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Challenging 21st-Century Competencies for STEM Students: Companies' Vision in Slovenia and Norway in the Light of Global Initiatives for Competencies Development

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Abstract: Rapid technological innovations are changing the jobs that Science, Technology, Engineering, and Mathematics (STEM) students are employed in after completing their education. Therefore, employers are looking for applicants with skills beyond the specialised professional competencies that can be acquired in the chosen subjects during formal education. Higher education institutions (HEIs) have an important role to play in this process, as they endeavour to equip graduates with the skills and knowledge for future jobs. Our study aims to identify the key competencies that Slovenian and Norwegian companies expect from graduates of selected STEM degree programmes in both countries. Based on these findings, the participating HEIs can tailor their degree programmes to the employability requirements of companies. This study first analysed European and international recommendations and initiatives relevant to skills development in STEM employment and education. We selected 30 key competencies and included them in the questionnaires in which companies' human resources managers (HRMs) defined their attitudes towards employability skills in the future. We focused on companies employing graduates of the Ecotechnologies and Civil and Environmental Engineering programmes of the participating HEIs. The analysis of the results showed that companies in the two countries have different attitudes towards skills. Four competencies were identified as more important in both countries: (i) management and design of processes, technologies, and people's work, (ii) adaptation to changes, (iii) ability to manage uncertainty, and (iv) innovation. Based on the analysis, we have developed a framework of ten employability skills for STEM students. In addition, this study provides the basis for operating a decision support system (DSS) to monitor the development of students' competencies. The DSS is being developed as part of the RESPO-VI project supported by the Norway Grants to better match the skills of STEM students as future job seekers with the needs of potential employers. The study's results will also help other formal and non-formal education adapt their curricula and thus reduce the employability skill gaps between current STEM education and future labour market needs.

Keywords: competency strategies; higher education; decision support system; 21st-century competencies; STEM

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1. Introduction

Rapid technological innovation is changing the professions in which science, technology, engineering, and mathematics (STEM) students are employed after graduation. As a result, employers are looking for candidates whose skills go beyond the technical competencies that can be acquired in their chosen subjects during formal education. Therefore, students must adopt new ways to work, learn, and participate in society. The green and digital transitions create new opportunities for people and the EU economy. To adapt to these changes and opportunities, individuals need to develop the right skills, from basic skills, such as literacy, numeracy, and digital technology, to vocational or technical skills, entrepreneurial and transversal skills, such as foreign languages, personal growth, and learning to learn. All these skills are needed to maintain an individual's well-being while contributing to society, productivity, and economic development.

Higher education institutions (HEIs) also have an important role in addressing these challenges, by providing formal education and non-formal training for students who constitute an important part of the labour market after graduation. On the one hand, higher education curricula do not cover some of the competencies that employers require from graduates [1–3]. On the other hand, the curricula of the target faculties chosen by prospective students do not match their aspirations, current abilities, or parental expectations [4]. Moreover, innovative teaching and learning models contribute significantly to stronger interactions between education, technological innovation, business, entrepreneurship, and social inclusion. Some examples of the application of new pedagogical methods in the field of sustainability are given by Grega and Pikoń [5].

The pedagogical methods should also be supported by advanced digital technologies, information and communication solutions, datafication, and artificial intelligence [6]. These challenges were also recognised by the International Society for Technology in Education (ISTE), which prepared ISTE Standards to help students and professors develop digital skills to become productive members of society in the 21st century. The ISTE standards provide an important framework to guide HE teachers in using digital technology in their pedagogical work and encourage students to participate and behave responsibly in the digital world. For instance, the Decision Support System (DSS) has already shown a potential to be integrated into higher education processes and pedagogical approaches. DSSs have been developed to support helping prospective students in finding the matched faculty [7], selecting appropriate courses [8], selecting suitable students for the most appropriate Erasmus+ short-term mobility [9], academic performance evaluation by student and programme assessment [10], and data mining in HEI management [11].

The working environment which students enter after graduation is constantly and rapidly changing due to technological advances. This is especially important for students studying science, technology, engineering, and mathematics (STEM) studies. If students do not develop competencies following the current needs of the industry during their education, they may find themselves unprepared for modern work challenges and inadequately competent for the jobs for which they have been educated. However, students with the right competencies are more easily integrated into the workplace and contribute to innovation and business growth. Matching competencies between HEIs and employers' needs is thus an important step towards improving the employability of STEM graduates. It also makes an important contribution to developing modern and sustainable industries.

Past studies have shown a need to monitor how employers value different STEM qualifications more frequently and inform students about STEM trends to increase their employability after studying in STEM-related industries [2]. Employers increasingly demand that students' skills be assessed and compared during higher education. They currently value more vocational, critical thinking, and problem-solving skills but less numeracy and related skills [1]. However, it is important to note that the key competencies demanded by the industry have changed over the years, so the set of key competencies in ten years could be significantly different from today. More substantial involvement of STEM students in real industrial environments during their studies and enhanced collaboration between

academics and employers benefit both graduates and society in facilitating STEM graduates' employability and developing relevant employability competencies.

Our study focused on competency gaps among STEM students in selected study programmes and employers' demands in Slovenia and Norway. The study aimed to provide valuable insights into the demands and risks faced by Slovenian and Norwegian companies in finding and developing a skilled STEM workforce for the future. The study addressed the specific research questions of the employers' competency requirements for STEM students in both countries and how cross-sectoral and bilateral cooperation can address these competency gaps and meet employers' requirements. It aims to provide practical insights and recommendations for improving the skills of STEM students through cross-sectoral collaboration. In this contribution, we present the results of a study conducted within the RESPO-VI project, co-funded by the Norway Grants. We prepared a selection of the most relevant competencies for STEM students, adapted to European and international policies, strategies, and other relevant initiatives, as well as to the needs of Slovenian and Norwegian employers. Therefore, this paper first summarises strategies and initiatives relevant to key 21st-century competencies for STEM students. Furthermore, we identify the importance of 30 competencies for employees in those workplaces in the company that require a higher level of STEM education from the employers' perspective. Based on the comparative analysis of the companies' answers obtained by questionnaires, we have prepared a framework of the top ten competencies important for STEM students in the 21st century and compare it with other STEM competency frameworks from the literature. The aim of this study goes beyond the presented results, as the developed competency framework for STEM students will be transferred to the DSS being developed in the RESPO-VI project and validated during the training of STEM students in selected HEIs.

2. Contextualising the Study Background

2.1. History of the Development of the RESPO Decision Support System for Monitoring Competency Development

The presented study was conducted within the RESPO-VI project, co-funded by the Norway Grants. The project aimed to identify competency gaps among students in selected study programmes and employers' demands. This was done by optimising an innovative Results-oriented Engagement System for Performance Optimisation (RESPO) [12] and individualised interdisciplinary training for students. Both activities were carried out in the framework of the RESPO-VI project by three partners from Slovenia and one from Norway. Two HEIs also participated in the project: Jožef Stefan International Postgraduate School (IPS) from Slovenia and the Norwegian University of Science and Technology (NTNU).

The initial version of the RESPO application was designed to monitor the development of competencies among employees in selected Slovenian companies investing in their workforce's development. It was first tested in practice for competence development on company employees within the Competence Centre at IPS [13]. Later, the system was transferred to educational institutions, namely to one of the secondary schools in Slovenia, to monitor the development of competencies of secondary school students. Finally, we decided to transfer the use of the system to higher education institutions [12]. The database architecture, the nomenclature of basic terminology, and the functionality of the original RESPO online system have been transformed into a new format suitable for HEIs and students. The first tests found that the core competencies database was not fully relevant to educational programmes, employers' future needs, and European Union (EU) strategies, recommendations, and initiatives. Therefore, in the RESPO-VI project, we decided first to prepare a selection of the most relevant competencies for the DSS database, which was adapted to the policies, strategies, and other relevant initiatives of the EU, the Organisation for Economic Co-operation and Development (OECD), the World Economic Forum (WEF), and the United Nations Educational, Scientific and Cultural Organization (UNESCO), as well as to the needs of employers. The new application concept brings together information on the required competencies tailored to the needs of the labour market and EU initiatives,

as well as selected STEM-oriented study programmes. Such a DSS serves to help students effectively develop competencies in both formal and non-formal education.

In the next chapter, we summarise the strategies and initiatives relevant to key 21st-century competencies for STEM students. A selection of 30 competencies was included in a questionnaire for Slovenian and Norwegian companies to express their need for individual competency. Furthermore, we identified the importance of competencies for employees in those workplaces in companies that require a higher level of education, i.e., bachelor's degree, master's degree, or doctoral degree. From the comparative analysis of the questionnaires, we prepared a list of the top 10 competencies highlighted by Slovenian and Norwegian companies. The skills list will be included in the database for the RESPO-VI DSS and tested during the training for STEM students, which will be implemented in spring 2024.

