Cultivating the next generation of green and digital innovators – the role of higher education

This is the third in a series of four analytical reports prepared by the OECD Higher Education Policy Team on developing competencies in support of innovation for the digital and green transitions. These reports facilitate knowledge exchange within the **Education and Innovation Practice Community (EIPC)**. The EIPC is an action of the European Commission (DG EAC), implemented in collaboration with the OECD under the New European Innovation Agenda, Flagship 4 "Fostering, attracting and retaining deep-tech talent".

This analytical report provides analysis and case studies related to Strand 2 of the EIPC project, which focuses on how traditional higher education degree programmes can best develop competencies important for green and digital innovation. Four key areas of action are discussed:

1. **Tracking and assessing competencies**: enhancing the capacity of higher education systems to track demand for and supply of competencies that support innovation, through improving anticipation and assessment methods.
2. **Curriculum development**: updating educational programmes and curricula to ensure they target the necessary knowledge and skills for green and digital innovation, encompassing relevant transversal and discipline-specific competencies.
3. **Student engagement:** increasing interest and motivation to develop competencies that contribute to innovation, which may involve improving incentives and greater attention to designing engaging learning experiences.
4. **Private sector partnerships**: strengthening partnerships with innovative businesses and industries to align higher education provision with their human capital needs.

For more information, contact the OECD Higher Education Policy Team (HigherEducation@oecd.org) or the European Commission (EAC-UNITE-C1@ec.europa.eu), and click here to join the EIPC network.

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Higher education's role in building human capital for green and digital innovation

A range of competencies are needed to support the green and digital transitions

The green and digital transitions will require unprecedented levels of innovation – new technologies, processes and practices that facilitate a quicker progression to net-zero economies, characterised by sustainable use of natural and man-made resources. Achieving this "green and digital innovation" will require education systems to equip more people with advanced levels of knowledge and skills and to nurture awareness, enthusiasm and a sense of responsibility among learners to drive positive change (OECD, 2023[1]; Van Reenen, 2021[2]). Innovation can be radical, creating new markets and transforming society, or incremental, gradually enhancing existing products and processes (Acemoglu, Akcigit and Celik, 2022[3]). It is a multifaceted process that likely depends on a diverse set of approaches and actions, depending on whether the focus is on development or disruption (Wu, Wang and Evans, 2019[4]).

Much remains unknown about the links between individuals' specific competencies and innovation outcomes, although it is clear that advanced disciplinary knowledge and transversal skills are important contributors (European Commission, 2020[5]; Biasi, Deming and Moser, 2021[6]). It is equally evident that there is a critical shortage of workers with the expertise and skills essential for making progress on the green and digital transitions (European Commission, 2023[7]), while some studies indicate that the rate of innovation in OECD economies has slowed despite surging investment in research and development (Jones, 2009[8]; OECD, 2023[1]).

Many technical competencies are considered to support successful innovation, including advanced analytical skills and up-to-date scientific knowledge (Biasi and Ma, 2022[9]; Borrás and Edquist, 2015[10]). Moreover, "evergreen" abilities, such as critical thinking, communication, social and emotional skills – generally when combined with relevant disciplinary knowledge – retain an enduring relevance in innovative industries (Deming, 2017[11]). The presence of these "softer" skills are thought to positively influence the way knowledge is absorbed, translated and creatively applied to develop new approaches to solving problems (Borrás and Edquist, 2015[10]).

Higher education attainment is associated with more advanced knowledge and skills and better social outcomes

Higher education remains a core supplier of advanced knowledge and skills to economies and societies, despite recent expansion of alternative providers and credentials (Kato, Galán-Muros and Weko, 2020[12]). Higher education institutions (HEIs) have always been at the forefront of developing and delivering advanced academic knowledge in all fields of study (Godin and Gingras, 2000[13]). In recent decades, HEIs have begun to shift focus towards developing skills of learners, including practical discipline-specific skills valued in a variety of economic and social settings. This shift occurred amid increasing policy interest in defining the learning outcomes and professional competencies students should attain from their academic programmes, as well as the emergence of more professionally-oriented HEIs such as universities of applied sciences, technical universities or polytechnics (OECD, 2012[14]).

