occurrences identified in the previous research phase, since they were expected to have insights on the topic. The aim was to interview teaching staff from all the of the included degree programmes. Typically, a lecturer in involved in teaching students of all the relevant degree programmes in their department, so the number of interviews isn't the same as the number of degree programmes. Not all those invited were able or willing to be interviewed, so a total of eight teaching staff interviews were carried out with at least one lecturer from each of the departments interviewed.

The interviews were carried out as semi-structured thematic interviews around themes of sustainable development in the study field, teacher skills and awareness on sustainable development and incorporating sustainable development in teaching and teaching planning. The guiding questions used under the themes were designed to reveal the interviewees thoughts on the concept of sustainable development and their perceptions on the guidance they have received in integrating SD content in their teaching. Teaching staff was also encouraged to share examples of how sustainable development is manifested as part of the topics they teach.

Similarly, to the interview of the Directors of Education, the data was analysed using qualitative content analysis (Puusa and Juuti, 2020) to reveal the key findings. Limitations of interviews as data gathering method include possibility of the interviewee giving responses they feel are expected (Puusa and Juuti, 2020). This possibility is emphasized, when the interviewees were discussing topics that may also be seen as criticizing their employer or colleagues. The interviews were therefore analysed in a manner that allowed presenting the results anonymously. Data was reduced using the presented themes and interviewee

responses grouped under these themes. Quotes representing the most interesting findings with regard to the research question were listed and contextualized (Brinkman, 2013).

The student viewpoints on the manifestation of sustainable development contents and sustainability competencies were studied using a digital survey as a data collection method. The survey link was delivered to the students in the degree programmes included in the curricula analyses that had begun their studies in years 2018 - 2021. The survey used three different forms to allow for both Finnish and English language versions as well as differentiating between Bachelor's and Master's degree programme students of the degrees offered in Finnish. A total of 65 Finnish Bachelor's degree programme student groups and 9 groups studying in the English Bachelor's degree programmes as well as 13 groups in the Finnish Master's degree programmes were sent the link to the survey. Since students complete their degrees at very variable paces, the group sizes varied significantly, which was one of the reasons for not utilizing statistical analysis methods. Survey questions (Appendix 1) were designed to reveal student perceptions on the development of the Key Sustainability Competencies during their studies, the occurrence of the aspects of sustainability in the courses they has completed and the importance of such topics in relation to their careers. An open-ended question allowed students to express their thoughts on how sustainable development related content could be increased in their study field education. The main aim was to identify examples of relevant contents and student perception on the importance of sustainable development on their study field, so the data was analysed qualitatively. This allowed the respondents a higher degree of anonymity since there was no need to gather data on background variables that may have resulted in identification of respondents. The quantitative data from the digital survey platform was used to discuss the degree of perceived importance and the open-ended question results were subjected to a qualitative content analysis.

6 Results and Analysis

The different research phases were designed to reveal the current situation on how sustainable development contents, including both the content directly increasing awareness on the aspects of sustainability and content promoting the development of the Key Sustainability Competencies, are manifested in the educational guidance, curricula, teaching and learning at Xamk School of Technology. The findings from the literature review, degree programme curricula analyses, staff interviews and student survey results are presented in more detail in this chapter, along with some recommendations based on the results and some discussion on the research limitations.

6.1 Sustainable Development in Educational Guidance at Xamk

The literature review allowed to establish the factors considered when updating or creating curricula content. The frameworks used to describe and evaluate educational content at Xamk are the European Qualification Framework and the Finnish National Framework for Qualification and Other Competence Modules (Xamk, 2020, 4). The guidelines for creating curricula specify certain courses to be included in all Bachelor's degree curricula (e.g., research and development skills, communication, and language studies) and refer to the recommendations for competencies set by Arene (Xamk, 2020). This indicates that sustainable development will be one of the content areas of future curricula development work once the updated recommendations (Arene, 2022, 5) are integrated in the guidance. This development confirms the multi-level perspective view of education for sustainable development, as the landscape level policy guidance is under pressure by the identified regime changes (Geels, 2002, 1260) and vice versa.

Each department Director of Education was convinced aspects of sustainable development are included in teaching in their department, although the primary aim of the educational activities was seen to be increasing professional competencies. Since sustainable development was not a guiding theme in the latest curriculum revision, it was not expected to be strongly included in the degree programme curricula. The occurrences were expected to be included thanks to the staff members that were enthusiastic about the topic and motivated to

include it in the course descriptions when they were last updated. This could also be seen as a niche level activity (Geels, 2002, 1260) that might eventually cause a more widespread change. The urgency for advancing in the transition; however, suggests a more active approach should be taken.

The interviewees perceived the teaching staff skills and awareness on sustainable development to be on a fairly good level in all departments of the School of Technology, indicating both recognition of existing skills on one hand and potential for improvement on the other. The most often referred to individual topics were environmental issues, particularly climate change related themes, but also other aspects of sustainability were identified after some discussion on the meaning and extent of the concept. This reflects how sustainable development is still communicated mainly as an environmental issue. The polarization of the expertise on sustainability topics was seen as a potential risk by the interviewees. Staff members who are interested and motivated will increase such topics further, whereas those not particularly interested will justify not including them at all by someone else already covering them sufficiently. This contradicts the idea of all technical professions requiring some degree of sustainability competencies as well as awareness on sustainable development and particularly sustainability challenges and risks the equal treatment of students. Even if polarization of expertise was seen as a risk, teaching staff isn't systematically guided to include sustainability aspects in their work, which is a clear improvement area.

A repeating theme during the Director of Education interview was if sustainable development and sustainability competencies really are a separate skillset, or something that should be imbedded in every staff member's professional competency and provided to students as such also. This is in line with how Pacis and VanWynsberghe (2020) call for a large-scale habit change simultaneously on several fronts. This theme was reflected in the discussion about the best method for measuring the degree of sustainable development and sustainability competence manifestation in degree programme curricula contents. The idea of measuring sustainable development or sustainability competencies independently from other aspects of educational activity performance evaluation was seen as a step in the wrong direction, as this may result in mere adding of a sufficient amount of suitable terminology in curricula, not actual enhancement of education for sustainable development. The key in the actual enhancement is in teaching staff motivation, skills and competencies, so they may identify themselves as agents of the sustainability transition (Koistinen, 2019, 27).

It was commonly agreed that promoting education for sustainable development would call for clarification of the used terminology within the organization. The commissioning organization should consider establishing a sustainability policy, that includes definitions for the key terminology in the Xamk organizational context. Each department could then use the same definitions as a basis of the guidance given for curricula updates and each staff member would easily identify the organizational commitment to the enhancement of sustainable development. The importance of documenting uniformly defined terminology was underlined by the idea of considering sustainable development awareness and competences in recruiting. Currently they are only considered, when these are a clear part of the new employee's course tray. It was agreed that including sustainable development awareness in recruitment criteria would call for commonly agreed on indicators and definitions.

Sustainable development topics are increasingly presented in the development of each field, and percolate from working life requirements to the teaching contents, but a question was risen about if teaching staff should be encouraged to give it more emphasis. The best way to achieve this was seen to be through increasing teaching staff understanding and awareness of sustainability challenges and potential solutions to them, ideally as part of the professional competencies of the field. Career and study planning, one of the courses mandated to be included in all Bachelor's degree programmes, could include discussion of how sustainable development is manifested in the types of tasks the students are likely to work with during their careers, but leaving the topic to be part of the generic course was seen to cause a risk of inflation of importance also. The competency recommendations made by Arene (2022) should be manifested throughout studies, not left as disconnected content.

The transition to a sustainable society calls for professionals with the competencies to enhance adaptation of sustainable technologies and awareness of the consequences of the decisions they make. Currently guidance to include sustainability topics in teaching at Xamk school of technology is relatively weak, as the inclusion of such topics is not presently required in the documented guidance for curricula development or teaching implementation, and the teaching staff is left to freely decide if they wish to include such contents in teaching. Rather than mandating sustainability contents in all teaching, teaching staff should be motivated to identify the aspects of sustainable development related to the topics (i.e., the professional competences) they teach. The updated competence recommendations (Arene, 2022) are likely to cause a need to include sustainable development more systematically in

curricula, however, teaching staff should be provided with the means to adequately increase their own skills for the update to be truly effective and actualized in teaching and, through teaching, student competencies.

6.2 Sustainable Development and Sustainability Competencies in Technical Degree Curricula at Xamk

The course description analysis indicated that topics of sustainable development and sustainability competencies are included in curricula even if seldomly titled "sustainable development" or even any directly linked term (Table 6). Approximately 28% (161/572) of the analysed course descriptions included occurrences of one or several of the contents manifesting sustainability as one of the aspects of sustainability or a sustainability competence. The majority (85%) of these were characterised as level 1 findings on the three-level scale from awareness to empowerment (Sterling, 2015, 98; Pacis and VanWynsberghe, 2020, 583), so technical degree programme curricula still have improvement potential in supporting overall sustainability transition and providing those planning and implementing education according to the course descriptions tools to help students build their sustainability competencies towards understanding (level 2) and empowerment (level 3).

Table 6. Categorization of the sustainability contents identified in the analyzed course descriptions. NOTE: some aspects listed under more than one category.

	Social and cultural (72 occurrences)	**Ecological** (35 occurrences)	**Economic** (43 occurrences)	**Overall sustainability** (listed under several categories)
LEVEL 1: AWARENESS (85% of the findings)	security, safety, information security, privacy, data integrity and availability, cultural aspects, occupational safety/health, public health, environmental and health hazards,	energy efficiency, waste, environmental aspects, environmental sustainability, resource efficiency, environmental impact, climate change, environmental know-how in business,	revenue logics, business responsibility, responsible business practices, economic efficiency, cost level impacts, resource efficiency, economic and environmental aspects,	sustainability aspects of sustainability principles of SD

	health risks caused by pollution, environmental and health risks, operational safety	emission reduction, environmental monitoring, environmental concerns, environmental problems, environmental risks/hazards, contaminants in the environment, environmental safety	environmental know-how in business, economic aspects of emission reduction, profitability of renewable energy	
LEVEL 2: UNDERSTANDING (14 % of the findings)	safety and economic performance	environmental management as part of organizational management, environmental awareness, environmental policy and economic guidance mechanisms	product LC responsibility, financing models, environmental management as part of organizational management, environmental policy and economic guidance mechanisms, economic feasibility/aspects, life cycle costs, safety and economic performance	sustainable resource use via CE changed requirements due to SD responsibility
LEVEL 3: EMPOWERMENT (1% of the findings)	responsible self-management			

Koistinen (2019, 12) claims the role change agents play in the sustainability transition should be put more emphasis on. The agency can only be formed through awareness, increased understanding and empowerment, so designing education in a way that enhances these is incremental. Engaging and empowering students allows them to see beyond the direct personal benefits (Geels, 2011, 25) and become actors in the overall societal changes (van der Leeuw, 2018), so the mere occurrence of some sustainable development content or competence is not a satisfactory achievement. The curricula changes should be actively guided to include more content aiming at elevating education to providing level 2 (understanding) and level 3 (empowerment) contents.

Figure 5 presents the number of different sustainability content occurrences as a percentage of the total findings for each department. The findings for each department are presented in more detail in Appendix 2. It should be noted that the total occurrences also include key

competence occurrences, which explains why the percentual fractions for each aspect do not add up to a 100%. There was some variation in how elaborately course descriptions were presented, which naturally influences the results. Comparisons between departments and degree programmes should be avoided, since there is a large variation in the number of courses analysed and naturally the aims of degree programmes vary also. It should also be noted that some of the mentions were categorized to more than one category, as they did not represent only one aspect of sustainability, e.g. “principles of sustainable development” was categorized to all three categories.