2.2. Review of EU and International Strategies and Initiatives Relevant to the Development of STEM Student Competencies

2.2.1. EU Strategies and Initiatives

The EU strives to equip people with the necessary skills by implementing various strategies and initiatives, which we summarise in this chapter. In this context, the European Commission updated and adopted the European Agenda for Skills a few years ago, specifically in 2020. This Agenda includes important recommendations and guidelines to encourage individuals and businesses to develop and use more effective skills [14,15]. It outlines policy priorities and initiatives that will continue to drive the green and digital transition while enhancing citizens' employability and providing skills for the future workforce. Improving competencies should:

- contribute to fostering the development of sustainable competitiveness, as also mentioned in the European Green Deal;
- contribute to social justice, which also contributes to the realisation of the first principle of the European Pillar of Social Rights on equal access to education for all and the availability of quality training and lifelong learning among people in the EU;
- strengthen resilience and response to crises, e.g., those caused by the COVID-19 pandemic or wars.

The Digital Education Action Plan (2021–2027), adopted in 2020, is an EU initiative with a vision for excellence, inclusive, and accessible digital education in Europe [16]. It encourages adapting existing formal education and non-formal training systems in EU countries to the challenges of the digital age. These became even more obvious during the COVID-19 pandemic, when online and blended learning became even more important, revealing new and creative approaches to teaching and learning activities while widening the gap between those with access to digital technologies and those without access. The action plan consists of two strategic priorities and 14 actions to support them.

Key Competences for Lifelong Learning is a European reference framework that defines key competencies, named competences in this European Commission document [17]. It provides a reference tool for policymakers, education/training providers, learners, etc. It supports efforts at all levels (European, national, regional, and local) to promote the development of these competencies in lifelong learning. The framework thus identifies eight key competencies:

- literacy competency;
- multilingual competency;
- mathematical competency and competency in science, technology, and engineering;
- digital competency;
- personal, social, and learning to learn competency;
- citizenship competency;
- entrepreneurship competency;
- cultural awareness and expression competency.

In Table 1, we summarise several other EU initiatives that were considered when preparing a list of 30 key competencies for the company's questionnaire, which will also be included in the RESPO-VI database.

Table 1. EU initiatives relevant for the selection of key 21st-century competencies for STEM higher education students.

Initiative	Short Description	Reference
The Digital Competency Framework for Citizens (DigComp and DigComp 2.2)	DigComp and its updated version, DigComp 2.2, have an important role in meeting the objectives of EU strategies and initiatives on digital literacy and understanding what digital competency is. The Digital Competency Framework is the basis for developing policies, curricula, and assessments of digital competencies in education and the labour market. It defines the conditions for remote working and considers emerging technologies such as artificial intelligence (e.g., machine learning, deep learning), virtual reality, and the Internet of Things.	[18,19]
ALMA (Aim, Learn, Master, Achieve)	ALMA (Aim, Learn, Master, Achieve) is an initiative by the European Commission that aims to support young people not in any kind of employment, education, or training (NEETs). By enhancing their skills, knowledge, and experience, the initiative allows integration into their home nation and will enable them to forge new connections across Europe.	[20]
The European Year of Skills	With a high percentage (75%) of EU companies saying that they have difficulty finding workers with the skills they need, the European Commission has declared 2023 the European Year of Skills. This aims to promote lifelong learning by encouraging investment in training and upskilling the European workforce and reskilling people as they move from one job to another. The focus is on activating women and young people, not in education, employment, or training and attracting people from third countries with the skills that the EU needs.	[21]
ESCO platform	The multilingual online platform ESCO (European Skills, Competences, Occupations, and Qualifications) defines a reference classification and terminology that can be used to describe skills. Among the set of skills, it is possible to find those necessary for a specific occupation and those that an individual should acquire in formal, non-formal, and lifelong learning. It can be implemented on different online platforms to provide services like matching job seekers with positions based on their skills and recommending training to those who want to reskill or upskill. Its purpose is to offer a "common language" on occupations and skills that many stakeholders can utilise for employment, education, and training.	[22]
EU Skills Panorama	This online tool provides access to quantitative and qualitative data and information on skill needs in occupations, sectors, and EU countries. All these data provide insights into European skills supply and demand trends and the gaps between them. The toolkit also provides access to information on national data and resources to help policymakers and other professionals keep up to date with the latest developments and trends when making further policy decisions. With its data and forecast compilations to identify the top "bottleneck" occupations, it aims to improve Europe's capacity to assess and foresee skill needs.	[23]
Youth Employment Support: A Bridge to Jobs for the Next Generation	The Youth Employment Support: A Bridge to Jobs for the Next Generation package aims to aid young people entering the labour market. This initiative includes activities based on the European Commission's ambitious Economic Recovery Plan. It offers a range of funding opportunities for all EU Member States to employ young people and invest in their career development. The Youth Employment Support package is designed around four strands that provide a bridge to jobs for the next generation.	[24]

Table 1. *Cont.*

Initiative	Short Description	Reference
New European Research Area	The European Commission adopted a new European Research Area for research and innovation. The European Research Area (ERA) is a single, borderless market for research, innovation, and technology in the EU, where countries cooperate and improve their research policies and systems and promote the free exchange of researchers, knowledge, and innovation. Built on the principles of excellence, competitiveness, openness, and talent prioritisation, it will improve the European Research and Innovation Area, accelerate the EU's transition to climate neutrality and digital leadership, help it recover from the social and financial impacts of the coronavirus crisis, and increase its resilience to future crises.	[25]
European Framework for Research Careers	The European Research Careers Framework has been designed as a reference tool for comparing career hierarchies across sectors and countries, helping researchers identify job opportunities and employers find suitable candidates. The descriptors apply to all researchers, and the framework is independent of the sector. The framework defines four profiles: R1 First Level Researcher, R2 Recognised Researcher, R3 Established Researcher, and R4 Lead Researcher. These profiles bridge sectoral and national differences but do not replace local or national nomenclature.	[26]
New European Innovation Agenda	The new European Innovation Agenda, adopted in July 2022, aims to put Europe at the forefront of deep technological innovation and start-ups that will contribute to developing new technologies to tackle society's most demanding challenges and successfully transfer them to the market for practical use. As part of this, Europe wants to improve access to financing for European start-ups and large companies, improve conditions for innovators, and create "regional innovation valleys" to better connect innovation players across Europe, including in lagging regions. The Agenda also aims to attract and retain talent in Europe by providing appropriate training and increasing the support for women.	[27]
European Institute of Innovation and Technology (EIT)	The EIT is a body of the EU that aims to foster innovation and integration between industry, education, and European research. The EIT works through its Knowledge and Innovation Communities (KICs), which focus on renewable energy, digital technology, climate change, etc. KICs aim to connect and collaborate with schools, universities, and industry through tailor-made programmes that foster the development of key skills in students. Thus, the EIT brings together businesses, educational institutions, and research institutions. This networking fosters entrepreneurship among students and researchers, interdisciplinary collaboration, and the development of a wide range of professional and soft skills, including entrepreneurship, communication, and leadership.	[28]
European Qualifications Framework (EQF)	The EU has set up the EQF to make understanding and comparing qualifications between different Member States easier. In this way, it helps facilitate employee and student mobility. The EQF comprises eight levels of qualifications, from level 1 (low) to level 8 (high). Each level is described in terms of the knowledge, skills, and competencies that an individual acquires after completing that level. The EQF also includes informally acquired knowledge and skills.	[29]
European strategy for universities	In 2022, the EU adopted a European strategy for universities to recognise their unique position at the intersections of education, research, and innovation. It aims to support universities and help them adapt to current challenges. The strategy highlights the need to adapt to the rapid changes in demand for green and digital skills. This way, universities will strengthen their role in Europe's social and economic development.	[30]
Eurostudent	EUROSTUDENT collects and analyses comparable data on the social dimension of European higher education. EUROSTUDENT VII Synopsis of Indicators 2018–2021 identifies some key skills contributing to successful employment after studies. Among the most essential skills that students can acquire during their studies are those developed during study-related work or practice.	[31]

2.2.2. OECD Skills Strategies

OECD policy primarily aims to promote investment in young people, including students in higher education, in particular, in developing their skills, which are crucial for

successfully integrating young people into the labour market and society. This is important not only for individuals to realise their potential and be equipped to face the challenges of the modern world but also for overall economic growth and social cohesion. This is particularly important in the current era when countries and nations are recovering from the COVID-19 pandemic and taking coordinated actions to help graduate and post-graduate students find their first jobs in the labour market, where they will be able to use effectively the knowledge in the workplace that they have acquired during their studies. In the long term, megatrends such as globalisation, climate change, technological advances, and demographic changes will continue to transform work and society, and countries should prepare today by developing the skills needed to succeed in the world of tomorrow.