Employers are also increasingly focused on skills rather than qualifications in their hiring processes, including in emerging or expanding green and technological industries where qualified experts are in short supply (Gonzales Ehlinger and Stephany, 2023[15]). Some employers have eliminated degrees as entry requirements for certain jobs, although some evidence suggests the share of recruitments affected by this trend – and hires to graduate jobs who lack a degree - may be limited to date (Lewis/LinkedIn, 2023[16]).

The OECD's Programme for the International Assessment of Adult Skills (PIAAC) shows a consistently positive relationship between educational attainment of adults, their levels of basic cognitive skills (literacy and numeracy), and their abilities to solve problems in technology-rich environments (OECD, 2019[17]). PIAAC data also show substantial variation across countries in skill levels of adults with tertiary education,

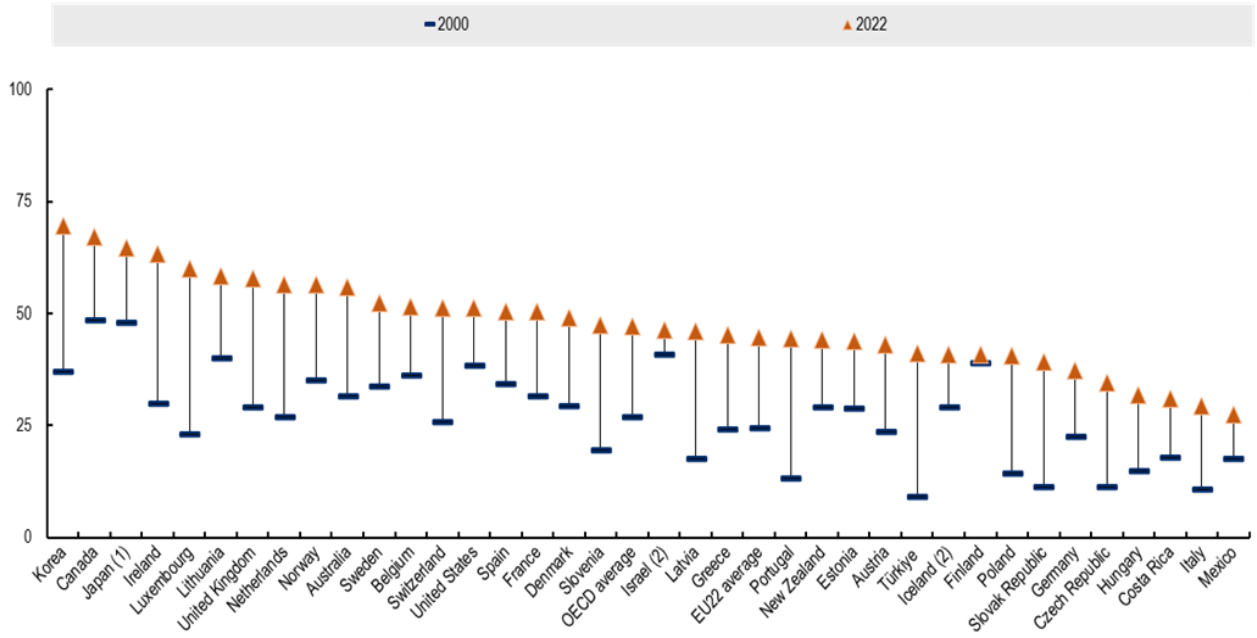
suggesting that equivalent levels of educational attainment across countries do not signal equivalent levels of skills in graduates. Nevertheless, even after adjusting for age, gender, immigrant and language background and parental educational attainment, a positive relationship between educational attainment and skills acquisition persists (OECD, 2019[17]). This positive relationship is observed across all participating countries, although the direction of causality cannot be fully determined[1].

Higher education attainment is also associated with more positive social outcomes. For example, on average across OECD countries with available data, tertiary educated people are more likely to make beneficial use of technology and get involved in civic activities, and less likely to believe in conspiracy theories (OECD, 2022[18]; OECD, 2023[19]).

Given substantial evidence indicating the beneficial outcomes of higher education, governments have targeted raising educational attainment as a means to boost population skill levels and achieve economic growth and societal progress. These efforts have shown significant success – on average higher education attainment of young adults across the OECD almost doubled between 2000 and 2022 (Figure 1).