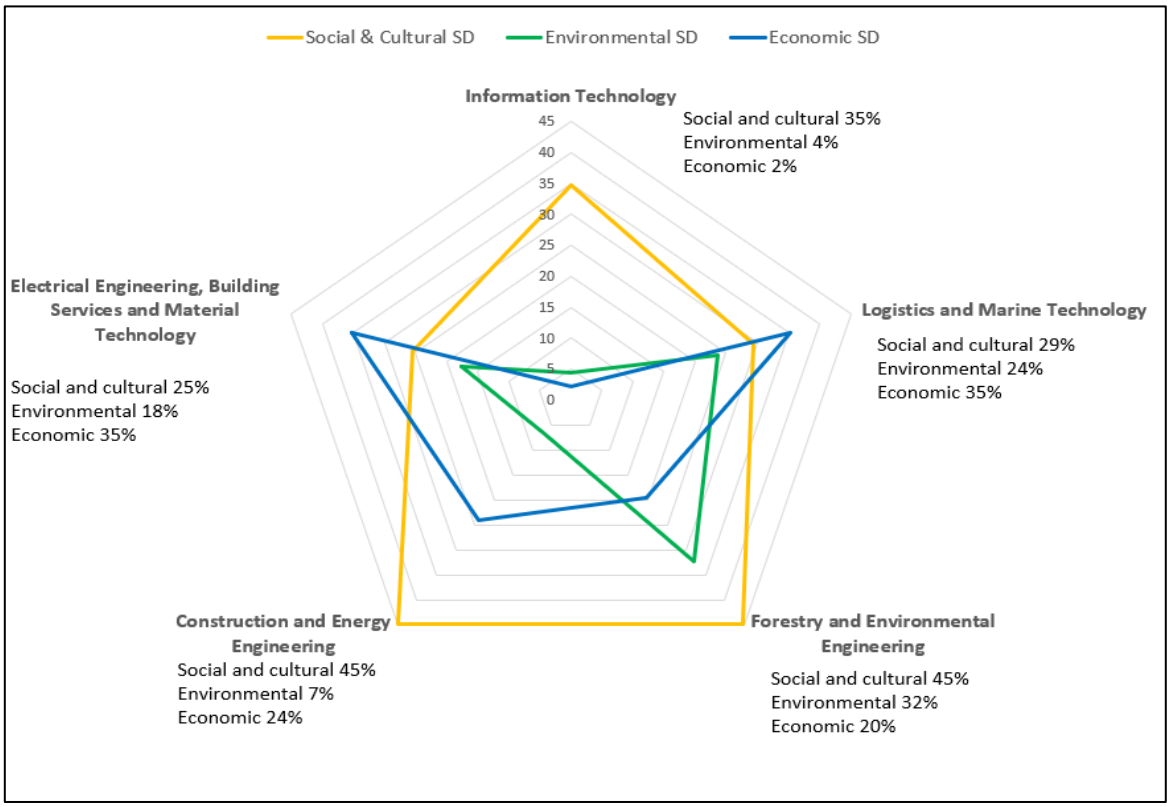

Figure 5. Number of SD occurrences in the analysed course descriptions as a percentage of total occurrences in each department. Note: the total occurrences include both KSCs and SD aspects, only SD are presented here.

As seen in Figure 5 the social and cultural aspect of sustainability was most often (72 in 572 courses) mentioned in the analysed course descriptions. There was variation between departments on the emphasis of different SD content, but social and cultural SD content was the

most often mentioned in three of the five departments. The total number of sustainable development content, 150 in 572 courses, reflects the potential to increase sustainable development content in curricula; however, course descriptions only reveal what the planned contents and study objectives for each course are. Measuring the degree of sustainable development in education should therefore not be left solely to calculating the number of occurrences of selected terminology or even contentual meanings in curricula. This concurs with the finding of Korhonen-Kurki et al. (2020, 23) on mere curricula SDG mapping not revealing the actualization of SD themes.

The selected Key Sustainability Competencies occurred in the analyzed course descriptions 49 times, which seems very low for the total number of course descriptions analyzed (572). This may reflect poor selection of key phrases more than low occurrence of the competencies, but also the fact that many of the competencies may not be included in the course descriptions simply because they are perceived too obviously included to be specifically mentioned. For example engineering typically involves problem solving, and UAS studies commonly seek to enhance interpersonal skills. The most often demonstrated key sustainability competence was interpersonal skills (24/49 occurrences) followed by problem solving skills (18/49 occurrences) as presented in Figure 6.

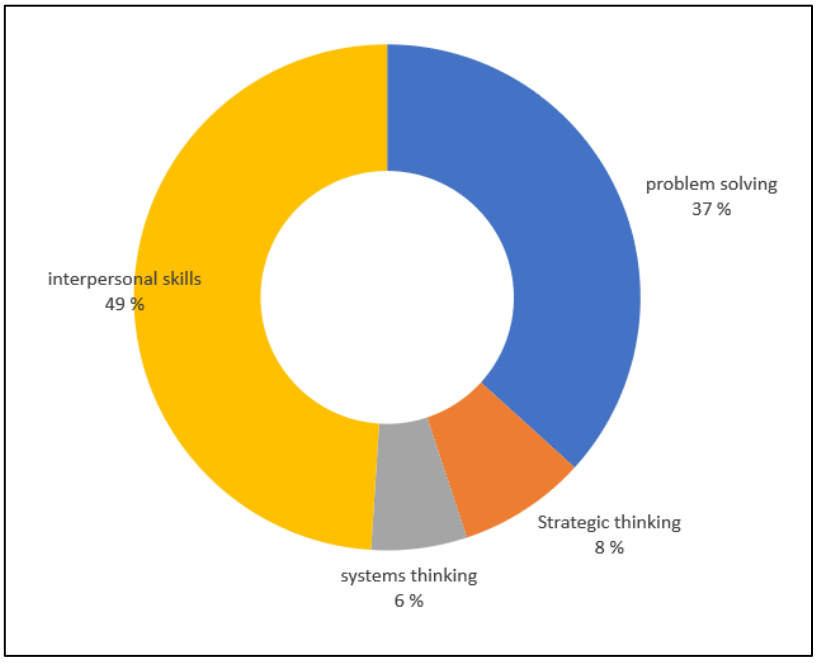

Figure 6. The fractions of the key sustainability competence occurrences in the analysed course descriptions as a percentage of total KSC occurrences.

A potential improvement to consider in the next curricula development would be to investigate the possibility of including aspects of sustainability in the course description evaluation process, similarly as the quality evaluation. The Pappas et al. (2013, 56) application of the Bloom's Taxonomy of Educational Objectives could provide a good reference for curricula development and facilitate more content on levels 2 (understanding) and 3 (empowerment) in the future.

6.2.1 Department of Information Technology

The Department of Information Technology degree programmes included in the curricula analysis were the Finnish and English Master's degree programmes on Cybersecurity, the English Bachelor's degree programme in Information technology and the Finnish Bachelor's degree programmes in Cybersecurity, Software engineering, Game programming and Information technology. SD or KSCs mentions were made in 22% (43/194) of the analysed courses with social and cultural aspects of sustainability being mentioned most often (16/43 mentions) and the most commonly occurring KSC being interpersonal skills (13/43 mentions). A few examples are listed in Text box 1.

"What are the components of a modern energy-efficient data center?"
"What are the security needs in a modern society?"
"You learn teamworking skills"

Text box 1. Some examples of the course description contents identified to manifest aspects of sustainability or KSCs in the Department of Information Technology

Cybersecurity is offered as Bachelor's and Master's level degree programmes. According to Xamk (n.d.d.) the foci is on information security from a strategic viewpoint, which was clearly reflected on the identified KSCs (strategic thinking, interpersonal skills) as well as the occurrence of social and cultural aspects of sustainable development (e.g., security, information security). Similar findings on SD aspects was made also in turn of the software

engineering degree, but the emphasis in KSCs was on problem solving and interpersonal skills. Information technology degree programme offers themes of networking, data centers and Internet of Things (IoT). The competencies developed in this degree programme, in addition to the technical field specific skills, include project management and networking (Xamk, n.d.d.), which are clearly reflected in the occurrence of problem solving and interpersonal skills in the curricula. Energy efficiency and security were the dominant of sustainable development topics mentioned. Game programming degree programme curricula demonstrated emphasis on problem solving skills, systems-thinking and interpersonal skills. In addition to information security, the course descriptions also contained aspects of cultural and economic sustainability.

6.2.2 Department of Logistics and Marine Technology

The logistics degree programmes (Master and Bachelor level) were included in the analysis since degree programmes in Marine technology were excluded from the scope of the study. Including these would make an interesting topic for a further study. Some examples are presented in Text box 2. The types of mentions in these degree programme curricula manifested not only level 1 (awareness), but also level 2 (understanding) and 3 (empowerment) contents.

"What are the environmental effects of logistic functions?"
"You are familiar with the key principles of business management and corporate responsibility."
"How ITS systems can support logistics processes and society, particularly sustainability?"

Text box 2. Some examples of the course description contents identified to manifest aspects of sustainability or KSCs in the Department of Logistics and Marine Technology

The results confirm the information given about logistics engineering degree programmes (Xamk, n.d.d.), as these degrees programmes provide students with a wider perspective on processes and the contextual process requirements and are in line with the requirements of technical sustainability as presented by Pappas et al. (2013, 55).

6.2.3 Department of Forestry and Environmental Engineering

The degree programmes in Forestry were excluded from the scope, as they are do not result in technical degrees, so only the English Bachelor's degree programme in Environmental Engineering and the Finnish degree programmes in Environmental Technology (Bachelor and Master levels) were analyzed in part of the Department of Forestry and Environmental Engineering. Some examples of SD content are given in Text box 3.

"You know the current state of the environment…"
"You'll study means to describe, estimate and minimize environmental health burden and costs…"
"You understand circular economy as a tool for achieving sustainability…"

Text box 3. Some examples of the course description contents identified to manifest aspects of sustainability or KSCs in the Department of Forestry and Environmental Engineering

Over half (42/71) of the analysed courses contained mentions of SD or KSCs. Interestingly enough, social and cultural aspects of sustainability dominated in these degree programme course descriptions also, even if the topic would suggest more emphasis on environmental sustainability contents. This may be due to the environmental health emphasis of the Environmental Technology degree programmes (Xamk, n.d.d.). Some course descriptions contained level 2 (understanding) sustainability content, such as sustainable resource use via circular economy

6.2.4 Department of Construction and Energy Engineering

The Bachelor's degree programmes of Energy Engineering, Construction Engineering, Robotics and Artificial Intelligence and Industrial Wood Construction as well as the Master's degree programme in Project and Sales Management were analysed from the department of Construction and Energy Engineering, and 20% (28/140) of the analysed courses contained mentions of SD or KSCs, with social and cultural sustainability once more being the most often mentioned (Text box 4.).

…”analyze the energy efficiency of renewable sources.”
“What is the practical implementation of the occupational safety organization”…
“Life-cycle costs”
“You know how to act as both a member of a project team and a responsible project manager.”

Text box 4. Some examples of the course description contents identified to manifest aspects of sustainability or KSCs in the Department of Construction and Energy Engineering

According to Wikman et al (2022, 22), there is a clear increase in skills of life cycle thinking, carbon balance calculations and environmental certification in the construction sector. In the energy sector requirements for systems-thinking skills are increasing (Wikman et al. 2022, 24). These were quite well represented in the analysed course descriptions, with mentions of life-cycle costs, energy efficiency perspective and the changed requirements caused by sustainable development being mentioned. Problem solving, systems-thinking and interpersonal skills were identified as the KSCs promoted in these degree programmes.

6.2.5 Department of Electrical Engineering, Building Services and Material Technology

The department of Electrical Engineering, Building Services and Material Technology degree programmes in Bioproduct Technology, Electrical and Automation Engineering and Building Services Engineering (Bachelor’s and Master’s levels) were included in the analyses. 25% (32/129) of the analysed courses contained mentions of SD or KSCs, economic aspects being the most often mentioned. Some examples are presented in Text box 5. Occurrences of all the named key competencies were found in the course descriptions analysed for this department.

"You take sustainable development principles and client objectives into account."
"What are the safety requirements for handling chemicals, considering their harmful chemical and physical properties to health and environment?"
…"you can balance heat distribution to meet the requirements of good thermal comfort and energy efficiency in buildings."

Text box 5. Some examples of the course description contents identified to manifest aspects of sustainability or KSCs in the Department of Electrical Engineering, Building Services and Material Technology

Bioproduct technology course descriptions included a versatile tray of sustainable development topic ranging from environmental impacts and awareness to safety, resource efficiency and economic aspects. This complies well with the degree programme description emphasizing the sustainable use of natural resources (Xamk, n.d.d.). Electrical and automation engineering degree programme description (Xamk, n.d.d.) emphasizes energy efficiency and planning, which are presented in the analysed course descriptions as safety and economic aspects, as well as the systems-thinking and interpersonal skills.

Interpersonal skills were also emphasized in the building services engineering course descriptions along with the theme of energy efficiency. Principles of sustainable development were also mentioned giving a rare example of the term being used in course descriptions. Energy efficiency and carbon neutrality are at the core of the degree programme descriptions also (Xamk, n.d.d.).

6.3 Sustainable Development Actualization in Teaching

The teaching staff was asked to give an example of how sustainable development is manifested in their field, without specifying any aspect of sustainability or giving the interviewees a definition for sustainable development. The responses (see examples in Text box 6) indicate that field specific sustainability topics are identifiable in enough detail for them to be utilized as a basis for curricula development and teaching implementation.

"Energy efficiency is taken into account in everything."

"Climate change mitigation, but also other emission control."

"Social inclusion." "Zero tolerance on inappropriate behaviour." "Code of conduct."

"Holistic planning, taking into account all aspects of sustainability."

"Circular economy, resource efficiency, zero waste and cradle to cradle -thinking are becoming more and more widely discussed topics."

"Operational "code of conduct", e.g., waste separation practises."

"Product recyclability and resource efficient production are getting more attention."

"Energy efficiency in a manner that does not cause health risks."

"Changes in the energy system increase pressures for energy efficiency and renewable energy"

"Carbon neutrality commitments cause need to change behaviour"

"The costs of changes caused by sustainability transformation"

"The trade-off between economic and ecological sustainability driven decisions."