The OECD is working with thirty countries to assess their challenges and opportunities in skills development, identify priority areas for action, and make concrete and targeted policy recommendations to build more effective skills systems that promote employment, productivity, and social cohesion. Because the situation in each country is unique, national project teams also collaborate in these projects to evaluate the state of each country.

Using the OECD Skills Strategy framework [32], they analyse the performance of skills in individual countries, taking into account the following aspects:

- the development of relevant skills across the life cycle from childhood to adulthood;
- the effective use of skills at work and in society;
- activating the supply of skills in the labour market;
- strengthening the governance of the skills system.

The OECD has also developed a tool that assesses skill sets to help individuals and career advisers identify a person's strengths and suggests some occupations that use these skills to help them decide on their next career path [33]. To identify the skills profile, the tool needs information on the hard skills of the individual (technical knowledge and training) and the soft skills (personal habits and characteristics). The tool obtains information on hard skills from the given level of education, the occupation with which the individual most closely identifies and the frequency with which the individual performs certain activities. To assess soft skills, the individual takes personality tests. These tests focus on the main soft skills that are most frequently referred to in the workplace:

- customer and personal service;
- time management and self-management skills;
- motivation and commitment;
- creative thinking.

2.2.3. WEF Recommendations

The Future of Jobs report [34], published by the WEF, presents the jobs and skills of the future, with a focus on monitoring the pace of change. It aims to highlight the following:

- the challenges posed by the COVID-19 pandemic in 2020 and the history of economic cycles;
- the expected outlook for technology adaptation, jobs, and skills in the coming years.

In Figure 1, we summarise the key findings of the WEF report. The report also provides in-depth information for 15 industrial sectors and 26 countries. We looked at the education sector in general in more detail. Below is a list of skills that are expected to become increasingly important in education in the coming years:

- creativity, originality, and initiative;
- active learning strategies;
- innovative technology development and programming;
- emotional intelligence;
- critical thinking and systematic analysis;
- complex problem-solving;
- analytical thinking and innovation;
- problem-solving and ideation;
- service orientation;

- resilience, stress tolerance, and flexibility;
- leadership and social impact;
- systems analysis and evaluation;
- persuasion and negotiation;
- technology use, monitoring, and control;
- instruction, mentoring, and teaching.

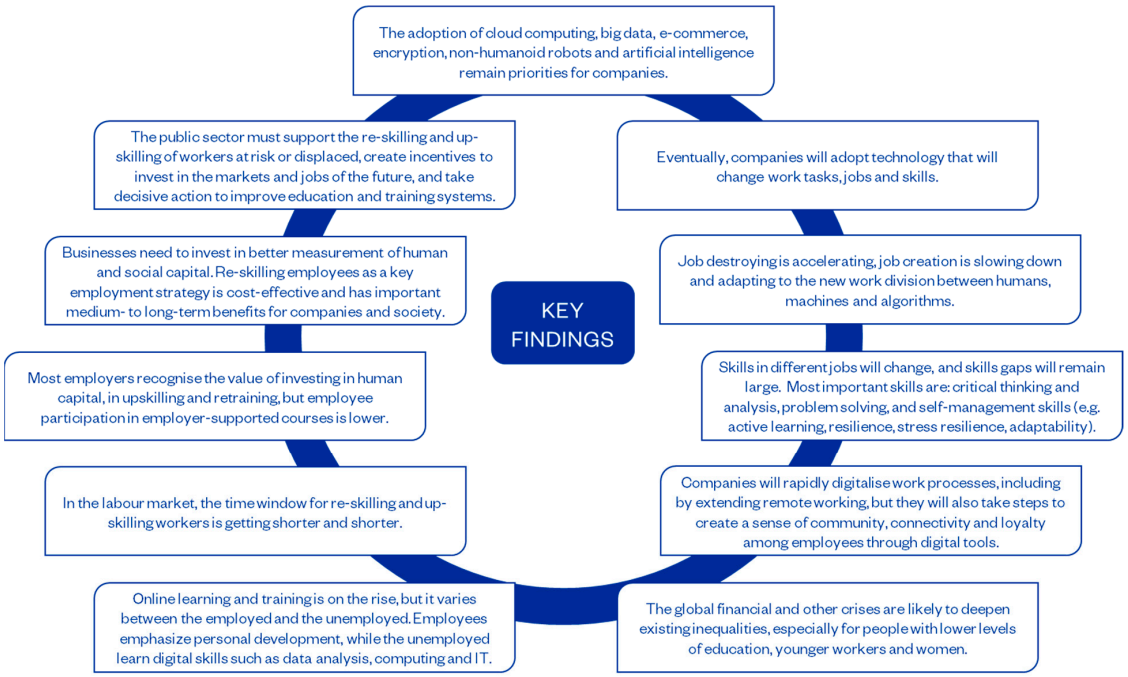

Figure 1. Key findings of the Future of Jobs Report from 2020.

Some digital technologies are expected to be adopted in the education sector in the following years. In Figure 2, we present these emerging technologies on the left-hand side. On the right-hand side, we present the most common barriers which educational institutions face when adopting such new technologies in the education process. The limitations and opportunities for integrating digital technologies into HE teaching and learning are strongly connected to the development of some of the key competencies for the 21st century.

Another WEF initiative, known as Forum's Reskilling Revolution platform (https://www.reskillingrevolution2030.org/, accessed on 5 December 2023), was launched in January 2020 and since then, it has been used by more than 100 million people. The platform prepares the global workforce to acquire the skills needed for their future careers, as technologies such as artificial intelligence enable increasing automation.

2.2.4. UNESCO Recommendations

UNESCO-UNEVOC is an International Centre for Technical and Vocational Education and Training focused on acquiring knowledge and skills for the workplace and supporting equitable and sustainable economic growth by assisting youth and adults in developing the skills necessary for employment, decent work, and entrepreneurship [35].

The demand for transversal skills is increasing as learners need to adapt successfully to changes and lead meaningful and productive lives. As defined in UNESCO-UNEVOC's TVETipedia, transversal skills are typically applicable in a wide range of situations and work settings rather than being specifically tied to a career, task, academic discipline, or area of expertise. They include six domains [36]:

- critical and innovative thinking;

- interpersonal skills (presentation and communication skills, organisational skills, teamwork, etc.);
- intrapersonal skills (self-discipline, enthusiasm, perseverance, self-motivation, etc.);
- global citizenship (tolerance, openness, respect for diversity, intercultural understanding, etc.);
- media and information literacy (the ability to find and access information, as well as to analyse and assess media content);
- others (physical health or religious values, etc.).

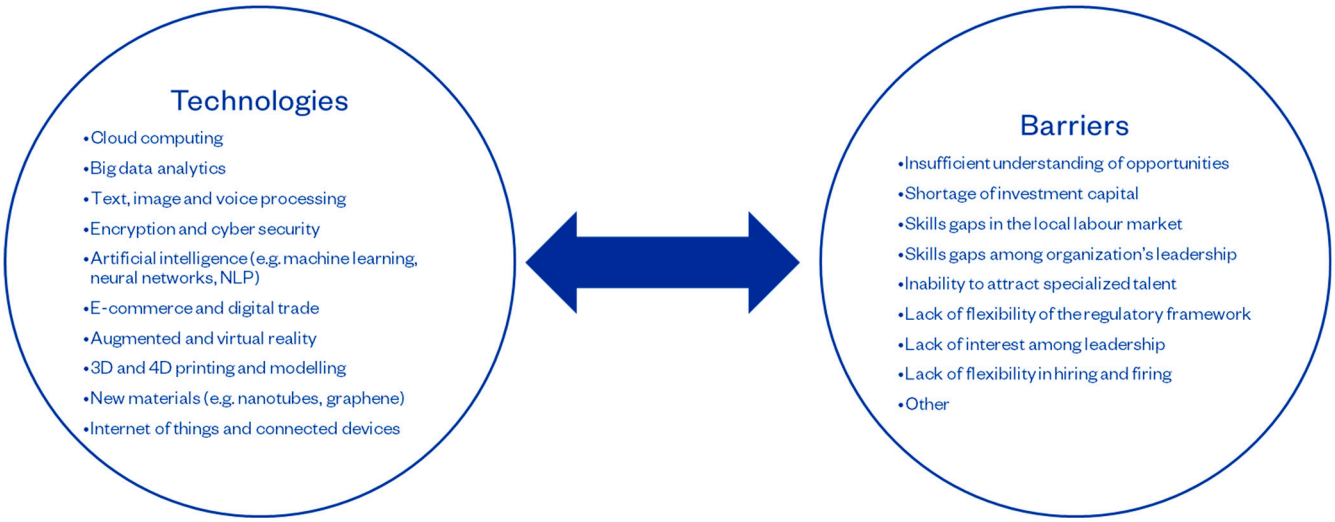

Figure 2. Emerging digital technologies and barriers to adopting them in the HE sector.