Figure 1. Higher education attainment has increased in all OECD countries in the past two decades

Share of the population aged 25-34 with a higher education qualification, 2000-2022



Notes: 1. Data for tertiary education include upper secondary or post-secondary non-tertiary programmes (less than 5% of adults are in this group).
2. Year of reference differs from 2000: 2002 for Israel and 2003 for Iceland.
Source: OECD (2023[19]), Education at a Glance Database, http://stats.oecd.org/

Higher education attainment also appears to increase capacity to innovate

A wealth of evidence also points to the positive relationship between educational attainment and capacity for innovation, at the level of both economies and individual firms (OECD, 2011[20]). Higher education graduates are more likely than those without higher education to participate in innovative processes, to

[1] As argued in OECD (2019[17]) – *"care should be taken not to interpret differences as the causal effect of education on skills. Even after accounting for a range of observable characteristics, it is likely that some unobservable trait (such as innate ability) influences both proficiency in the PIAAC assessment and educational attainment. The direction of causality would then partly run from skills to education, rather than from education to skills."*

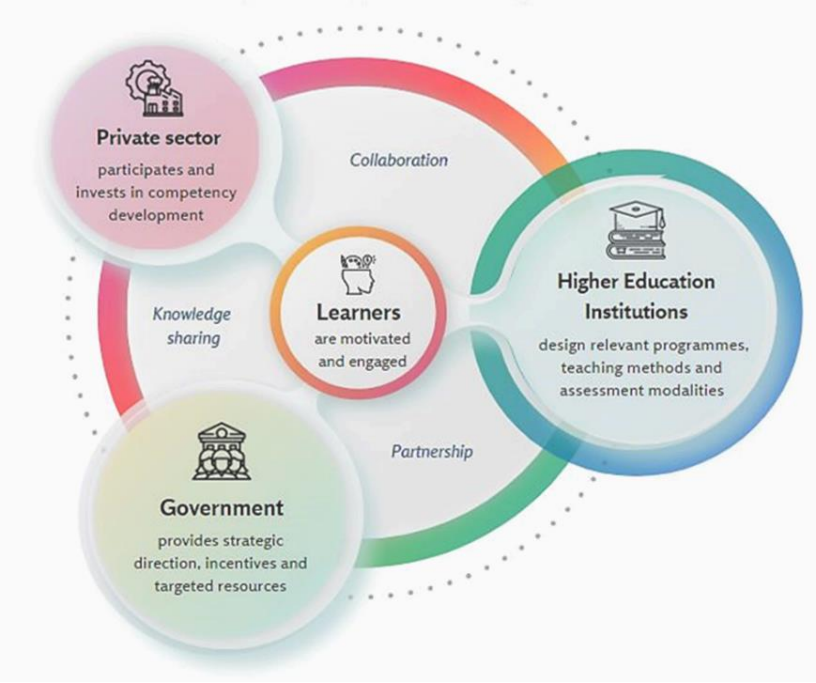
invent, and to perform better in the labour market amidst technological innovation (Biasi, Deming and Moser, 2021[6]). What is less clear is which specific factors and actions within HEIs are most effective in driving this increased propensity among graduates to innovate. Higher education attainment alone does not make somebody an innovator. Moreover, skills assessments of higher education students seem to indicate substantial variations in the extent to which learners gain knowledge and skills from their higher education experience (Van Damme and Zahner, 2022[21]).

High quality higher education can bring potential innovators closer to the frontier of knowledge, but, as noted, propensity to innovate is also associated with a range of different cross-cutting attitudes, values and personality traits. HEIs are increasingly expected to deepen these cross-cutting competencies, building on foundations developed earlier in the education lifecycle (OECD, 2023[22]). They have a range of potential approaches available to develop such competencies – through their traditional educational activities, through whole-of-institution strategic efforts to deepen their entrepreneurial capacities (OECD, 2022[23]) and through their "third mission" responsibilities (Compagnucci and Spigarelli, 2020[24]).

Many actors and actions can influence competency development in higher education

The effectiveness of higher education for developing competencies, including competencies for green and digital innovation, is not solely determined by what HEIs do on their own initiative. Governments are influential in shaping the higher education offer, through providing system-level strategic vision, incentives and resources. Private sector participation and investment also influences the relevance and utility of education programmes for developing the knowledge and skills most important in real-world settings. Finally, the agency and motivation of learners ultimately predicts their capacity to develop the competencies important for innovation (Figure 2).