Text box 6. Some field specific examples of sustainable development revealed in teaching staff interviews

Including these field specific sustainability issues in degree programme learning objectives in the context of overall sustainability would allow students to understand their role in the sustainability transition more tangibly and potentially empower them to develop their sustainability competencies further:

> "Sustainable development awareness is a side product of technical content teaching, not the main objective." (An interviewed teaching staff representative, 2022)

This concurs with the recommendation already made about not adding sustainability as a disconnected topic, possibly in a generic course, but helping each course teacher identify the sustainability content as an integral part of each course content and as part of the professional competencies each course aims to build. Connecting such examples to the wider context of sustainability (e.g., with the help of the SDG matrix), would allow students to develop their sense of empowerment by developing their understanding and allowing the type of mind-set change (Koistinen, 2019, 27) called for sustainability agency formation.

The most often mentioned sustainability issue (Figure 7) was related to the energy system and the intensifying energy efficiency requirements, which was to be expected as fields of construction, building services and energy technology are all exposed to significant pressures for increased energy efficiency and logistics as a field is similarly going through an energy transformation. More generally resource efficiency is a timely topic, especially since the limitedness of resources has been made so tangible by the supply chain disruptions caused by the Covid-19 pandemic, so it is not surprising this was the second most commonly mentioned topic.

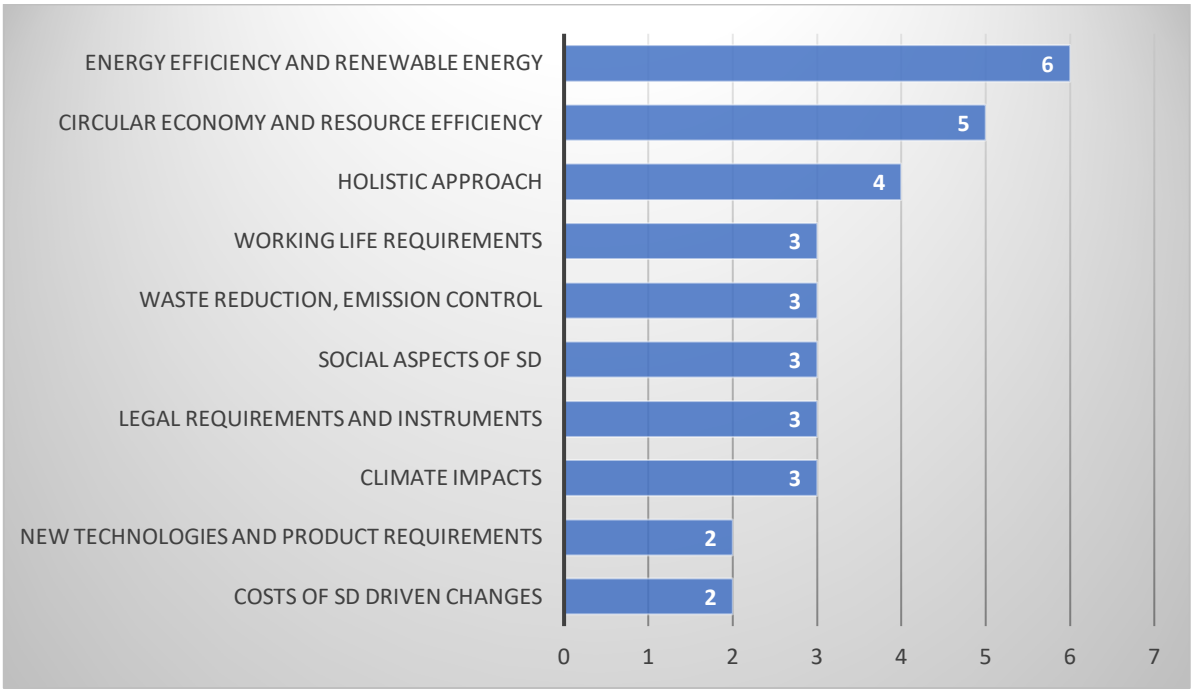

Figure 7. Aspects of sustainable development most often included in teaching staff examples (number of mentions in 8 interviews)

The interviewed teaching staff was not given information about the identified Key Sustainability Competencies used as a basis of the curricula analyses, so the extent to which these arose during the interviews is likely to represent their perceptions on their importance. Holistic approach, systems-thinking and a life-cycle approach were all mentioned while the interviewees explained the field specific sustainability examples, which would underline the true importance of such competencies in technical fields and confirm the importance of

adopting the comprehensive approach framework of generalism, holism and holarchism suggested by Willamo et al. (2018, 2). The necessity of incorporating sustainability competencies in education (Rieckmann, 2012, 129) was also echoed in how the initiatives for sustainable development projects arise most often from working life partners, although some interviewees also mentioned student motivation and interest as the initiator for course assignments, projects or theses related to sustainable development. Many interviewees shared the opinion of the best way of increasing student awareness on sustainable development being though a working life related assignment or project, particularly the type that would be closely related to their personal experiences. These were seen the most effective way of engaging students into realizing the influencing potential they possess as future professionals and reflects the highest level of the LfS Core Competence Framework (Pacis and VanWynsberghe, 2020, 583) as well as the empowerment (ESD III) level described by Sterling (2015, 98), which were used as the basis for the curricula analyses.

As established by Alm et al. (2021), work-integrated learning projects enhance learning and deepen understanding about SDGs, so increasing the opportunities for these, as the results suggest, is likely to enhance both meeting the societal expectations and needs of sustainability competencies as well as enhancing student learning and understanding on the importance of sustainability as part of their professional competencies. The existing model of development forums organized to address student concerns about teaching could be extended to cover working life partners also, and the aspects of sustainable development and sustainability competencies included in such development forums. Periodical events for regional cooperation partners might provide a forum for a more systematic review on the current working life competence requirements and open a new platform to create contacts between teaching staff and working life representatives. Along with helping teaching staff to identify field specific sustainability issues, these events might act as drivers for the cooperation partners to enhance their action towards more sustainable practices.

Personal interest was the most common driver for seeking to increase teaching staff sustainability skills and knowledge. It should be noted that the interviews were based on personal decisions, so it is likely that there was a stronger than average interest in sustainability topics among the interviewees. Coupled with the question of what type of support lecturers have had, or would have wished for, in improving their personal sustainable development knowledge and in integrating sustainable development topics in their teaching, the results

indicate that those members of the teaching staff that are interested in sustainable development topics have found ways to increase their own knowledge and skills on the topic without organizational guidance. From a Multi-Level Perspective (Geels, 2002, 1260) viewpoint this indicates that the landscape level guidance does not automatically translate into regime changes, even if individual actors are motivated to drive the change. Once again, the large-scale habitual change calls for large scale action on all levels, which can only be achieved if enough actors are involved. Thus, leaving the decision up to individual actors, is not likely to promote the transition.

The use appropriate terminology in the correct meaning was a concern for many of the interviewees, as highlighted by the following quote:

> "It's likely that many teachers actually do include sustainable development themes in teaching, not realizing that that is what they do. Use of terminology makes one of the challenges." (An interviewed teaching staff representative, 2022)

This confirms the findings of the previous research phase and highlights the importance of documented, commonly defined terminology. Understanding and using correct terminology was seen as a common improvement area, and access to more formal training on the topic was seen as a possibility to alleviate this concern. Participating seminars, courses, or workshops as well as conversations with colleagues were mentioned as the most efficient methods for increasing sustainable development awareness among teachers.

Organizing a "benchmarking club" around the theme of sustainable development might offer teachers a channel for sharing their views and experiences on teaching sustainability topics, especially if coupled with a platform for sharing educational contents, such as assignment examples and lecture material, and good information sources. A similar model already works for enhancing digital pedagogic skills. This would allow for all the good practises to be more widely adopted in teaching and provide a forum for establishing a uniform level of understanding throughout the School of Technology teaching staff. Naturally the successful implementation of such a model would also require allocation of resources for this type of work. The "sustainability benchmarking club" could even be extended to allowing teachers to participate courses on entirely different fields of study to expand their viewpoints on the versatility and multidimensionality of sustainability challenges and exposing oneself to the role of a student would also help improve pedagogical skills more generally. The idea of a

holistic, multidimensional approach was a frequently mentioned theme in the interviews and well condensed in the following quote:

> "Sustainable development as a concept is multidimensional, so one should not expect to be able to teach it one-dimensionally." (An interviewed teaching staff representative, 2022)

An important aspect of increasing teaching staff skills is the measurement of the efficiency of the action taken. A systematic baseline evaluation on the competence needs in relation to the teaching contents would reveal the competence gaps and another review after the selected action is taken to fill the gap would reveal the effectiveness of the action and potential need for alterations. This would also be an interesting topic for further research.

> "Xamk should take a stronger role in ensuring sustainable development is incorporated in teaching, beginning from educating the teaching staff and testing effectiveness of the action taken." (An interviewed teaching staff representative, 2022)

According to several interviewees, an important aspect of education for sustainable development is providing students with tools to influence the current operational models:

> "What is the overall importance of buildings on climate change and how is the studied topic linked to this big picture?" (An interviewed teaching staff representative, 2022)
>
> "Giving students a larger perspective and allowing them to understand how their actions as individuals or professionals influence the big picture." (An interviewed teaching staff representative, 2022)

Ideally providing students the tools for influencing sustainability challenges as part of their professional competencies will empower them to take action not only during their studies, but throughout their professional careers. This could be achieved if more empowerment enhancing content (Sterling, 2015, 98; Pacis and VanWynsberghe, 2020, 583) was included in their studies. The problem of measuring learning outcomes and the competence formation can only be solved after there is consensus on the terminology used to describe the concepts and instruments for competence development are developed (Adomßent et al., 2014, 5). The effectiveness of competence building teaching activities can truly be measured once the graduates put these in use in working life. The manifestation of sustainable development topics and competencies in working life activities should be studied to truly establish how successfully these have been promoted in their studies.

Another interesting topic for further research would be to interview the staff members that participated writing the course descriptions to better understand their motivation for including the sustainable development and Key Sustainability Competencies mentions that were identified in the curricula analysis.

6.4 Student Perceptions on Sustainable Development Contents in Their Studies

The aim of the student survey was to identify potential instruments for including sustainability aspects in the technical degree programme curricula and teaching implementation as well as to better understand the perceived importance and current level of addressing sustainability topics in teaching. A total of 169 responses were given by the students in the selected student groups leaving the response rate very low (about 8%). This can indicate that students don't perceive the topic interesting or important enough to take the time to respond to a survey, but a more likely reason is that the number of surveys students are exposed to has diminished their appeal. For more reliable results, selected student groups should also be interviewed, or some other data collection method used to gather more representative data on their perceptions. The numbers of respondents for each degree programme are listed in Appendix 1. Even with the low response rate, the number of responses can be seen sufficient for a qualitative analysis and for the purposes of this study.

The respondents felt their studies have increased their problem-solving competencies (97/169 respondents) as presented in Figure 8, and problem-solving competence was also selected as one of the most important competencies for the respondents' future careers (Table 7). Ecological sustainability was perceived the most often manifested aspect of sustainability (Figure 9), which contradicts the finding of social and cultural sustainability being the most often included in the course descriptions. The main aim of the survey was to identify student views on the ways in which aspects of sustainable development are included in their studies, or how they could be included in them more, and the open-ended questions provided some insights on these. The responses were analysed using qualitative content analysis.