2.3. Selection of Companies and Preparation of the Questionnaire for the Study

The RESPO-VI project set out to update the database of key competencies that STEM students need when they enter the labour market and later work in relevant jobs. For this purpose, in addition to a comprehensive analysis of European and international strategies and initiatives, we have sought answers from companies as future employers. Target groups such as SMEs and large companies were involved in a need analysis on 21st-century competencies, for which a specific questionnaire was developed to obtain feedback on the general and specific competencies needed in the labour market in Slovenia and Norway. Their feedback in the form of a list of the top ten competencies was prepared and will be integrated into a RESPO-VI database and web application that will be made available to participating HEIs and students to monitor the competency development of students based on the optimal training offered.

Table 2 summarises the sample of companies on which the study was carried out. We invited Slovenian and Norwegian companies employing graduates of IPS and NTNU in the selected study programmes of Ecotechnology and Civil and Environmental Engineering. Therefore, we collected responses from manufacturing, construction, and ICT companies. As many postgraduate students remain in the academic and scientific spheres after graduation, we also included institutions in educational and scientific-technical activities. The questionnaire was sent to more than 100 organisations' email addresses in Slovenia and Norway. We received 15 completed questionnaires from Slovenian institutions and 13 from Norwegian institutions. Unfortunately, the response from companies to participate in this type of study was not high. There may be several reasons for companies' low level of cooperation in this study. Companies today often experience time and resource constraints and may have found the questionnaire too time-consuming or effort-consuming to participate in. They may not have seen a direct benefit from participating in the study. The project partners could have presented these benefits more clearly and attractively to companies in sending invitations or explained how the results would be exploited. However, some

companies already have a general tendency not to participate in such studies. The low participation rate implies limited representativeness of the validity of the study results, as the survey results may not reflect the full spectrum of labour market needs due to the small proportion of participating companies. As companies from some sectors were more likely to participate, this may have also introduced possible biases and limited the results' overall validity. The low response rate also makes it more difficult to generalise the findings to the whole sector of companies employing STEM students. Still, the obtained feedback was enough for the needs of the project, where we focused on the students of the participating HEIs and the employers where these students can find jobs. It would certainly make sense to repeat the study and involve a larger number of companies from as diverse a range of sectors as possible to improve the representativeness and validity of the results.

Table 2. Distribution of completed questionnaires by country of cooperation.

Country	Number of Sent Invitations	Number of Questionnaires Completed	Percentage of Questionnaires Completed in Relation to Invitations Sent
Slovenia	48	15	31.25%
Norway	58	13	22.41%
All	106	28	26.42%

To include the relevant competencies in the database for the RESPO-VI DSS, we developed a questionnaire for companies, divided into two sections. The first set focused on the general aspect of employment in companies. In contrast, the second set focused on developing expected general and specific 21st-century competencies in employees and job seekers, which include STEM students of both participating HEIs at the end of their education. In the questionnaire, we included competencies that will be required by new jobs in the future, as already identified in the EU strategies and initiatives, such as creativity, innovation, empathy, critical thinking, problem-solving, self-management, and information technology. We also focused on social and civic competencies, self-initiative and entrepreneurship, learning to learn, artificial intelligence, digital literacy, etc. Most of these competencies are also highlighted in the programme of the RESPO-VI funder, i.e., Norway Grants. In identifying these 30 competencies, we considered various aspects of companies' expectations. One key aspect is whether companies can access training that helps employees develop the competencies needed for their jobs. The changing nature of jobs requires continuous adaptation and upgrading of employees' competencies, so companies often look for different sources of training, such as in-house programmes, external providers, or cooperation with educational institutions. It is also important to understand how companies identify competency gaps in employees with different levels of education. In this study, we focused on jobs that require higher education, e.g., bachelor's degree, master's degree, or doctoral degree. This paper refers to the second part of the questionnaire. In this respect, we asked employers why they decided to employ recent graduates (graduates, postgraduates, doctoral students). Furthermore, several factors influence employers and employees to take intelligent risks in their recruitment and career progression. Accordingly, we wanted to find out from companies how different causes and risks may affect their future recruitment of STEM students.

The questionnaires for Slovenian respondents were prepared in an online version. For the Norwegian companies, the Slovenian printed version of the questionnaire was translated into Norwegian, and the content was minimally adapted to the Norwegian employer market. Invitations to participate in the survey were sent to a mailing list generated by all project partners. Participation in the survey was entirely voluntary, and complete anonymity was guaranteed. The collected data were processed and presented at the common RESPO-VI project level, without the possibility of identifying individual respondents and companies. All data collected (responses) were recorded exclusively in the RESPO-VI

database. Respondents were given up to 10 min to complete the questionnaire. During the completion, they could save the questionnaire for later completion. The questions in the first set addressed the following:

- the field of activity of the participating organisation;
- the current employment situation in the company;
- the experience and skills of the staff responsible for career development and recruitment in the organisation;
- reasons for difficulties in filling vacancies;
- the reasons for recruiting recent graduates (graduates, postgraduates, doctoral students).

The second set of questions concerned companies' expectations in regard to developing 21st-century competencies in the labour market. Companies were asked to indicate the relevance of each competency for their company and employees. A list of the competencies that we included in the questionnaire is given in Figure 3. The questions also asked about the following:

- accessibility of the company to additional training for employees;
- the causes and risks that may affect future employment in the company;
- general views on providing the right skills and competencies in the company's workforce now and in the future.

(1-not important, 2-less important, 3-neither important nor unimportant, 4-more important, 5-very important)

Competence		1	2	3	4	5
1	Creative problem solving					
2	Critical thinking					
3	Systems and analytical thinking					
4	Creativity					
5	Innovation					
6	Collaboration and networking (with colleagues, clients)					
7	Managing and planning processes, technologies and people work					
8	Reliability and accuracy					
9	Basic technical skills					
10	Engineering design					
11	Advanced computer/IT skills (e.g. artificial intelligence)					
12	Information management and processing (data interpretation and analysis)					
13	Manipulative skills (correct and safe use of devices and substances)					
14	Experimentation and testing					
15	Intercultural communication					
16	Media literacy					
17	Adapting to change					
18	Ability to cope with uncertainty					
19	Environmental justice					
20	Social responsibility and inclusion					
21	Written and oral communication skills in a foreign language					
22	Application of STEM (science, technology, engineering, mathematics) skills in a professional environment					
23	Written and oral communication skills					
24	Business and entrepreneurial skills					
25	Versatility (capacity to fill absences)					
26	Willingness to work excessively (overtime, time off work)					
27	Self-initiative and self-management					
28	Empathy					
29	Learning to learn (ability to learn and persist in learning, organise own learning)					
30	Ensuring safety (data privacy, public health, environmental protection, working safely with devices)					

Figure 3. Competencies that the companies in the analysis have identified as being required. The competencies relate to the company's employees and are relevant for jobs that require higher education (university degrees, master's degrees, doctoral degrees).

3. Selection of Key 21st-Century Competencies for STEM Students

3.1. Different but Similar Conceptions and Taxonomy of Key Competencies for Students

The European Council has repeatedly underlined the key role of education and training for the future economic growth, long-term competitiveness, and social cohesion of the EU. This can be achieved by strengthening the knowledge triangle "research-innovation-education" elements already in schools and HEIs [37]. To further improve the role of education and training in shaping the future of the EU, we could further increase investment in early childhood education programmes, build closer links between educational institutions and businesses, and promote innovative approaches to teaching that better reflect the needs of a rapidly changing labour market.

The competencies and learning habits that young people acquire in school during their education are essential for developing new skills throughout their lives, including for the STEM jobs of the future. The EU has identified the main challenges facing education systems, which can best be improved by working together in three areas [17]:

- a focus on competencies;
- high-quality learning for every learner;
- teachers and school staff.

There is a growing awareness that current HE environments will need to be modernised to make them more flexible and adaptable to individual needs. Such learning environments can encourage learners to develop different competencies according to their preferences, needs, and abilities while maintaining sufficient knowledge to enable personal progress. Such approaches include integrating new pedagogical methods, cross-curricular integration and complementarity, and greater participation of learners in curriculum design. Literacy and numeracy are key competencies for further learning and career progression. Moreover, STEM competencies are also recognised as a key to full participation in the labour market. They also assist in integrating into the knowledge society and the competitive modern economies.

Employers verify STEM job applicants for different soft skills. In particular, they need to be able to work collaboratively, and communicate and solve problems—skills that are developed primarily through social and emotional learning. Soft skills combined with professional skills will enable STEM students to achieve success and life satisfaction in a shorter time, which is increasingly challenging in a rapidly developing digital economy and fast-changing, technology-driven society. The WEF has grouped the following 21st-century skills for learners into three categories:

- foundational literacies: literacy, numeracy, scientific literacy, ICT literacy, financial literacy, cultural, and civic literacy;
- competencies: critical thinking and problem-solving, creativity, communication, collaboration;
- character traits: social and cultural awareness, curiosity, initiative, perseverance, participation, decisiveness, commitment, adaptability, and leadership.