Figure 2. Actors influencing competency development in higher education



Note: Developed by OECD Secretariat

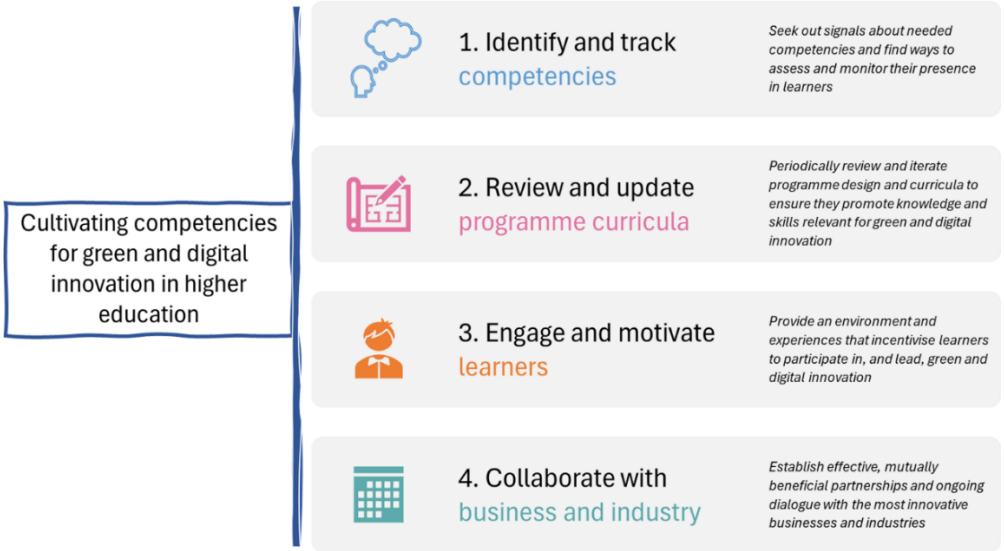
Much remains unknown about the impact of institutions' organisation, governance and approaches to teaching and learning on the key competencies that innovators will need in the future. Some evidence indicates that greater HEI autonomy supports more positive outcomes, in terms of research productivity,

educational attainment and students' competencies (Smidova, 2019[25]; Aghion et al., 2010[26]). The HEInnovate project also advocates maximising autonomy and individual ownership of initiatives to catalyse widespread institutional support for innovation (OECD/ European Union, 2014[27]). At the same time, the positive impact of autonomy may be maximised in the presence of supportive government policy, for example through the provision of adequate public funding and an effective external quality assurance system (Ritzen, 2016[28]).

Thus, optimising higher education to better cultivate the competencies crucial for green and digital innovation may be best achieved through a dual approach, with policy makers working to create favourable conditions and HEIs proactively improving their educational offerings. Figure 3 summarises four important avenues that higher education policymakers and practitioners can pursue to better cultivate competencies that support green and digital innovation:

1. **Identifying and tracking competencies** important for innovation: making increased efforts to assess and monitor innovation-related competencies among higher education students and to listen to external signals of demand for competencies.
2. **Reviewing and updating programme curricula:** ensuring that the content of programmes remains fit-for-purpose as industries and societies evolve, and that curricula promote important transversal and discipline-specific competencies.
3. **Engaging and motivating learners:** recognising that some learners need greater incentives to participate in higher education in general, and to engage in programmes and experiences that are most likely to build their competencies for innovation.
4. **Promoting fruitful partnerships with business and industry:** establishing effective collaboration with centres of innovation to ensure the relevance of higher education provision for innovative processes.

Figure 3. Avenues for higher education to cultivate competencies for green and digital innovation



The following sections discuss each of the four avenues identified in Figure 3 in turn, summarising insights from available evidence and options for policy and practice. The analysis is enriched with reflections and case studies contributed from members of the EIPC, and summaries of insights shared during the EIPC Strand 2 International Knowledge Exchange event, which brought together more than 200 higher education policymakers and practitioners (see Annex A for the event agenda).

1. Tracking competencies needed for green and digital innovation

Insights from evidence and experience

Available evidence suggests a combination of advanced domain-specific knowledge, high proficiency in certain transversal skills including critical thinking, creativity and communication, and positive attitudes and values towards innovation create favourable "starting conditions" for innovative processes (Bell et al., 2018[29]; European Commission, 2020[5]; Biasi and Ma, 2022[9]). Demand for specific competencies will continue to evolve rapidly as we move towards more sustainable and technologically advanced societies.