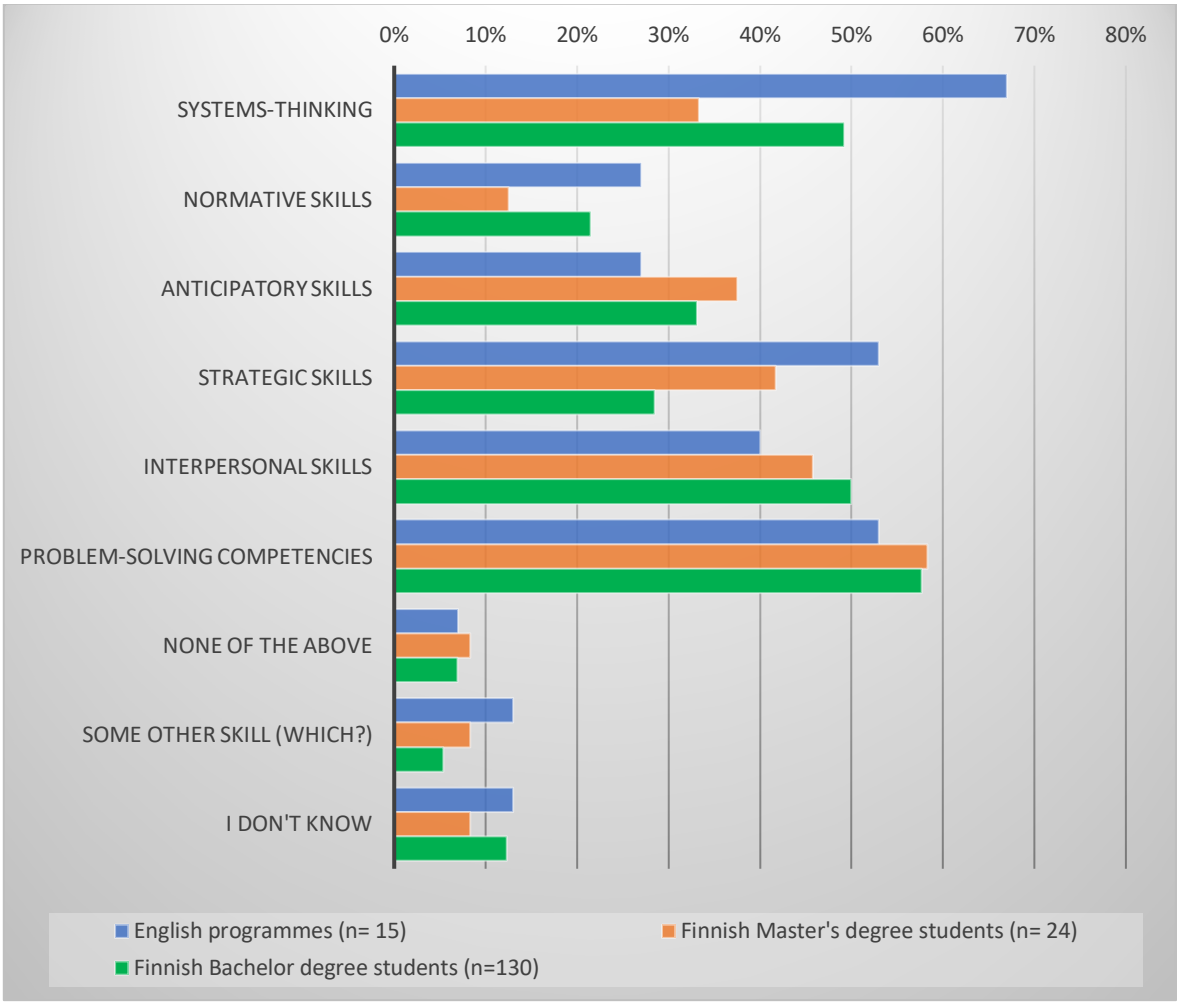

Figure 8. Respondents' views on the competencies and skills developed during the studies (Question 3.) presented as a percentage of respondents in each response group. Other skills and competencies mentioned were self -direction and management, creative thinking, reporting skills, computer skills, mathematical skills, and logical thinking.

Table 7. Median values (scale 1-5, with 1 very low and 5 very high importance) for the perceived importance of the listed skills in terms of future careers (Questions 10 and 11).

	English degree programme students (n= 15)	Finnish Master's degree students (n= 24)	Finnish Bachelor's degree students (n=130)
Problem solving skills	**5**	**5**	**5**
Systems thinking	**4**	**4**	**4**
Interaction and teamworking skills	**4**	**5**	**5**
Strategic thinking	**4**	**4**	**4**
Language skills	**4**	**4**	**4**

Occupational health and safety	4	4	5
Environmental awareness	5	4	5
Economic efficiency	4	4	4
Cultural aspects	4	3	3
Energy efficiency	4	4	5
Life cycle costs	4	5	5
Other than the listed (Q 11)	Creative thinking	Risk assessment Management skills	Management skills Well-being at work Self-appreciation Resource and material efficiency work planning, avoiding unnecessary travel. "Life-cycle costs not included at all"

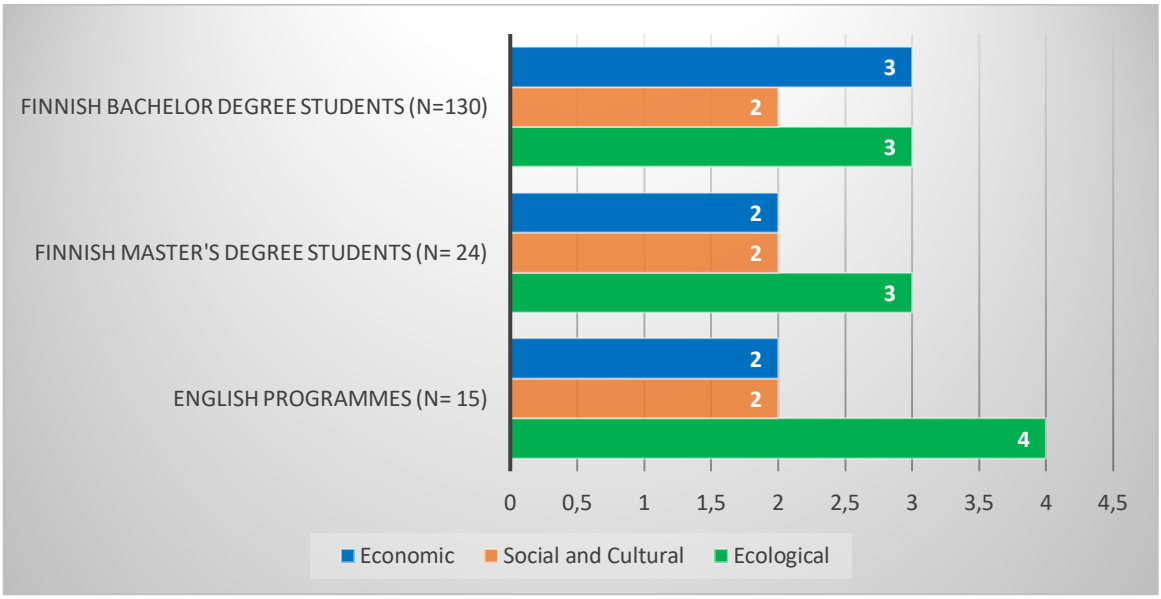

Figure 9. The median value of the respondents' views on how much (scale 1-5, with 1 very little and 5 very much) the aspects of sustainability have been included in their studies presented as the median answer for each respondents group.

6.4.1 Finnish Bachelor's Degree Students' Views

Examples of ecological sustainability were the most frequently mentioned by the Finnish Bachelor's degree respondents (Figure 10) including mentions of specific courses or lecturers and topics. Some mentioned the examples were from optional course they had selected based on their own interest and several mentioned that sustainability had not been included

in their studies at all, or only mentioned briefly. The examples included many similar topics as highlighted in the previous study phases, namely energy efficiency and the use of renewable energy, climate change, material efficiency and resource efficiency. For social and cultural aspects, the examples expressed the importance of international cooperation and how social sustainability is put in practise by equal treatment of students. Economic aspects in construction, material selection, energy system selection, energy efficiency, use of natural resources, business perspective, and procurement were given as specific examples of economic sustainability included in the respondents' studies.

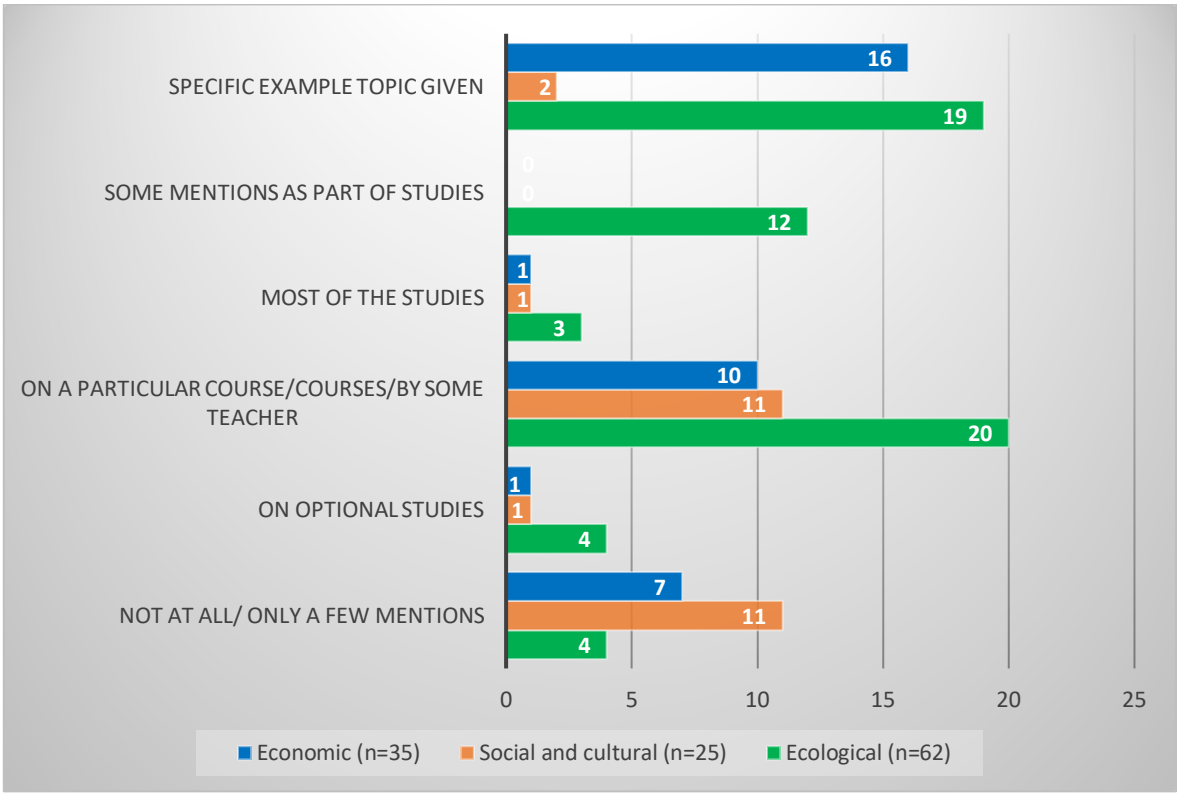

Figure 10. Grouping of the examples of the aspects of sustainability included in the respondent's studies by the Finnish Bachelor's degree programme students.

The respondents were asked to give examples of how they would increase sustainable development topics in their studies. A total of 47 responses were given, ranging from naming some specific aspect of sustainability to increase (e.g., "more information about environmental impacts") to the manner in which these should be included in studies (e.g., "integrated

in all courses"). Some respondents (7/47 responses) were content with the current level of sustainable development discussion in their studies and felt no need to increase it. An equal number of respondents (7/47) wished for a specific course on sustainable development, possibly as optional studies. Some respondents (4/47) suggested integrating sustainable development topics to some existing course and some respondents felt the topic should be integrated in all courses somehow.

The methods mentioned as effective ones included increasing working life cooperation (e.g., company visits and commissioned assignments), taking a more holistic view on the course contents (e.g., increasing life cycle thinking and the possibilities provided by circular economy) and suggestions on specific content topics to cover more extensively (e.g., carbon balance, resource efficiency, or a specific aspect of sustainable development). This suggests that even the awareness level (Sterling, 2015, 98; Pacis and VanWynsberghe, 2020, 583) content identified in the curricula analyses is not sufficiently included in degree programmes form the respondents' perspective.

The survey link was sent to the Bachelor's degree programme student groups who had begun their studies between 2018 and 2021. According to the enrolment data in Xamk Peppi (2022), 1641 students are enrolled in these groups in total and 130 responses were given. No responses were given by Information technology students, so the survey may not have reached them. The very low response rate naturally means the results can't be generalised to represent the entire student body very reliably; however, the results give an indication of the overall situation.

6.4.2 English Bachelor's Degree and Finnish Master's Degree Students' Views

The English degree programme students in groups of Information Technology and Environmental Engineering were sent a link to an English version of the survey. According to the enrolment data in Xamk Peppi (2022) 185 students are enrolled in these groups and only 15 responses were given. The low response rate (about 8%) naturally means the results should not be interpreted to represent the overall perceptions of the international students. The Master's degree programme student groups the survey link was sent to were Cybersecurity, Logistics, Environmental Technology, Project and Sales Management, and Building Services Engineering. According to the enrolment data in Xamk Peppi (2022), 225 students are

enrolled in these groups in total, so the 24 responses collected, again, leave the response rate very low (about 11 %). Due to the small number of responses in these respondent groups, the results are discussed together.

The Master's degree programme students and the English degree programme students' examples on how ecological, social and cultural, and economic aspects of sustainability have been included in their studies mostly gave examples of specific courses with some of these contents. Some mentions about these topics not being discussed, or being discussed very little, were made, similarly to the responses given by Finnish Bachelor's degree students. The methods for increasing sustainable development topics in studies were also quite similar to those suggested by the Finnish Bachelor's degree students, namely adding more working life contacts and tangible, practical examples, as well as taking a more holistic view on discussing the topic.

The clearest differences between English and Finnish Bachelor's degree students' responses was in which aspect of sustainability was most included in their studies (Figure 10). This can reflect the degree programme contents, as the majority of these respondents were environmental engineering students. The Finnish Master's degree students' responses were quite well aligned with the other respondent groups' answers, so the idea of Master level studies offering students a wider perspective on their study field wasn't reflected in the responses.