The Global Skills Taxonomy can also forecast emerging and needed skills for STEM students at global, national, and sectoral levels. The taxonomy can be used to understand how the skills needed change in individual workplaces. It can be used to guide employers' decisions on retraining, upskilling, and reallocating skills among employees. Moreover, according to WEF reports [12], we can see how the list of the ten most important job skills has changed over the last ten years and the expectations for the next decade (Figure 4). The list suggests that future workers and job seekers will need to develop more analytical, critical, systematic, innovative, and creative skills. They will need to become active lifelong learners who can handle stress and be ready to adapt to rapid changes. For job seekers, this means constantly upgrading their skills and adapting to the dynamic demands of the labour market. The working conditions for such development will need to be designed with employers, promoting the development of competencies and enabling sustainable success in a rapidly changing economic environment.

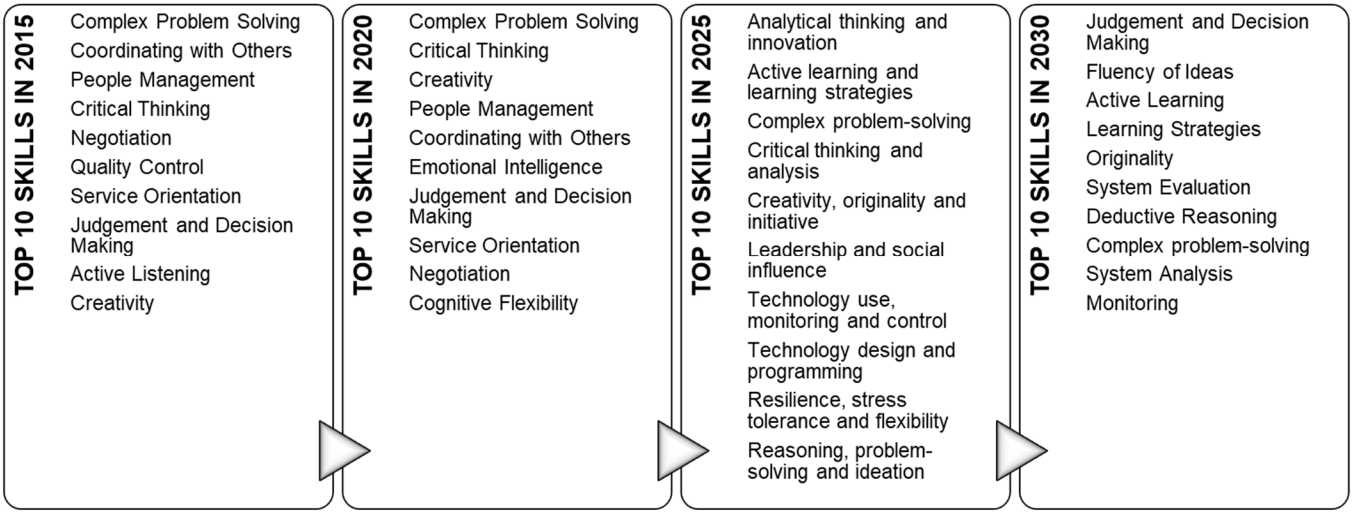

Figure 4. Changing the top ten skills between 2015 and 2030, according to the WEF reports.

3.2. 21st-Century STEM Competencies

The current era is characterised by a growing need for a new skill set, often called generic or 21st-century skills. These also include STEM skills, which remain challenging for science, technology, engineering, and mathematics undergraduates, as STEM graduates are sometimes underprepared for what today's professions require. Students' academic achievement level rarely matches their relevant levels of 21st-century skills and the demands of employers. Several studies and research set the framework for STEM competencies in the 21st century [38–42]. Many of them also address teaching and learning methods that will need to be transformed in the future to achieve a level of STEM competencies in students that will meet the competency demands of employers and workplaces of the future.

Additionally, the United Nations' 2030 Agenda for Sustainable Development, entitled "Transforming our World", established 17 Sustainable Development Goals (SDGs) to tackle global issues such as poverty, climate change, food shortage, and the protection of the planet and to ensure that all enjoy peace, prosperity, and a good quality of life [43]. STEM education plays a crucial role in achieving these goals. Lavi et al. [44] applied the following competency framework for STEM students for their analysis:

- domain-general skills: complex problem-solving, critical thinking, individual learning, and question-posing;
- soft skills: creativity, entrepreneurship, collaboration, oral communication, and written communication;
- STEM-specific skills: engineering design, experimenting and testing, STEM knowledge application, and systems thinking.

Different interpretations of STEM in practice arise depending on the perspective from which the field is approached in the education system. Generally, STEM competencies include both 'know-what' (knowledge, attitudes, and values related to the discipline') and 'know-how' (the skills to apply this knowledge, taking into account ethical attitudes and values, to act appropriately and effectively in a given context) [45]. Furthermore, epistemological, procedural, and technical knowledge are key components of STEM knowledge related to the individual STEM disciplines. Still, they also illustrate how ideas, concepts, principles, and theories overlap and interrelate. Procedural knowledge provides the basis for acquiring, applying, and practising STEM skills such as measuring data, determining its accuracy, validity and reliability, and selecting and displaying it. Technical knowledge, on the other hand, is related to the effective application of knowledge, skills, attitudes, and values in a specific field or profession, such as construction [45]. The UNESCO framework for STEM competencies is presented in Figure 5.

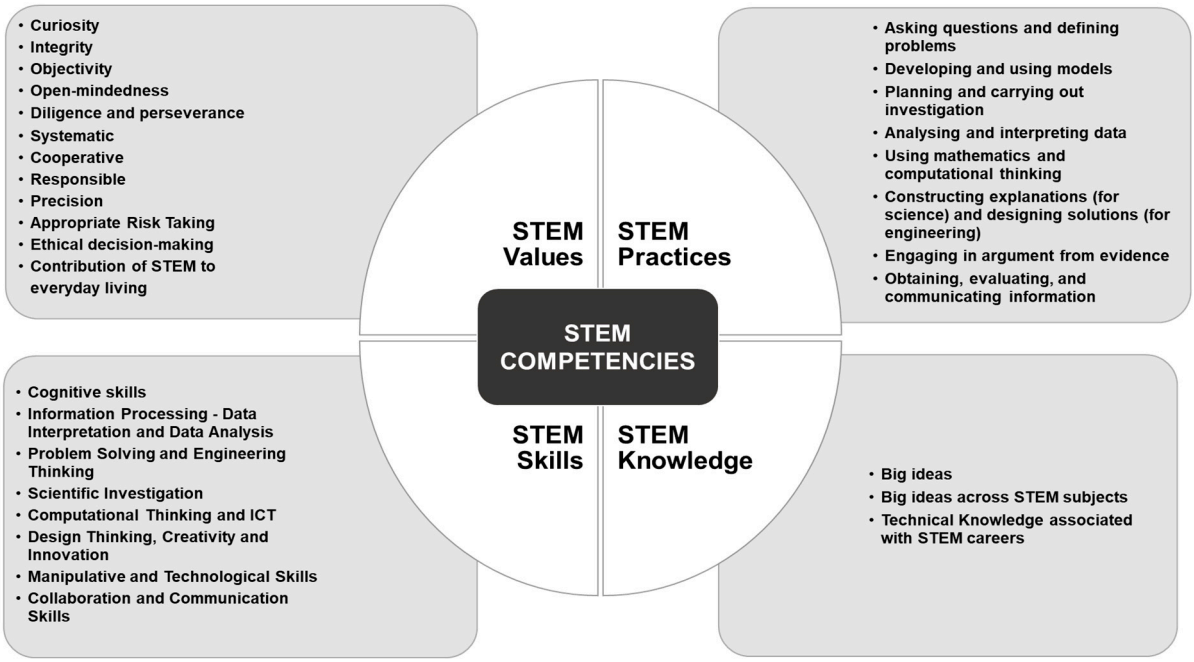

Figure 5. UNESCO framework for STEM competencies.

The EU STEM Coalition (https://www.stemcoalition.eu/, accessed on 3 December 2023) is a pan-European network to improve European STEM (science, technology, engineering, mathematics) education. They aim to shape STEM education policies and practices promoting economic growth, opportunity, and prosperity. They provide a unique forum and knowledge hub for data and analysis, exchange of best practices and direct support, from reducing the skills shortage in STEM to fostering new ways of collaboration between educational institutions, businesses, and governments. They stress that we need to ensure that STEM subjects in higher education provide students with a wide range of competencies, including important cross-cutting skills such as creativity, flexibility, and an entrepreneurial mindset.

The ATS STEM Conceptual Framework [46] determined a comprehensive taxonomy of essential STEM competencies. It provides a systematic approach to understanding and assessing the multidimensional domain of STEM skills and contributes to a more accurate understanding of the complex interaction of different STEM competencies. This taxonomy encompasses eight core categories into which the 243 specific STEM skills were grouped, derived from an exhaustive literature analysis. The identified core competencies are as follows:

- problem-solving;
- innovation and creativity;
- communication;
- critical thinking;
- meta-cognitive skills;
- collaboration;
- self-regulation;
- disciplinary competencies.