Public authorities monitor demand for competencies through a variety of qualitative and quantitative approaches, such as focus groups, expert workshops, sector studies, skills surveys, forecasting models, foresight and scenario development, graduate surveys and vacancy surveys (ILO/ OECD, 2018[30]). For example, many national governments have established multi-stakeholder expert advisory committees and councils to advise on the evolution of competency needs and current or future shortages (OECD, 2020[31]).The findings of such expert groups provide valuable insights and expertise that HEIs can leverage to reshape their educational offer. However, achieving broad consensus among the subjective views of experts from diverse sectors can be challenging (OECD, 2020[31]).

Surveys targeting workers, graduates, or employers provide a structured framework for assessing competency demands. Such surveys are in use across OECD countries, with variations in the degree of resources invested, the coverage of relevant populations, and the comprehensiveness of the approach taken (OECD, 2016[32]). The reliability of survey methods for gathering skills intelligence hinges on the thoroughness of the methodology and the quality of collected data – many methods currently employed are prone to reporting biases and measurement error. Without careful evaluation of their results, there is a risk that they will provide skewed messages for policy makers and practitioners (OECD, 2020[31]).

Technological advancement allows new quantitative approaches to gain insight on skills needs that can complement more qualitative or subjective input. For example, methodological advancements in text analysis and machine learning, combined with increased computational power, permit the efficient distillation and categorisation of information from millions of online vacancy postings to be conducted as a single analytical project. This type of analysis is increasingly used to provide new insights into competencies demanded for jobs across different economic sectors and employer types, including those with high innovation potential (Borgonovi et al., 2023[33]).

It is equally important to gain insight into the available supply of competencies, to understand to what extent demand is being served. Efforts to estimate supply tend to focus on what is measurable – the attainment of education qualifications – which tend to be awarded based on assessments of knowledge. Although some OECD countries have advanced on empirically measuring cognitive and transversal skills of higher education learners, progress has been incremental at best, and beset with conceptual and operational difficulties (Van Damme and Zahner, 2022[21]). Challenges include the complexity of developing appropriate assessment instruments for measuring high-level expertise, securing the widespread support of governments and HEIs and recruiting learners to participate in testing (Van Damme and Zahner, 2022[21]; Foster and Piacentini, 2023[34]). In addition, unlike at school level (e.g. through PISA or national assessments), there are few validated and reliable assessments of competencies of higher education students specifically related to green and digital transitions such as environmental awareness (Balcerak and Wozniak, 2022[35]) or digital competence (Sillat, Tammets and Laanpere, 2021[36]).

In the future, as demand continues to evolve, more resources will need to be devoted to improving and co-ordinating methodologies for identifying skill shortages. At the same time, more emphasis will need to be placed on gathering empirical information on the skill levels of higher education learners. A clearer picture of the supply and demand for competencies can help provide the insights needed to target higher education provision towards the needs of green and digital innovation.

EIPC reflections - tracking competencies important for innovation

At the Strand 2 EIPC International Knowledge Exchange event, speakers and the audience reflected on the competencies necessary for innovation in the context of the digital and green transitions – what they are and how to measure them. Some speakers argued that the digital transition and emergence of artificial intelligence (AI) have made access to knowledge more freely available than ever, which depreciates its value to some extent, relative to other types of competencies, such as specific skills, attitudes and values. HEIs are no longer the primary source of knowledge for business and society, and therefore need to re-think which competencies their programmes should seek to cultivate in their students. Together, the green and digital transitions bring new demands to the business sector and a new impetus for HEIs to rethink their value proposition in this changing landscape.

> *"Companies' skill needs are evolving due to digital and green transitions. While some jobs are fading out, new occupations are emerging (…) A survey of our member companies reveals that the most in-demand skills are in science, technology, engineering, and mathematics (STEM), digital and entrepreneurial skills, along with systemic and critical thinking".*
>
> **Robert Plummer,** Senior Advisor, Social affairs, Business Europe

It was also noted that the competencies required for the green and digital transitions are highly connected. Critical thinking, systems thinking, problem-solving and digital skills are extremely sought-after competencies by our economies and societies to support both change processes. Advanced levels of cross-cutting skills are especially important to adapt to climate change, which requires the ability to analyse and reflect upon sustainability issues in a wide variety of contexts and identify leverage points for innovation.