6.5 Research Limitations in Light of the Key Results

Based on the findings of the curricula analysis the current level of sustainable development content can be stated to promote awareness (level I) of sustainability topics with some indications of understanding (level II) and empowerment (level III) level contents. The relatively low occurrence (about 28%) of such contents indicates improvement potential. The method of curricula analysis based on predetermined key words holds the potential for biases and poor selection of key words will return inaccurate results. This may have been the case in identifying KSCs in curricula analysis. It is also quite difficult to identify some competencies from the course descriptions, as the subject described is unfamiliar to the analyser. To decrease false interpretations of the curricula analyses, another research using similar methodology but by several different analysts could increase the reliability of results by providing a wider tray of interpretations for the selected wordings. Some course descriptions contained

wording, such as “operating environment”, that would potentially return a false result if the analysis was solely conducted by counting the occurrence of specific words. This puts even more emphasis on contentual analysis, rather than focusing on the wording only.

The literature review and staff interviews revealed that the guidance for including contents to promote sustainable development awareness and Key Sustainability Competencies in curricula and in teaching could be increased. Qualitative data analysis holds a relatively high risk of false interpretations, as people perceive wordings and meanings differently. To decrease this risk, the interviewees were given an opportunity to review the results prior to their publication. Interviewing a higher number of teaching staff representatives would be likely to reveal more details about how sustainable development is approached in teaching at Xamk School of Technology. Selecting the interviewees randomly, rather than based on their motivation towards sustainability topics, would be likely to give a more accurate overview of the extent to which sustainability topics are included in teaching. Observing teaching on selected courses could provide more in-depth information on the different methods of how sustainability aspects are, and could be, included in teaching. This would allow identification of how the concept of sustainable development is broken down into pragmatic pedagogical content.

The student survey indicated ecological sustainability content to be most familiar to students, and potential to increase sustainability contents overall. Surveys typically return only a sample of the overall data, and in the case of this research the number of responses given reflects this phenomenon. Results can’t be interpreted as the overall student perception; however, some generalisations can be made since responses were given by students of nearly all of the degree programmes included in the study scope. The responses to open-ended questions revealed some possible methods for promoting SD awareness, but for more elaboration, students could also be interviewed, or some other data collection method utilized.

The results (Figure 11) are used to identify improvement potential in mainstreaming sustainable development contents in the degree programme curricula and teaching at the case example organization. The student survey and the staff interviews indicated some potentially efficient methods for this, while highlighting the necessity of uniformly defined terminology. The importance of sustainable development is reflected mostly via certain contentual topics, such as energy efficiency, climate change and resource efficiency.

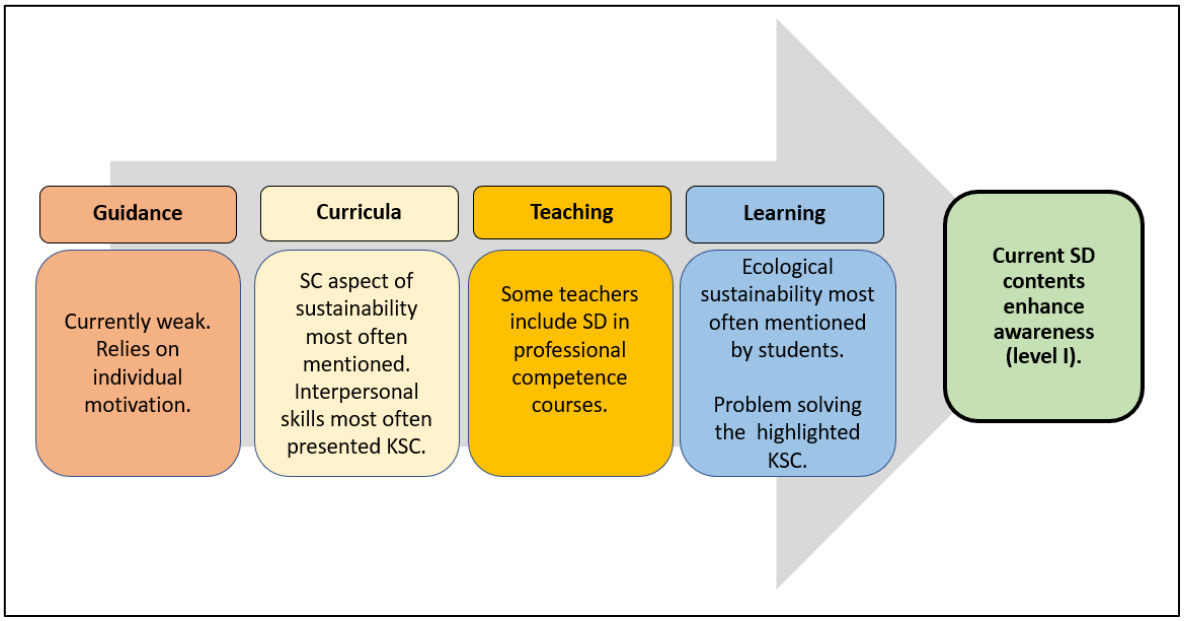

Figure 11. The key results from research phases.

Both students and teaching staff mention the need for more working life connections and working life related examples of how sustainable development is manifested specifically on their field, so a more systematic method for collecting information from working life should be established. Ideally this would increase staff awareness on working life sustainable development competence expectations and provide a cooperation platform benefitting both the UAS and regional development.

7 Conclusions

The changes aiming at a socio-technical transition towards sustainability are not likely to deliver immediate and personal benefits, so engaging a sufficiently large number of change agents calls for a widespread understanding of the necessity of the change and a sense of empowerment to maintain it (Geels, 2011, 25). Significant potential for enhancing the sustainability transition exists in higher education, as it provides students and their future employers the skills and operational models that, for their part, drive the transition. This is also reflected in including the degree of mainstreaming education for sustainable development in educational policy, curricula, teacher education and student assessment (UN, 2022) in the indicators for UN SDG target 4.7. The methods for measuring the "degree of mainstreaming" (OKM, 2020) are under development. The aim of this research was to establish the current sustainable development awareness and sustainability competencies content in the case example organization curricula and teaching, set on a three level framework from awareness (level I) to understanding (level II) and empowerment (level III). Based on the results the majority of sustainable development content included in curricula and implemented in teaching promotes awareness (level I) and clear potential to increase sustainability contents exists.

The results indicate that the guidance for including sustainable development awareness or Key Sustainability Competencies in higher education should be actively established and communicated if the aim is to reach empowerment (Sterling, 2015, 98) and agency (Pacis and VanWynsberghe, 2020, 583) that are they keys for a large-scale habitual change. Using the multi-level perspective terminology (Geels, 2005, 682) to describe the issue, a transition throughout the nested hierarchies of niches, regimes and the landscape of educational activities succeeds by mainstreaming the activities and contents that promote sustainability awareness and competencies. The current landscape already provides a platform for the topic to be an elemental part of educational policy, both international and national, and the educational content innovated by motivated teachers influences the niche level. While these are important elements of the overall transition, regime change is needed for a full scale mainstreaming and the action of each educational institution is a vital part of the regime change. Based on the results, Institutions of Higher Education may not have assumed their role in this. The results show that the guidance for including sustainability content in curricula or teaching is weak, even if the importance of these is acknowledged. Leaving the decision of

the extent and type of sustainable development contents to depend on the individual motivation of those writing the course descriptions and implementing educational activities can deliver some sustainability awareness (level I), but for more thorough understanding (level II) and empowerment (level III) active guidance should be employed. This guidance should be based on a systematic procedure of setting aims and measuring the achieved results to evaluate the effectiveness of the defined procedure. Coupled with providing the staff the resources to increase their personal sustainability competencies and knowledge this could prove an effective method of integrating sustainability contents in higher education.

Mainstreaming education for sustainable development in curricula also calls for a systematic procedure with aim setting and result measurement. Having been set as one of the indicators for UN SDG Target 4.7. (Statistics Finland, 2022) getting comparable and reliable measurement results is vital for the monitoring of how well the set goals have been reached. The curricula analysis methodology used in this research identified some potential difficulties. Measuring sustainable development contents in curricula should not be left to counting the occurrence of certain phrases but include contentual analysis also, and more research is needed to identify the framework best suitable for identifying the key contents. In terms of measuring the promotion of Key Sustainability Competencies (Wiek et al., 2011, 207) a curricula analysis can reveal a very limited view. The development of KSCs during studies could be better identified by a longitudinal study of selected student groups.

The curricula development procedure should include instructions for inclusion of sustainability contents both in curricula creation or updating and during the acceptance of changes (i.e., the curricula assessment and acceptance procedure). Staff members responsible for curricula development should have access to information about the aspects of sustainability and Key Sustainability Competencies relevant to the professional field in question. Rather than attempting to cover the entire sphere of sustainability topics all at once, focusing on certain field specific examples could become an effective method of increasing sustainability contents in higher education. An elemental part of the guidance is documented mapping the sustainability contents to cover in each degree programme curriculum and measurement of how these are included, in light of the field specific focus areas. The results also show that the teaching staff already finds ways to explain the connection between a professional competence topic and overall sustainability. This is not likely to represent the overall situation in the case example organization, as the interviewees were selected from those teaching

courses with existing SD content and their motivation to participate an interview also reflected their interest on the topic. This still represents a potentially effective method for teaching SD content, so effort should be put in activating more teaching staff to become involved in identifying sustainability content in their area of expertise. To enhance identification of SD aspects as part of the professional competencies, teaching staff should have sufficient resources to develop their own knowledge on the topic and tools for identifying professional field specific examples of sustainability. These vary depending on the field and focusing on the field specific examples would be likely to help motivate students as well as providing teaching staff with suitable pedagogical content to facilitate empowered agency.

Increasing working life connections to educational activities could be an effective method for enhancing identification of the field specific sustainability actions and linking them to the grand challenges of sustainability. This should be extended to a systematic cooperation model between working life partners and regional development drivers, to facilitate a review of working life expectations for institutions of higher education. Increasing teaching staff Key Sustainability Competencies should also be a more systematically managed activity, including establishment of the baseline level, the desired level and measuring the efficiency of the action taken to fill the gap between these. As established in this research, reliable measurement of competencies requires more than counting the occurrence of selected phrases, especially since sustainability terminology is ambiguously used. Clear definitions of the terminology used would help in demonstrating commitment to both operational and contentual sustainability action in an Institution of Higher Education, and the model used for describing an organizational policy in international management system standards could prove usable for establishing an organizational sustainable development policy. Such a policy is only effective if sufficiently communicated to staff and students to demonstrate that sustainable development is an elemental part of the organizational culture.

All students, not only those motivated to study sustainability topics, should be provided with a basic level education on the concepts of sustainability to ease their understanding of how sustainable development awareness and Key Sustainability Competencies are an integral part of their professional competencies. Rather than adding this as a separate content of a generic course, it could be a requirement for a degree programme element that requires individual work, such as the reporting of their practical training periods. This could also benefit the practical training employer, as it would help identify sustainable development aspects of

their operations. Including sustainability in course evaluation criteria, could also help motivate students, but would most likely be more effective if included in thesis evaluation criteria. Student perceptions on sustainable development topics included in their studies reflect their study fields and the current public discussion on, e.g., the energy system transition, resource efficiency and climate change. Presenting students the linkage between grand challenges of sustainability and the profession they study for will not only allow them to become aware of the challenges but help them understand the different aspects and consequences and, most importantly, empower them to see themselves as the future sustainability agents they are. Facilitating the formation of such empowerment is the responsibility and privilege of Institutions of Higher Education, and this role should be assumed more actively.