3.3. Companies' Expectations of the Development of 21st-Century Competencies for STEM Students in Slovenia and Norway

The future workforce will need a wide range of 21st-century competencies to adapt effectively to a rapidly changing business environment and technological advances. Training and developing the workforce's competencies is crucial to the success and competitiveness of businesses in the modern economy. In this context, it is important to understand whether

companies can access the right kind of training to help employees develop their competencies in different areas. Our study found that more than 90% of Slovenian companies have access to training that enables employees to adapt to digital working. They also have good access to training for managing work processes, technologies, and employees. As seen from the graph in Figure 6, they have less access to training for career management. The situation is slightly better for Norwegian companies. In management skills, companies can use advanced digital, such as RESPO DSS, which allow human resource managers (HRMs) to monitor the career development of their employees. This is particularly important in assessing the skills needed to perform well and successfully in the jobs that they have been assigned or to which they can be promoted.

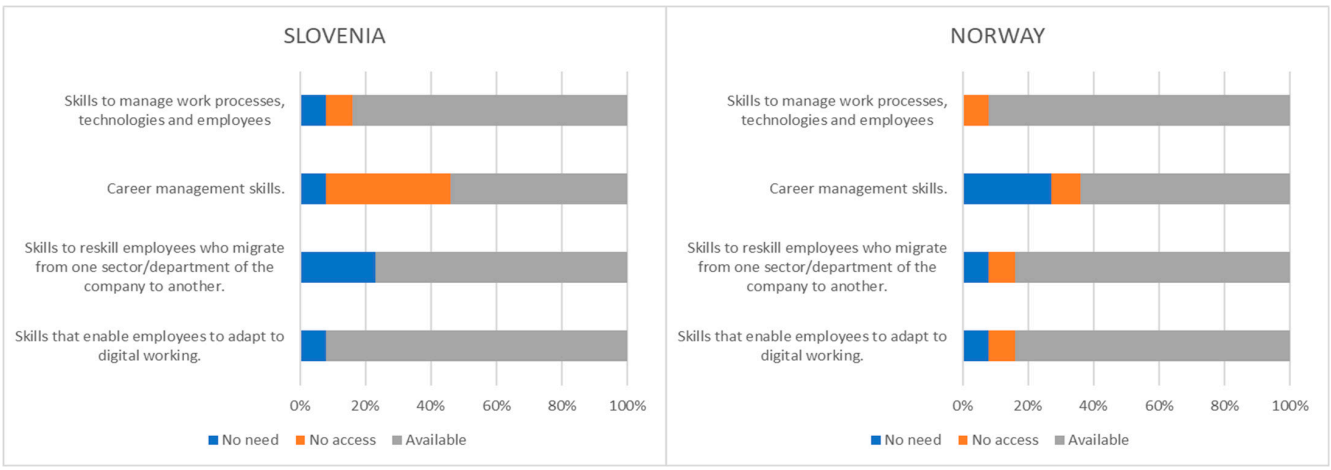

Figure 6. Access to training for Slovenian and Norwegian companies in developing workforce competencies.

Furthermore, we have identified the importance of competencies for employees in those positions in the company that require a higher level of education. HRMs in the selected companies assessed a list of 30 competencies on a scale of 1 to 5, where a value of 5 means that they strongly agree that the competency is important for job seekers for future employment, and a value of 1 means that they strongly disagree. This analysis shows differences between Slovenian and Norwegian companies regarding the importance of competencies for employees. We have made a comparative analysis of the importance of competencies for companies in both countries and found that four competencies, namely (i) managing and designing processes, technologies, and people's work, (ii) adapting to changes, (iii) ability to manage uncertainty, and (iv) innovation, are important for participating companies, while for the remaining competencies, companies gave different levels of importance. Figure 7 shows an evaluation of 30 competencies by HMRs of Slovenian and Norwegian companies for the RESPO-VI project.

Our study aimed to explore the drivers behind companies' decisions to employ young professionals who have recently graduated. Employing recent graduates, masters, or doctoral candidates is common among companies looking for fresh talent and innovative ideas. Slovenian companies still favour personal skills over professional skills when recruiting young people who have just graduated. They believe that young people are more adaptable, motivated, and success-oriented, which is necessary to create a successful career and favourable living conditions later in life. The survey results for Norwegian companies in Figure 8 show that companies recognise the many advantages of employing recent graduates. Fresh graduates, masters, and doctoral students bring new skills, fresh perspectives, and innovation to the workplace. Their motivation and high progress orientation are also important factors that companies value. The adaptability of recently graduated individuals is important in a rapidly changing business environment. However, there are also some challenges in recruiting recent graduates. Despite their high motivation, they may lack

practical experience, which they gain over time. Companies must be willing to invest time and effort in training and mentoring them to develop their skills and become effective members of the organisation.

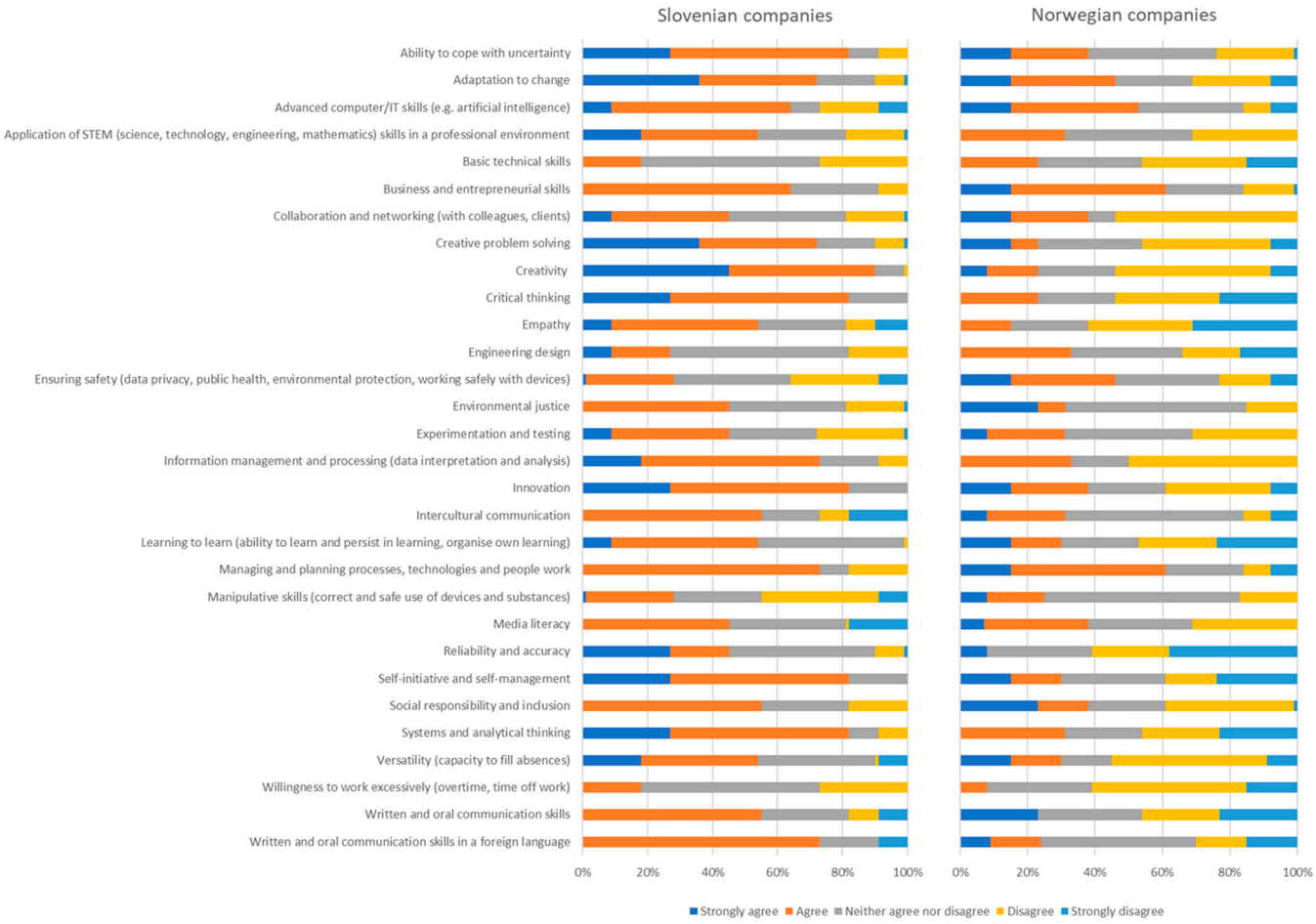

Figure 7. Evaluation of selected competencies by Slovenian and Norwegian companies for the RESPO-VI project.

The last part of the analysis shows that Slovenian companies are still not the most favourable for remote and virtual working for all employees whose workplace allows it. The digitalisation deficit is also evident in the reluctance to use workforce analytics and databases to predict and monitor employee skill gaps. The same is valid for automation and technology's replacement of human labour. Still, there is an awareness that automation and artificial intelligence will influence future needs for developing new skills in the workforce. Companies do not significantly consider the local availability of skills when developing their business and recruitment strategy. Still, they are aware that environmental issues, often linked to the local environment, significantly impact the company's business management planning. Moreover, they are not convinced that working with policymakers can help them address the skill gaps in the workforce in the sector in which they operate. More than policymakers, they value cooperation with educational institutions, which can also provide employees with training opportunities for retraining and lifelong learning.

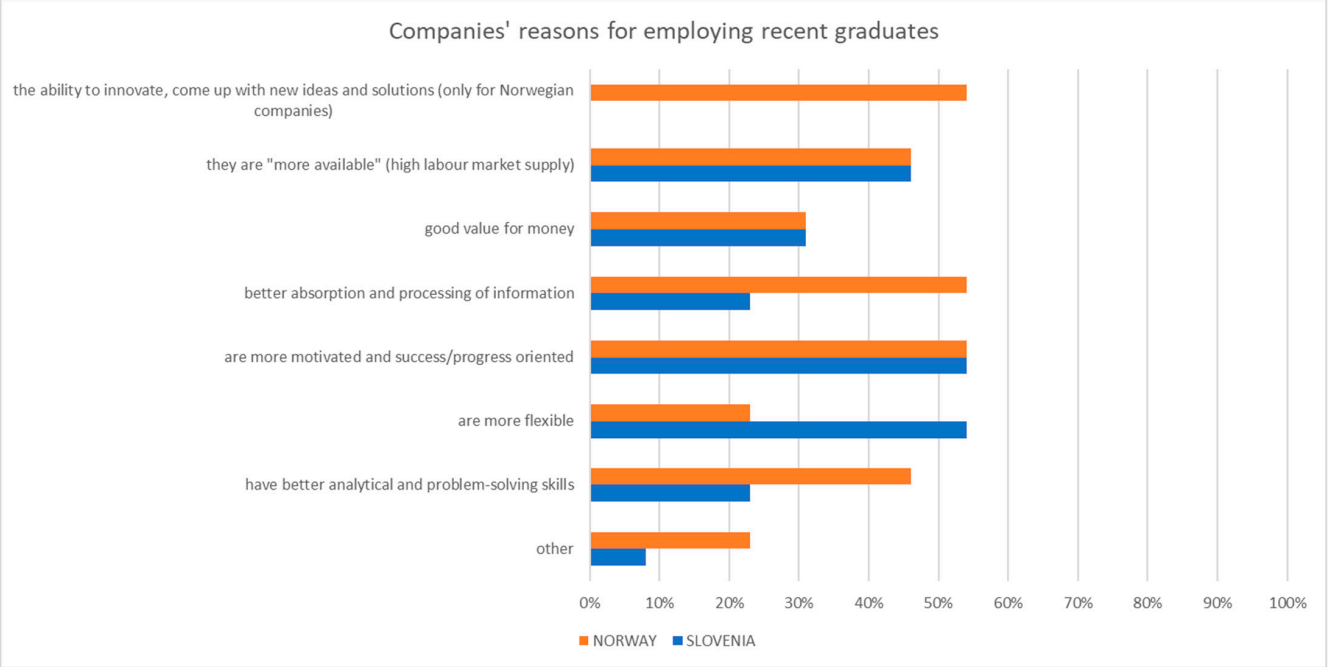

Figure 8. Reasons for Slovenian and Norwegian companies to employ recent graduates.

3.4. Developing a Framework of 21st-Century Competencies for STEM Students in Selected Study Programmes

Based on the comparative analysis of the questionnaires, we selected, among all 30 competencies listed in Figure 7, a shortlist of competencies that companies identified as more or very important and related to EU and global skills development initiatives. The designed framework includes general and specific competencies that employers perceive as the most important and that the industry needs now and in the future. In addition to the ten competencies in the framework, the list also includes a core bridging competency for STEM students, i.e., application of STEM (science, technology, engineering, mathematics) knowledge in a professional environment.

When designing the competency framework for STEM students, we first selected the top competencies for each country. For Slovenia, we selected the most important competencies where the sum of "strongly agree" and "agree" responses was greater than 70%. For Norway, we selected the most important competencies where the sum of these two responses was greater than 35%. Among the competencies we identified as cross-sectional and relevant to companies, only four appeared in the lists for both countries. These competencies are listed in positions 1 to 4 and circled by a red ellipse in Figure 9. The following six competencies on the list were selected according to the three most important per country, considering the EU and other recommendations related to skills development. In Figure 9, six competencies for Slovenia are marked with a blue circle in front of the competency name, while seven competencies for Norway are marked with an orange circle on the x-axis of the chart. Thus, the framework of employability competencies for STEM students includes the following ten competencies:

1. Managing and designing processes, technologies, and people's work;
2. Adapting to changes;
3. Ability to manage uncertainty;
4. Innovation;
5. Systemic, analytical, and critical thinking;
6. Creativity;
7. Self-initiative and self-management;
8. Business and entrepreneurial skills;
9. Advanced computer/IT skills (e.g., artificial intelligence);

10. Ensuring safety (data privacy, human health, environmental protection, working safely with devices).

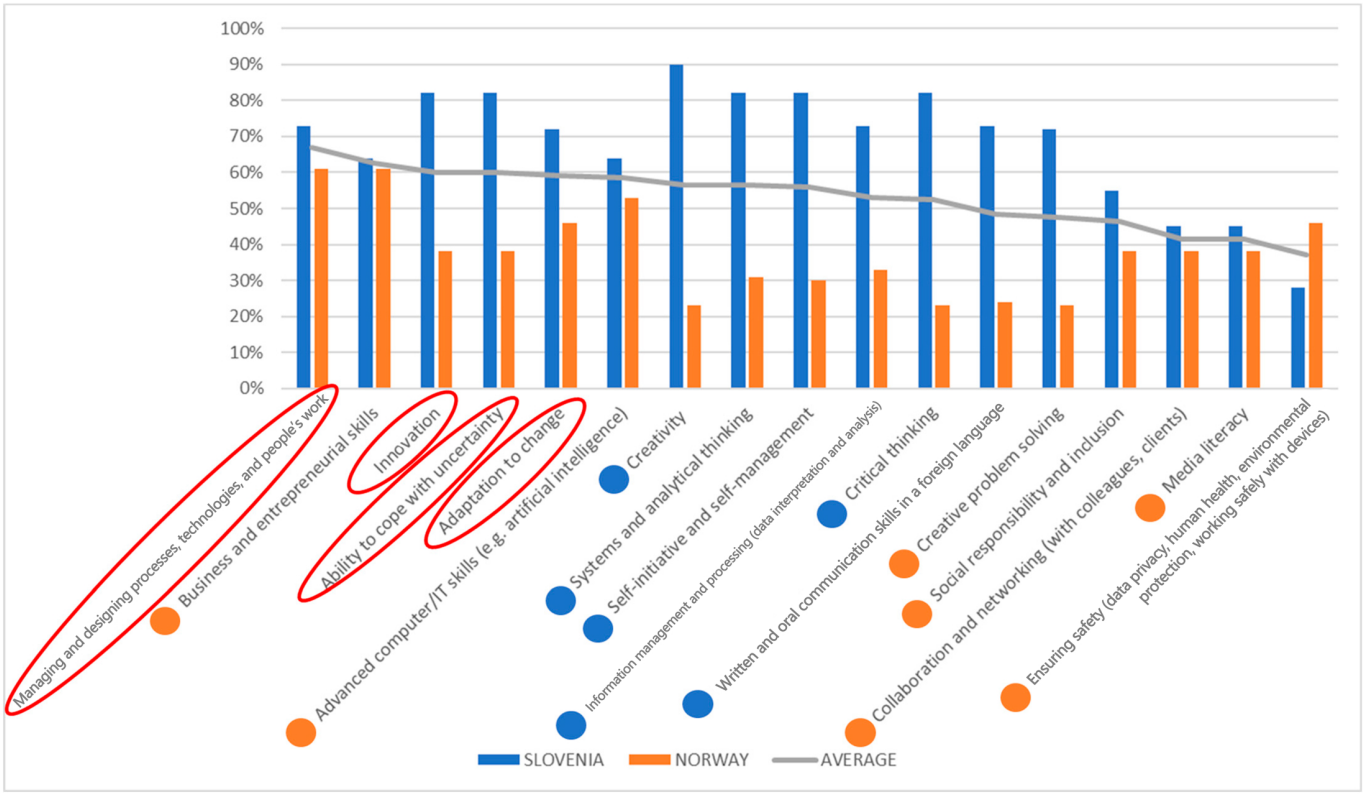

Figure 9. The four cross-sectional competencies selected by Norwegian and Slovenian companies (circled in red), and a selection of the other most important competencies by country (Norwegian choice marked with an orange circle, Slovenian choice marked with a blue circle).