References

Adomßent, M., Fischer, D., Godemann, J., Herzig, C., Otte, I., Rieckmann, M. and Timm, J.. 2014. Emerging areas in research on higher education for sustainable development e management education, sustainable consumption and perspectives from Central and Eastern Europe. Journal of Cleaner Production 62 (2014) 1-7. [online] [Retrieved 15.4.2022]. From: http://dx.doi.org/10.1016/j.jclepro.2013.09.045

Alm, K., Beery, T., Eiblmeier, D. and Fahmy, T. 2021. Students' learning sustainability – implicit, explicit or non-existent: a case study approach on students' key competencies addressing the SDGs in HEI program. International Journal of Sustainability in Higher Education Vol. 23 No. 8, 2022 pp. 60-84. Emerald Publishing Limited 1467-6370 [online] [Retrieved 5.4.2022]. From: DOI 10.1108/IJSHE-12-2020-0484

Alppisara, J. and Knuuttila, K. 2020. Opiskelijoiden näkemyksiä kestävästä kehityksestä – case JAMK in Kiertotalousosaamista ammattikorkeakouluihin. Lapin ammattikorkeakoulun julkaisuja. Sarja B Tutkimusraportit ja kokoomateokset. ISSN 2489-2637 [online] [Retrieved 5.4.2022]. From: https://www.lapinamk.fi/loader.aspx?id=802bc409-4b18-493d-a8dc-95b4096b1986

Ammattikorkeakoulujen rehtorineuvosto Arene ry. 2020. Sustainable, responsible and carbon-neutral universities of applied sciences. [Online]. [Retrieved 5.1.2022]. From: https://www.arene.fi/wp-content/uploads/Raportit/2020/Sustainable%2C%20responsible%20and%20carbon-neutral%20universities%20of%20applied%20sciences.pdf?_t=1606145574

Ammattikorkeakoulujen rehtorineuvosto Arene ry. 2021. Ammattikorkeakoulujen hiilijalanjälkilaskuri. [Online]. [Retrieved 5.1.2022]. From: https://www.arene.fi/julkaisut/muut/arenen-hiilijalanjalkilaskuri/

Ammattikorkeakoulujen rehtorineuvosto Arene ry. 2022. Suositus ammattikorkeakoulujen yhteisistä kompetensseista ja niiden soveltamisesta [Online]. [Retrieved 7.4.2022]. From: https://www.arene.fi/julkaisut/raportit/suositus-ammattikorkeakoulujen-yhteisista-kompetensseista-ja-niiden-soveltamisesta-2022/

Ammattikorkeakoululaki. 14.10.2014/932 (Universities of Applied Sciences Act)

Arcada. n.d.a. Strategy 2030. [Online]. [Retrieved 5.2.2022]. From: https://www.arcada.fi/en/about-us/strategy

Arcada. n.d.b. Sustainability and social responsibility. [website]. [Retrieved 5.2.2022]. From: https://www.arcada.fi/en/about-us/sustainability

Arola, Johanna. 2022. Senior lecturer. South-Eastern Finland University of Applied Sciences. Interview. Teams. 17.3.2022

Brinkmann, S. 2013. Qualitative interviewing. New York: Oxford University Press. [E-book]. [Retrieved 26.3.2022]. From: https://lut.primo.exlibrisgroup.com/permalink/358FIN_LUT/1js2888/alma991474073906254

Cambridge University Press. 2022. Cambridge Dictionary: Education [Online]. [Retrieved 2.2.2022]. From: https://dictionary.cambridge.org/dictionary/english/education

Campusonline. 2022. [website]. [Retrieved 6.2.2022]. From: https://campusonline.fi/en/

Cebrian, G. and Junyent, M. 2015. Competencies in Education for Sustainable Development: Exploring the Student Teachers' Views. Sustainability 2015, 7, 2768-2786 [online] Retrieved 6.1.2022]. From: doi:10.3390/su7032768 ISSN 2071-1050

Centria. n.d.a. Centria UAS. [website]. [Retrieved 4.2.2022]. From: https://web.centria.fi/

Centria. n.d.b Strategia 2021-2024 (2030). [Online]. [Retrieved 4.2.2022]. From: https://web.centria.fi/esittely/centria-ammattikorkeakoulun-strategia

Cook J. (eds). 2019. Sustainability, Human Well-Being, and the Future of Education. Palgrave Macmillan, Cham. [online] [Retrieved 6.2.2022] From: https://doi.org/10.1007/978-3-319-78580-6_2

da Silva, A. 2020. Important dimensions of SDG target 4.7 are missing in UNESCOs monitoring framework. United Nations Associations of Norway. [online]. [Retrieved 4.2.2022]. From: https://www.fn.no/nyheter/important-dimensions-of-sdg-target-4.7-are-missing-in-unescos-monitoring-framework

Diak. n.d.a Responsibility [website]. [Retrieved 4.2.2022]. From: https://www.diak.fi/en/

Diak. n.d.b. Diakin strategia 2021-2030 n.d.b [online]. [Retrieved 4.2.2022]. From: https://www.diak.fi/diak/organisaatio/strategia/

Drayson, R., Bone, E., Agombar, J., Kemp, S. 2014. Student attitudes towards and skills for sustainable development. The Higher education Academy. [online]. [Retrieved 6.1.2022]. From: https://www.iau-hesd.net/sites/default/files/documents/student_attitudes_towards_and_skills_for_sustainable_development-2014.pdf

Dufva, Kari. 2022. Director of Education for the Department of Electrical Engineering, Building Services and Material Technology. South-Eastern Finland University of Applied Sciences. Group interview. Teams. 22.2.2022

Eklöf, N. and Laanterä, S. 2021. Vastuullisuus ja kestävä kehitys hyvinvointialan opetussuunnitelmissa. Kaakkois-Suomen ammattikorkeakoulu. Xamk Next [online journal] [Retrieved 2.2.2022]. From: https://next.xamk.fi/vastuullisesti/vastuullisuus-ja-kestava-kehitys-hyvinvointialan-opetussuunnitelmissa/

Eskola, J., & Suoranta, J. 2014. Johdatus laadulliseen tutkimukseen. Vastapaino. ISBN: 9789517680356

ESG (Standards and Guidelines for Quality Assurance in the European Higher Education Area). 2015. Brussels, Belgium. [Online]. [Retrieved 5.1.2022]. From: https://www.enqa.eu/wp-content/uploads/2015/11/ESG_2015.pdf

Etelä-Savon maakuntaliitto. 2021. Maakuntaohjelma. [Online]. [Retrieved 5.2.2022]. From: https://www.esavo.fi/resources/public/Kehittaminen/Maakuntaohjelma/Maakuntaohjelma_2022_2025_digi.pdf

Finnish Education Evaluation Centre Karvi (FEEC). n.d. Higher Education. [website] [Retrieved 5.2.2022]. From: https://karvi.fi/en/higher-education/

Geels, F. 2011. The multi-level perspective on sustainability transitions: Responses to seven criticisms. [online]. Environmental Innovation and Societal Transitions 1 (2011) 24–40. [Retrieved 18.1.2022]. From: doi:10.1016/j.eist.2011.02.002

Geels, F. W. 2005. Processes and patterns in transitions and system innovations: Refining the co-evolutionary multi-level perspective. Technological forecasting & social change. [Online] 72 (6), 681–696. [Retrieved 10.10.2021] From: DOI: 10.1016/j.techfore.2004.08.014

Geels, F. W. 2002. Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. Research Policy 31 (2002) 1257–1274.

Glasser, H. 2019. Toward Robust Foundations for Sustainable Well-Being Societies: Learning to Change by Changing How We Learn. In: Cook J. (eds) Sustainability, Human Well-Being, and the Future of Education. Palgrave Macmillan, Cham. [online] [Retrieved 6.2.2022] From: https://doi.org/10.1007/978-3-319-78580-6_2

Global Alliance for Monitoring Learning (GAML). 2017. Measurement strategy for SDG Target 4.7 [online] [Retrieved 6.2.2022] From: http://uis.unesco.org/sites/default/files/documents/gaml4-measurement-strategy-sdg-target4.7.pdf

Haaga-Helia. n.d.a. Haaga-Helian Strategia ja arvot. [website] [Retrieved 4.2.2022] From: https://www.haaga-helia.fi/fi/haaga-helian-strategia-ja-arvot.

Haaga-Helia. n.d.b. Accountability [website] [Retrieved 4.2.2022] From: https://www.haaga-helia.fi/en/accountability

Hamk. n.d.a. Strategy 2030. [online] [Retrieved 4.2.2022] From: https://www.hamk.fi/strategy/?lang=en

Hamk. n.d.b. Sustainable Hamk. [website] [Retrieved 4.2.2022] From: https://www.hamk.fi/sustainable-hamk/?lang=en

Helin, J. 2021. Indicators. The Need and Challenges of Tracking Implementation of SDG Target 4.7. Bridge 47. [online] [Retrieved 4.2.2022] From: https://sloga-platform.org/wp-content/uploads/2021/08/4_indicators.pdf

Helle, Ari. 2022. Director of Education for the Department of Logistics and Marine Technology. South-Eastern Finland University of Applied Sciences. Group interview. Teams. 22.2.2022

Humak. n.d.a. Strategy 2030. [website] [Retrieved 4.2.2022] From: https://www.humak.fi/en/info/strategy-2030/

Humak. n.d.b. Information about Humak. [website] [Retrieved 4.2.2022] From: https://www.humak.fi/en/info/

Jamk. n.d.a. Strategy 2020-2030. [online] [Retrieved 4.2.2022] From: https://www.jamk.fi/sites/default/files/2022-01/creating_competence_strategy_of_jamk_university_of_applied_sciences_2020-2030.pdf

Jamk. n.d.b. . [website] [Retrieved 4.2.2022] From: https://www.jamk.fi/en

Jylkkä, Hanna. 2022. Senior lecturer. South-Eastern Finland University of Applied Sciences. Interview. Teams. 23.3.2022

Kamk. 2020. Kamk'30 Strategy. [online] [Retrieved 4.2.2022] From: https://www.kamk.fi/loader.aspx?id=53a7c861-c67f-469a-bc76-7037081d2602

Kamk. n.d. Kamk. [website] [Retrieved 4.2.2022] From: https://www.kamk.fi/en/KAMK

Karelia. 2022a. Karelia 2030 -sustainable vitality. [online] [Retrieved 4.2.2022] From: https://karelia.fi/wp-content/uploads/2016/09/Karelia-UAS-strategy-2020-2030.pdf

Karelia. 2022b. About us. [website] [Retrieved 4.2.2022] From: https://karelia.fi/en/about-us/

Kauppi, Henna. 2022 Senior lecturer. South-Eastern Finland University of Applied Sciences. Interview. Teams. 24.3.2022

Knuuttila, K. 2021. Toimenpiteitä ammattikorkeakouluilla kohti hiilineutraaliutta ja kestävyyttä. Jyväskylän ammattikorkeakoulun julkaisuja 298. ISSN 1456-2332

Koistinen, K. 2019. Actors in Sustainability Transitions. Dissertation. Lappeenranta-Lahti University of Technology. LUT University Press 2019. Acta Universitatis Lappeenrantaensis 846

Komonen, K. and Tuikkanen, R. 2021. Kestävä kehitys yhteisöpedagogi- ja restonomikoulutuksen opetussuunnitelmissa. Kaakkois-Suomen ammattikorkeakoulu. Xamk Next [online journal] [Retrieved 2.2.2022]. From: https://next.xamk.fi/vastuullisesti/kestava-kehitys-yhteisopedagogi-ja-restonomikoulutuksen-opetussuunnitelmissa/

Korhonen-Kurki, K., Koivuranta, R., Kuitto, V. Pietikäinen, J., Schönach, P. Soini, K. 2020. Towards Realising SDGs in the University of Helsinki in G. Nhamo, V. Mjimba (eds.), Sustainable Development Goals and Institutions of Higher Education, Sustainable Development Goals Series [eBook] [Retrieved 6.1.2022]. From: https://doi.org/10.1007/978-3-030-26157-3_2

Koskinen, I., Peltonen, T. and Alasuutari, P.. 2005. Laadulliset menetelmät kauppatieteissä. Tampere: Vastapaino. ISBN: 978-951-768-175-9

Kuusela, Anu. 2022. Senior lecturer. South-Eastern Finland University of Applied Sciences. Interview. Teams. 17.3.2022

Kymenlaakson liitto. 2021. Maakuntaohjelma 2022-2025. [Online]. [Retrieved 5.2.2022]. From: https://maakuntaohjelma.kymenlaakso.fi/

LAB. n.d.a. The Best of Both Worlds – LAB strategy 2030. [online] [Retrieved 4.2.2022] From: https://lab.fi/sites/default/files/2020-08/LAB%20Strategy%202030.pdf

LAB. n.d.b. Sustainable development and responsibility. [website] [Retrieved 4.2.2022] From: https://www.lab.fi/en/info/about-us/sustainable-development-and-responsibility

Lapland UAS. n.d.a. Strategy. [online] [Retrieved 4.2.2022] From: https://www.lapinamk.fi/en/Who-we-are/Strategy-2030

Lapland UAS. n.d.b. Sustainability and ciruclar economy in Lapland UAS [website] [Retrieved 4.2.2022] From: https://www.lapinamk.fi/en/Who-we-are/Sustainability-and-Circular-Economy

Laurea UAS. 2019. Societal impact and interaction 2019. [online] [Retrieved 4.2.2022] From: https://www.laurea.fi/globalassets/uusi-kansio/vaikuttavuusraportti-2019_a4_eng_rgb.pdf

Laurea UAS. n.d. Strategy 2030. [online] [Retrieved 4.2.2022] From: https://www.laurea.fi/globalassets/laurea/documents/strategia-2030_eng-lowres.pdf

Männynsalo, Jarkko. 2022. Principal lecturer. South-Eastern Finland University of Applied Sciences. Interview. Teams. 18.3.2022

Mäntylä, Jukka. 2022. Director of Education for the Department of Forestry and Environmental Technology. South-Eastern Finland University of Applied Sciences. Group interview. Teams. 22.2.2022

Martin, R. 2019. The High Price of Efficiency. Harvard Business Review, 97 (2019), 42–55. [online] [Retrieved 12.12.2021] From: https://hbr.org/2019/01/the-high-price-of-efficiency

Mässeli, Niina. 2022. Senior lecturer. South-Eastern Finland University of Applied Sciences. Interview. Teams. 24.3.2022

Meadows, D. 2014. Envisioning a Sustainable World. In R. Costanza & I. Kubiszewski (Eds.), Creating a Sustainable and Desirable Future: Insights from 45 Global Thought Leaders (pp. 9–14). Singapore: World Scientific. . [eBook]. [Retrieved 6.2.2022]. From: https://search-ebscohost-com.ezproxy.cc.lut.fi/login.aspx?direct=true&db=e000xww&AN=752587&site=ehost-live&ebv=EB&ppid=pp_9