3.5. Comparison of the Developed Competency Framework for STEM Students with Existing STEM Competency Frameworks

We compared the key similarities and differences between our competency's framework for STEM students with other STEM skill frameworks, i.e., the ATS STEM conceptual framework, UNESCO framework, and WEF 2030 competencies. First, we compared our list of competencies with the ATS STEM Conceptual Framework, which identified the core STEM competencies. We noticed some common points but also some differences. Some competencies overlap, while others differ probably due to different emphases and perspectives. The common competencies that both frameworks recognise as important in STEM fields are problem-solving, innovation and creativity, and critical thinking. The ATS STEM Conceptual Framework includes specific professional competencies related to disciplinary knowledge, while our list focuses on general competencies that can be applied to different disciplines. It should also be noted that our list includes the STEM competency as a core umbrella competency that links all ten competencies. Whereas the ATS STEM Conceptual Framework includes metacognitive skills, our list focuses more on self-initiative and self-management. Moreover, cooperation is mentioned explicitly in the ATS STEM Conceptual Framework. Still, our list emphasises it more indirectly under competencies such as the ability to manage processes, technologies, and people's work.

4. Limitations of the Study and Future Work

When interpreting the results of this study, including the selected top 10 competencies, it should be noted that these are subjective opinions of the respondents, i.e., HRMs in selected Slovenian and Norwegian companies. Organisations and companies should

consider these different views and consider how they can develop and strengthen important competencies for workplace success. Depending on the respondents in the study, the important skills related to the employability of STEM students vary. This makes it difficult, if not impossible, to create specific recommendations suitable for all industry sectors and all STEM study programmes. In addition, conducting further research on a larger sample size of companies from different sectors would be helpful to gain additional insights into the relevance and development of competencies in employees in different workplaces. It is also important to consider other factors, such as various education systems in different countries as well as the training and experience of employees, which may influence the development of these competencies. Other research methods, such as interviews or observation of employees' work, would be helpful to obtain a better picture.

As the results of the study show, there is a wide variation between countries, i.e., Norway and Slovenia, in assessing the importance of individual competencies. The significant difference in the sum of the percentages of "strongly agree" and "agree" responses for each competency may be due to different expectations and values about what are considered important competencies in each country. Culture, the education system, and social norms can influence which competencies are valued and supported in a given society. The need for certain competencies may also depend on the economic situation in a country. Different economic orientations and structures may influence which competencies are more emphasised. Differences may also arise from different education systems. Variations in curricula, teaching approaches, and learning methods can lead to different perceptions of the importance of certain competencies. Percentages may also vary according to each country's important industries and sectors. If one sector is more prominent in one country, competencies related to that sector may be more prominent. Finally, demographic characteristics such as the age, education, and experience of respondents from both countries may also influence the differences in responses.

By comparing our proposed framework for 21st-century STEM student competencies with other STEM competency frameworks, we can see that various competency frameworks focus on different aspects and areas. Understanding these similarities and differences between various competency frameworks is an excellent basis for designing and adapting STEM education programmes and guiding the development of students' skills and knowledge. However, it should be realised that the different competency frameworks constantly evolve to reflect the current needs of society and the economy. Knowledge of these frameworks allows us to monitor trends in competence development and to be prepared for future changes in job-seeking and education.

The designed framework of competencies for STEM students will be integrated into a database of RESPO DSS that will be accessible to the users of the RESPO-VI online application. We will develop and implement interactive training for STEM students from Norway and Slovenia based on the selected competencies. The developed RESPO-VI application will be used during the training to monitor the development of these competencies. The experience gained during the training and validation of the RESPO-VI application will further enhance the level of 21st-century skills acquired by STEM students. At the same time, it will provide formal education and non-formal training providers with the insight that digital solutions can contribute to closing the skill gap between the competencies that students have at the end of their education and those that employers expect from employees.

5. Recommendations for Implementing the Developed Competency Framework in STEM Study Programmes

In addition to the ten competencies in the framework, the list also includes a core bridging competency for STEM students, i.e., applying STEM knowledge (science, technology, engineering, mathematics) in a professional environment. The focus on these competencies reflects the need for a broader range of skills beyond the purely technical knowledge that can be acquired in various educational STEM degree programmes. STEM

students can take courses outside their core study programme that cover different areas of knowledge, including project management, entrepreneurship, and communication skills. They can work with their supervisors and professors on projects and research, allowing them to gain hands-on experience and develop problem-solving skills. Erasmus+ also provides students with many opportunities to participate in international exchanges, gain experience with different cultures, and develop intercultural skills. They can develop leadership, communication, and team-building skills by joining different associations and organisations. HEIs can organise additional training and workshops or send them to companies for internships. Students should also be aware of developing self-learning and self-evaluation skills, which is the key to adapting quickly to new challenges in the labour market and becoming competent individuals who are of interest to employers. For STEM students, specialised knowledge in a specific field and developed soft skills are the keys to success in the future dynamic and demanding world of work.

6. Conclusions

The EU, OECD, WEF, and UNESCO policies and guidelines emphasise that skills are crucial for individual career progression and life satisfaction, as well as for sustainable economic competitiveness, resilience, and social inclusion. This is also the guiding principle of the European Skills Agenda, which focuses on strengthening investment in lifelong learning for people in the EU so that we can recover as quickly as possible from the COVID-19 pandemic and other crises around the world and be ready to face the biggest challenges of the digitalisation era and the sustainable economy. Adaptations to these changes are already underway or being accelerated in many areas. Lower-educated and highly educated people will need to acquire new skills or improve their existing ones to better adapt to the rapid technological, economic, and social changes ahead. Rapid adaptation and high competitiveness are the keys to their success and satisfaction in the future labour market. This is where HEIs play an important role in equipping HE students with the right competencies that are not covered by the curriculum but can be acquired through non-formal training. To identify the gaps in the skills that individuals acquire during their formal education and those required by employers, HEIs or employers can use a variety of digital tools based on decision-support systems and advanced artificial intelligence algorithms. These tools can identify skill gaps early and offer the most optimal solutions to bridge them already during education. One such solution will also be offered to students during the RESPO-VI project. The developing tool will enable HEIs and companies to understand the needs of students better and provide them with a personalised learning experience. At the same time, it will allow students and supervisors to track their progress accurately and identify areas for further skills development.

Nevertheless, the results of this study provide a starting point to understand further the competence development needs of the company's employees and the prospective needs of the labour market in Slovenia and Norway. However, the comparative analysis of the competencies highlighted in the different strategies and guidelines (EU, OECD, WEF, UNESCO) with those identified as important by the companies in the questionnaires led to the selection of key competencies related to the selected STEM degree programmes of the participating HEIs, namely IPS and NTNU. To summarise, after graduating from a STEM degree programme, companies expect a person who combines technical knowledge with the ability to be creative and think innovatively. The expected profile includes the ability to solve complex challenges, perform effective process management and successful technology and people management, have an appreciation for flexibility, carry out analytical and critical thinking and skilful handling of uncertainty, and possess entrepreneurial and business management skills. Organisations are looking for individuals who are able to navigate a rapidly changing work environment, apply their expertise to innovation, and drive the company's overall success. While it may be unattainable to cultivate all of these competencies within a single degree programme, acquiring this comprehensive range of knowledge and skills through a blend of educational experiences is possible. Students

focusing primarily on one particular STEM area can expand their skills through additional activities and learning opportunities. These may include online tools that provide access to various resources, learning platforms, and opportunities for self-directed learning.

Nevertheless, the results of this study provide a starting point to understand better the skills development needs of the company's employees and the likely needs of the labour market in Slovenia and Norway. The RESPO application will help trainees to develop further and monitor their competencies. This way, the application will help close the skill and education gaps exacerbated by technological advances, the COVID-19 pandemic, and the coming green and digital transitions. Investment in similar DSSs for higher education teaching and learning programmes as well as human capital management is needed to reskill and upskill people globally to avoid future skill gaps. The next decade is expected to play a key role in determining the future forms of work and education in the 21st century, where various digital tools will also play a crucial role.

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Data Availability Statement: All presented data are available at IPS, which has the coordinator role in the RESPO-VI project. Participation in the company survey was completely voluntary with complete anonymity guaranteed. The data collected were processed and presented at the aggregated RESPO-VI project level, without the possibility of identifying individual respondents and companies. All data collected (responses) are recorded exclusively in the RESPO-VI database.

Conflicts of Interest: Authors Bojan Cestnik and Aram Karalič were employed by the company Temida d.o.o. The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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