Metropolia. 2020a. Strategy 2021-2030. [video]. [Retrieved 5.2.2022]. From: https://youtu.be/jCs8WdhvrFI

Metropolia. 2020b. Sustainable development. [website]. [Retrieved 5.2.2022]. From: https://www.metropolia.fi/kestavakehitys/en/Home

Metropolia. 2021. Metropolia edistää kestävän kehityksen osaamista ainutlaatuisen tekoälyratkaisun avulla. [website]. [Retrieved 5.2.2022]. From: https://www.metropolia.fi/fi/metropoliasta/ajankohtaista/uutiset/metropolia-edistaa-kestavan-kehityksen-osaamista-ainutlaatuisen-tekoalyratkaisun-avulla

Mochizuki, Y. and Fadeeva, Z. 2010. Competences for sustainable development and sustainability. Significance and challenges for ESD. International Journal of Sustainability in Higher Education Vol. 11 No. 4, 2010 pp. 391-403. Emerald Group Publishing Limited 1467-6370 [online]. [Retrieved 6.1.2022]. From: DOI 10.1108/14676371011077603

Mulari, Jyri. 2022. Senior lecturer. South-Eastern Finland University of Applied Sciences. Interview. Teams. 24.3.2022

National Forum for Skills Anticipation (NFSA). 2019. Osaaminen 2035. Osaamisen ennakointifoorumin ensimmäisiä ennakointituloksia. [online report]. [Retrieved 18.1.2022]. From: https://www.oph.fi/fi/tilastot-ja-julkaisut/julkaisut/osaaminen-2035

Novia. 2020. Strategy 2030. [Online]. [Retrieved 5.2.2022]. From: https://www.novia.fi/assets/Sidor/4/3058/strategi2030-A4-eng3.pdf

Novia. n.d. About us. [website]. [Retrieved 5.2.2022]. From: https://www.novia.fi/about-us

Oamk. n.d.a. Impact – openly and responsibly,. Strategy of Oulu University of Applied Sciences 2020–2030. [online]. [Retrieved 5.2.2022]. From: https://www.oamk.fi/images/oamk_strategy_2020_en.pdf

Oamk. n.d.b. Sustainable and responsible campus life 2025. [website]. [Retrieved 5.2.2022]. From: https://www.oamk.fi/en/about-oamk/sustainable-campus-life

Opetus- ja kulttuuriministeriö (OKM). 2021a. Education System in Finland. [website]. [Retrieved 18.1.2022]. From: https://okm.fi/documents/1410845/15514014/Education+system+in+Finland/7c5a920b-47a5-c3ce-cbca-818ff3a5f848/Education+system+in+Finland.pdf?t=1631015290321

Opetus- ja kulttuuriministeriö (OKM). 2021b. Korkeakoulujen kestävän kasvun ohjelma. [website]. [Retrieved 18.1.2022]. From: https://okm.fi/hanke?tunnus=OKM049:00/2021

Opetus- ja kulttuuriministeriö (OKM). 2020a. Sustainable development policy of the Ministry of Education and Culture and its administrative branch. [online document]. [Retrieved 18.1.2022]. From: http://urn.fi/URN:ISBN:978-952-263-706-2

Opetus- ja kulttuuriministeriö (OKM). 2020b. Roadmap for Research, Development and Innovation. [online]. [Retrieved 18.1.2022]. From: https://okm.fi/en/rdi-roadmap#:~:text=The%20National%20Roadmap%20for%20Research,develop%20the%20RDI%20operating%20environment

Opetus- ja kulttuuriministeriö (OKM). 2020c. Opetus- ja kulttuuriministeriön ja Kaakkois-Suomen ammattikorkeakoulun välinen sopimus kaudelle 2021-2024. [online]. [Retrieved 6.1.2022]. From: https://okm.fi/documents/1410845/3992295/Kaakkois-Suomen+ammattikorkeakoulu+sopimus+2021-2024.pdf/63ce9fd4-f732-a000-88f6-06d9d038a28d/Kaakkois-Suomen+ammattikorkeakoulu+sopimus+2021-2024.pdf?version=1.1&t=1611924721763

Opetus- ja kulttuuriministeriö (OKM). 2019. Strategy 2030. Publications of the Ministry of Education and Culture 2019:14 [online document]. [Retrieved 18.1.2022]. From: https://urn.fi/URN:ISBN:978-952-263-632-4

Opetus- ja kulttuuriministeriö (OKM). n.d. Korkeakoulut, muut julkiset tutkimusorganisaatiot ja tiedelaitokset. [website]. [Retrieved 18.1.2022]. From: https://okm.fi/korkeakoulut-ja-tiedelaitokset

Opetus- ja kulttuuriministeriö (OKM). n.d.a.. Ammattikorkeakoulut Suomessa [website]. [Retrieved 4.2.2022]. From: https://okm.fi/ammattikorkeakoulut

Osakeyhtiölaki 21.7.2006/624 (Limited Liability Companies Act)

Pacis, M. and VanWynsberghe, R. 2020. Key sustainability competencies for education for sustainability. Creating a living, learning and adaptive tool for widespread use. [online]. International Journal of Sustainability in Higher Education Vol. 21 No. 3, 2020 pp. 575-592 [Retrieved 11.1.2022]. From: DOI 10.1108/IJSHE-12-2018-0234

Pálsdóttir, A. and Jóhannsdóttir, L.. 2021. "Key competencies for sustainability in university of Iceland curriculum", Sustainability, Vol. 13 No. 16, p. 8945. [Retrieved 11.4.2022]. From: doi: 10.3390/su13168945.

Pappas, E., Pierrakos, O. and Nagel, R. 2013. Using Bloom's taxonomy to teach sustainability in multiple contexts. Journal of Cleaner Production 48. 54-64. [online]. [Retrieved 28.2.2022]. From: http://dx.doi.org/10.1016/j.jclepro.2012.09.039

Puusa, A. and Juuti, P.. 2020. Laadullisen tutkimuksen näkökulmat ja menetelmät. Gaudeamus. ISBN : 978-952-345-616-7

Raworth, Kate. 2017. Doughnut economics: seven ways to think like a 21st-century economist. [e-book]. Cornerstone Digital [Retrieved 4.3.2021] From: https://r1.vlereader.com/Reader?ean=9781473517813

Rieckmann, M.. 2012. "Future-oriented higher education: which key competencies should be fostered through university teaching and learning?", Futures, Vol. 44 No. 2, pp. 127-135. [online]. [Retrieved 4.3.2021]. From: doi: 10.1016/j.futures.2011.09.005.

Rockström, Johan, Steffen, Will, Noone, Kevin, Persson, Åsa, Chapin,F. Stuart; et al. 2009. A Safe Operating Space for Humanity. Nature Vol. 461, Iss. 7263, : 472-475. [Retrieved 4.4.2021] From: DOI:10.1038/461472a

Ropponen, Jouni. 2022. Senior lecturer. South-Eastern Finland University of Applied Sciences. Interview. Teams. 23.3.2022

Samk. n.d.a. Samk2030 - Strategy. [Online]. [Retrieved 5.2.2022]. From: https://www.samk.fi/en/about-samk-2/strategy/

Samk. n.d.b. Environmentally Conscious SAMK. [website]. [Retrieved 5.2.2022]. From: https://www.samk.fi/en/about-samk-2/strategy-and-management/environmentally-conscious-samk/

Savonia. 2022. Explore Savonia. [website]. [Retrieved 5.2.2022]. From: https://www.savonia.fi/en/savonia-uas/explore-savonia/

Savonia. n.d. Strategia 2021-2030. [Online]. [Retrieved 5.2.2022]. From: https://www.savonia.fi/app/uploads/2020/12/Savonian-strategia-2021-2024-tiivistelma-1.pdf

Seamk. 2019. Kokoaan suurempi ja entistä verkottuneempi SeAMK. [Online]. [Retrieved 5.2.2022]. From: https://storage.googleapis.com/seamk-production/2020/02/seamk-strategia-2020-2024-nettiin.pdf

Seamk. n.d. Sustainability at SeAMK. [website]. [Retrieved 5.2.2022]. From: https://www.seamk.fi/en/aboutus/sustainability/

Siitonen, Paula. 2022. Director of Education for the Department of Information Technology. South-Eastern Finland University of Applied Sciences. Group interview. Teams. 22.2.2022

Sinkko, Arja. 2022. Director of Education for the Department of Construction and Energy Engineering South-Eastern Finland University of Applied Sciences. Group interview. Teams. 22.2.2022

Statistics Finland. 2022. Sustainable Development UN Indicators. [online database]. [Retrieved 18.1.2022]. From: https://pxnet2.stat.fi/PXWeb/pxweb/en/SDG/

Statistics Finland. 2016. National classification of education 2016. [online database]. [Retrieved 18.1.2022]. From: https://www2.tilastokeskus.fi/en/luokitukset/koulutus/koulutus_1_20160101/?code=073&name=Architecture%20and%20construction

Sterling, S. 2015. Separate Tracks or Real Synergy? Achieving a Closer Relationship between Education and SD. [online]. Journal of Education for Sustainable Development 8:2 (2014): 89–112 SAGE Publications. Vol 8(2): 89–112 10.1177/0973408214548360. [Retrieved 20.1.2022]. From: https://journals-sagepub-com.ezproxy.cc.lut.fi/doi/pdf/10.1177/0973408214548360

Tamk. n.d.a. Tampereen korkeakouluyhteisön strategia [Online]. [Retrieved 5.2.2022]. From: https://www.tuni.fi/fi/tutustu-meihin/korkeakouluyhteison-strategia#expander-trigger--0f217194-a486-4fb3-8a4c-9c349b0bc483

Tamk. n.d.b. Tampere Universities Sustainable development commitments and memberships. [website]. [Retrieved 5.2.2022]. From: https://www.tuni.fi/en/about-us/sustainable-development-at-tampere-universities/sustainable-development-commitments-and-memberships

Turku amk. n.d.a. Excellence in Action: Strategy 2019–2031. [Online]. [Retrieved 5.2.2022]. From: https://www.tuas.fi/en/about-us/operations-and-organization/values-and-strategy/

Turku amk. n.d.b. Sustainable development. [website]. [Retrieved 5.2.2022]. From: https://www.tuas.fi/en/about-us/operations-and-organization/sustainable-development-at-turku-uas/

United Nations (UN). n.d. The 17 Goals. [website]. [Retrieved 20.1.2022]. From: https://sdgs.un.org/goals

United Nations Educational, Scientific and Cultural Organization (UNESCO). n.d. [website]. [Retrieved 20.1.2022]. From: https://www.unesco.org/en

United Nations Educational, Scientific and Cultural Organization (UNESCO). 2021. Global Education Monitoring Report. [online]. [Retrieved 1.4.2022.] From: https://unesdoc.unesco.org/ark:/48223/pf0000379875.page=463

United Nations Educational, Scientific and Cultural Organization (UNESCO). 1974. Recommendation concerning Education for International Understanding, Co-operation and Peace and Education relating to Human Rights and Fundamental Freedoms. [online]. [Retrieved 2.2.2022]. From: http://portal.unesco.org/en/ev.php-URL_ID=13088&URL_DO=DO_TOPIC&URL_SECTION=201.html

United Nations. 1948. Universal Declaration of Human Rights. [online]. [Retrieved 3.2.2022]. From: https://www.un.org/sites/un2.un.org/files/udhr.pdf

United Nations. 2022. SDG Indicators Metadata repository. [website]. [Retrieved 16.1.2022]. From: https://unstats.un.org/sdgs/metadata/?Text=&Goal=4

Vaasan ammattikorkeakoulu (Vamk). 2022a. Strategy. [Online]. [Retrieved 5.2.2022]. From: https://www.vamk.fi/en/meidan_vamk/me/strategia/

Vaasan ammattikorkeakoulu (Vamk). 2022b. Sustainable development and responsibility. [website]. [Retrieved 5.2.2022]. From: https://www.vamk.fi/en/meidan_vamk/korkeakoulu/kestavakehitysohjelma/

Valtioneuvosto (VN). 2019. Government Programme. [online]. [Retrieved 18.1.2022]. From: https://valtioneuvosto.fi/en/marin/government-programme

Väisänen, M., Siekkinen, T. and Aittola, H. 2015. Yliopistojen ja ammattikorkeakoulujen koulutustehtävän yhteiskunnallinen vaikuttavuus in Vastuullinen ja vaikuttava. Tulokulmia korkeakoulujen yhteiskunnalliseen vaikuttavuuteen. Opetus- ja kulttuuriministeriön julkaisuja 2015:13. [online]. [Retrieved 4.2.2022]. From: https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/75117/okm13.pdf

van der Leeuw, S. 2018. Closing remarks: novel approaches to complex societal change and sustainability. Sustainability Science. 13. 1589-1596. [online]. [Retrieved 2.4.2022]. From: https://doi.org/10.1007/s11625-018-0581-2(0123456789().,-volV)(0123456789().,-volV)

Wiek, A., Withycombe, L. and Redman, C. 2011. Key competencies in sustainability: a reference framework for academic program development. [online]. Sustainability science. 6 (2), 203–218. [Retrieved 18.1.2022]. From: DOI 10.1007/s11625-011-0132-6

Wikman, M., Nyrhilä, L. and Roschier, S. 2022. The effect of the Green Transition to the Employment and Educational Requirements of Engineers in Finland. Engineers Finland. Gaia Consulting. [online]. [Retrieved 4.4.2022]. From: https://www.tek.fi/sites/default/files/attachments/The%20Effects%20of%20the%20Green%20Transition%20to%20the%20Employment%20and%20Educational%20Requirements%20of%20Engineers%20Finland_0.pdf

Xamk (Kaakkois-Suomen ammattikorkeakoulu Oy). 2022. Degree Regulations. [unpublished source] [Retrieved 22.2.2022] From. Xamk intranet.

Xamk (Kaakkois-Suomen ammattikorkeakoulu Oy) Peppi. 2022. [digital platform] [Retrieved 27.3.2022]

Xamk (Kaakkois-Suomen ammattikorkeakoulu Oy). 2021a. Planning of Education. [unpublished source] [Retrieved 22.2.2022] from Xamk intranet.

Xamk (Kaakkois-Suomen ammattikorkeakoulu Oy). 2021b. Henkilöstö- ja koulutussuunnitelma. [unpublished source] [Retrieved 2.2.2022] from Xamk intranet.

Xamk (Kaakkois-Suomen ammattikorkeakoulu Oy). 2020. Xamk - opetussuunnitelmien perusteet 2021 - 2024. [unpublished source] [Retrieved 22.2.2022] from Xamk intranet.

Xamk (Kaakkois-Suomen ammattikorkeakoulu Oy). n.d.a. Strategy 2020-2030. [online] [Retrieved 4.2.2022]. From: https://www.xamk.fi/en/xamk2/strategy/

Xamk (Kaakkois-Suomen ammattikorkeakoulu Oy). n.d.b. Social Responsibility and Sustainability at Xamk. [website] [Retrieved 4.2.2022]. From: https://www.xamk.fi/en/social-responsibility-and-sustainability-at-xamk/

Xamk (Kaakkois-Suomen ammattikorkeakoulu Oy). n.d.c About us. [website] [Retrieved 6.1.2022]. From: https://www.xamk.fi/en/xamk2/

Xamk (Kaakkois-Suomen ammattikorkeakoulu Oy). n.d.d. Education. [website] [Retrieved 7.4.2022]. From: https://www.xamk.fi/en/education/degree-programmes/

Yliopistolaki 24.7.2009/558 (The Universities Act)

Appendix 1. Student Survey Questions and Number of Respondents

The survey questions are listed below and the numbers of respondents to the student survey are presented in Tables A1-1, A1-2 and A1-3.

THE SURVEY QUESTIONS:

1. When did you begin your studies?
    - 2018
    - 2019
    - 2020
    - 2021
    - other (initiates command “end survey”)
2. Which study programme do you study in?
    - form 1: (listing of Bachelor’s degree programmes included in scope)
    - form 2: (listing of English degree programmes included in scope)
    - form 3: (listing of Master’s degree programmes included in scope)
    - Some other degree programme (initiates command “end survey”)

The aim of questions 1 and 2 was to ensure responses from students excluded from the research scope would not be included in the results.

3. In your opinion, which of the following skills and competencies have been enhanced in your studies (you may select several)?
    - systems-thinking
    - normative skills
    - anticipatory skills
    - strategic skills

- interpersonal skills
- integrative problem-solving competencies
- none of the above
- some other skill (which?)
- I don't know

The following additional information was provided for the respondents to ease answering questions 4.-9.:

Sustainable development means ensuring that future generations have the same access to ecological, social, cultural and economic opportunities as the current generations enjoy in pursuit of their well-being. Ecological sustainability includes aspects such as environmental protection, nature preservation and emission reduction. Social and cultural sustainability can be, for example, inclusion and ensuring equal rights to everyone. Economic sustainability is, for example, steady economic growth within the planetary boundaries and access to responsible financing instruments, like loans or investments.

Next you are asked to evaluate how these aspects of sustainable development have been included in your studies. Please give examples (e.g., course names, assignment types etc)

4. To what extent has ecological sustainability been included in the courses you have studied? (0 is not at all, 5 is very much)
5. Please give examples
6. To what extent have social and cultural sustainability been included in the courses you have studied? (0 is not at all, 5 is very much)
7. Please give examples
8. To what extent has economic sustainability been included in the courses you have studied? (0 is not at all, 5 is very much)
9. Please give examples

10. How important, in your opinion, are the following for your future career? (1 is not very, 5 is extremely important)
    - Problem solving skills
    - Systems thinking
    - Interaction and teamworking skills
    - Strategic thinking
    - Language skills
    - Occupational health and safety
    - Environmental awareness
    - Economic efficiency
    - Cultural aspects
    - Energy efficiency
    - Life cycle costs
11. If you feel something important was missing from the list, please add it here.
12. How would you increase sustainable development awareness in your study field and study programme?
13. If you wish to take part in the pin raffle, please add your contact information.

Thank you for your participation!

RESPONDENTS

Table A1-1. Respondents in Finnish Bachelor's Degree Programmes

Degree programme	Responses
Bioproduct technology	7
Energy engineering	8
Cyersecurity	3
Logistics	9
Software engineering	2

Game programming	3
Construction engineering	18
Robotics and artificial intelligence	1
Electrical and automation engineering	20
Building services engineering	14
Industial wood contruction	23
Information technology	0
Environmental technology	22
Some other	0
TOTAL	130

Table A1-2. Respondents in Finnish Master's Degree Programmes

Degree programme	Responses
Cybersecurity	2
Logistics	0
Project and sales management	12
Environmental technology	7
Building services engineering	0
Some other	3
TOTAL	24

Table A1-3. Respondents in English Degree Programmes

Degree programme	Responses
Cybersecurity	0
Environmental Engineering	11
Information Technology	4
Some other	0
TOTAL	15

Appendix 2. Degree Programme Curricula Contents Analysis Results by Department

Table A2-1. Department of Information Technology

	Number of core competence courses* analyzed				Number of courses including SD or KSC occurrences					
Department of Information Technology	**2018**	**2019**	**2020**	**2021**	**2018**	**2019**	**2020**	**2021**	**Examples**	**Notes**
Cybersecurity (MEng, 60 CU)	-	5	-	-	-	1	-	-	information security	
Kyberturvallisuus (*Cybersecurity*) (MEng, 60)	-	-	5		-	-	1		information security	2020 and 2021 curriculum the same
Master level courses total		**5**	**5**			**1**	**1**			
Information Technology (BEng, 240 CU)	23		22		5		7		security, energy efficiency, data integrity and availability. problem solving skills, interpersonal skills	2018 and 2019 curricula the same; 2020 and 2021 curricula the same
Kyberturvallisuus (*Cybersecurity*) (BEng, 240 CU)	-	22		23		6		5	security, strategic thinking, interpersonal skills.	2019 and 2020 curriculum the same
Ohjelmistotekniikka (*Software Engineering)* (BEng, 240 CU)	-	-	-	22	-	-	-	4	information security, problem solving skills, interpersonal skills	
Peliohjelmointi (*Game programming)* (BEng, 240 CU)	-	21	21		-	7	4		financing models, revenue logics, cultural aspects, information security and privacy, problem solving skills, systems thinking, interpersonal skills	2020 and 2021 curricula the same. Course ”Johdatus pelituotantoon” 10 CU
Tieto- ja viestintätekniikka (*Information technology*) (BEng, 240 CU)	30	-	-	-	3	-	-	-	information security, problem solving skills, interpersonal skills	
Bachelor level courses total	**53**	**43**	**43**	**45**	**8**	**13**	**11**	**9**		
TOTAL	53	48	48	45	8	14	12	9		

*generic courses, thesis and practical training excluded. Typically a course is 5 CU

Table A2-2. Department of Logistics and Marine Technology

	Number of core competence courses analyzed*				Number of courses including SD or KSC occurrences					
	2018	**2019**	**2020**	**2021**	**2018**	**2019**	**2020**	**2021**	**Examples**	**Notes**
Logistiikka (*Logistics*) (MEng)	4	-	-	-	1	-	-	-	Strategic thinking	
Master level courses total	**4**				**1**					
Logistiikka *(Logistics*) (BEng)	16		18		6		9		business responsibility, environmental impacts, economic efficiency, waste management, sustainability responsible business practices, product LC responsibility, occupational safety, cost level impacts, responsible self-management, safety, security	2018 and 2019 curricula the same; 2020 and 2021 curricula the same
Bachelor level courses total	**16**		**18**		**6**		**9**			
TOTAL	20		18		7		9			

*generic courses, thesis and practical training excluded. Typically a course is 5 CU

Table A2-3. Department of Forestry and Environmental Technology

	Number of core competence courses* analyzed				Number of courses including SD or KSC occurrences					
	2018	**2019**	**2020**	**2021**	**2018**	**2019**	**2020**	**2021**	**Examples**	**Notes**
Ympäristöteknologia (*Environmental technology*) (MEng 60 CU)	-	4	-		-	4	-		environmental policy and economic guidance mechanisms, environmental and health risks, energy efficiency, environmental safety	2019 and 2021 curricula the same
Master level courses total		**4**				**4**				
Environmental Engineering (BEng, 240 CU)	20		17		14		11		aspects of sustainability, climate change, contaminants in the environment, economic and environmental aspects, emission reduction, environmental and health risks, environmental impact assessment, environmental management, environmental monitoring, environmental problems, environmental sustainability, health risks caused by pollution, occupational health and safety, profitability of renewable energy, resource efficiency	2018 and 2019 curricula the same; 2020 and 2021 curricula the same
Ympäristöteknologia (*Environmental Technology*) (BEng, 240 CU)	11		19		6		6		Sustainable resource use, environmental safety, environmental health risks, occupational safety, environmental awareness, energy efficiency, environmental safety.	2018 and 2019 curricula the same; 2020 and 2021 curricula the same
Bachelor level courses total	**31**		**36**		**20**		**17**			
TOTAL	31	4	36		20	4	17			

*generic courses, thesis and practical training excluded. Typically a course is 5 CU

Table A2-4. Department of Construction and Energy Engineering

	Number of core competence courses* analyzed				Number of courses including SD or KSC occurrences					
	2018	**2019**	**2020**	**2021**	**2018**	**2019**	**2020**	**2021**	**Examples**	**Notes**
Projekti – ja myyntijohtaminen *(Project and sales management)* (MEng, 60 CU)	5		1		1		1		interpersonal skills	Only one course change in 2018 and 2020 curricula
Master level courses total	**5**		**1**		**1**		**1**			
Energiatekniikka (*Energy engineering*) (BEng, 240 CU)	20		19		6		5		safety, occupational safety, economic feasibility, energy efficiency, changed requirements due to SD, operational safety	2018 and 2019 curricula the same; 2020 and 2021 curricula the same
Rakennustekniikka (*Construction engineering*) (BEng, 240 CU)	16		22		3		3		Life cycle costs, energy efficiency, health and safety, problem solving, systems thinking	2018 and 2019 curricula the same; 2020 and 2021 curricula the same
Robotiikka ja tekoäly *(Robotics and Artificial Intelligence)* (BEng, 240 CU)	-	-	-	19	-	-	-	3	Occupational safety, responsibility interpersonal skills,	
Teollinen puurakentaminen *(Industrial Wood Construction)* (BEng, 240 CU)	17		21		3		3		Life cycle costs, health and safety, problem solving	2018 and 2019 curricula the same; 2020 and 2021 curricula the same
Bachelor level courses total	**53**		**62**	**19**	**12**		**11**	**3**		
TOTAL	58		63	19	13		11	3		

*generic courses, thesis and practical training excluded. Typically a course is 5 CU

Table A2-5. Department of Electrical Engineering, Building Services and Material Technology

	Number of core competence courses* analyzed				Number of courses including SD or KSC occurrences					
	2018	**2019**	**2020**	**2021**	**2018**	**2019**	**2020**	**2021**	**Examples**	**Notes**
Talotekniikka (MEng, 60 CU)	-	5	-		-	5	-		Energy efficiency, LC costs, principles of SD, safety	2019 and 2021 curricula the same
Master level courses total		**5**				**5**				
Biotuotetekniikka (BEng, 240 CU)	18		18		5		4		Environmental and health hazards, safety, energy efficiency, environmental, safety and economic performance, problem solving, strategic thinking	2018 and 2019 curricula the same; 2020 and 2021 curricula the same
Sähkö- ja automaatiotekniikka (BEng, 240 CU)	24		24		4		4		systems thinking, interpersonal skills, economic aspects, safety	2018 and 2019 curricula the same; 2020 and 2021 curricula the same
Talotekniikka (BEng, 240 CU)	21		19		5		5		interpersonal skills, principles of SD, energy efficiency	2018 and 2019 curricula the same; 2020 and 2021 curricula the same
Bachelor level courses total	**63**		**61**		**14**		**13**			
TOTAL	63	5	61		14	5	13			

*generic courses, thesis and practical training excluded. Typically a course is 5 CU