The overarching message from the EIPC's speakers and members is that the learners of today will require new tools, working methods and mindsets for thinking about, and responding to, global challenges. Moreover, HEIs need to find new ways to evaluate and monitor progression of these competencies in their students that allow for more transparent signalling of student and graduate attributes – what they know and can do.

> *"Sustainability cannot be measured by conventional approaches, exams, or tests. Rather, we need innovative means of evaluating progress (…) Learners should be encouraged to think globally while acting locally, understanding how local actions can have a global impact and vice versa"*
>
> **Walter Leal,** Professor of Climate Change Management & Environment and Technology, Hamburg University of Applied Sciences and Manchester Metropolitan University

> *"It is key to evidence and evaluate transversal skills in a rigorous manner. To authentically assess these skills, they must be articulated in a 'rubricable' way, meaning there should be a clear rubric we can use for formal assessment."*
>
> **Ciarán Dunne,** Transversal Skills Director, Dublin City University

Note: *This information is derived from the presentations and discussions at the international online knowledge exchange 'Cultivating the next generation of green and digital innovators – the critical role of mainstream higher education' held on 11 January 2024. The event agenda is available in Annex A.*

Options for policy and practice

Creating a systemic, multidimensional framework for competency needs anticipation

The complexity of skills anticipation requires a new generation of diverse approaches that, together, can deliver robust, reliable and actionable skills intelligence. This implies moving towards a more organised and systematic framework, linking existing and emerging anticipation methods with each other, and also with the activities of public authorities, stakeholders and education and training providers (CEDEFOP, 2024[37]). This more holistic approach to identification and tracking of competencies could deliver more reliable and actionable signals for both policymakers and higher education providers. Evidence-based principles for effective skills anticipation systems established by the International Labor Organization (ILO) and OECD highlight the importance of establishing clear goals, effective stakeholder engagement, supportive information systems and efficient dissemination and use of collected data. Thus, methodological drawbacks of individual anticipation and assessment approaches can be diminished through making combined use of them, connected within a systematic framework (ILO/ OECD, 2018[30]). Box 1 provides examples of connected approaches to skills anticipation.

Box 1. Comprehensive, connected approaches to skills anticipation at CEDEFOP and Finland

CEDEFOP's approach to skills anticipation

CEDEFOP, the European Centre for the Development of Vocational Training, provides comprehensive evidence on labour market trends and skills needs through its activities. In 2021, CEDEFOP launched Skills-OVATE, a machine learning tool analysing online job adverts to provide insights into employer demands. CEDEFOP also provides assessments of the extent to which countries in Europe can meet skills needs through its composite European Skills Index. In addition, CEDEFOP monitors national skills anticipation mechanisms, and carries out quantitative projections of skills needs through its Skills Forecast (CEDEFOP, 2024[38]), and through structured foresight exercises with expert stakeholders. Recent CEDEFOP analysis highlights the importance of strengthening STEM education at all levels to support the digital and green transitions in Europe (Cedefop, 2023[39]).

The role of VATTAGE and MITENNA models in shaping national education strategies in Finland

In Finland, the forecasting of future skill requirements is a collaborative effort involving multiple organisations and approaches. The VATT Institute of Economic Research generates the VATTAGE model, which provides long-term baseline future employment needs based on various macroeconomic variables as well as sectoral and occupational employment data. The Finnish National Agency of Education, operating under the Ministry of Education and Culture, integrates this data into its MITENNA model, which calculates the education and training provision needed to meet forecasted demand (CEDEFOP, 2022[40]). A multi-sector Skills Anticipation Forum was also established in 2017, comprising nine industry-specific groups with employer, employee, research sector and education provider representatives. Insights from Finland's skill anticipation exercises have led to the conclusion that high-skill occupations have the greatest potential to drive green and digital transitions. As these occupations overwhelmingly require tertiary education, the Finnish Ministry of Higher Education aims to increase the share of 25-34 year old tertiary graduates to 50% by 2030 (European Commission, 2021[41]).

Sources: CEDEFOP (2024[38]), Online tools; European Union https://www.cedefop.europa.eu/fr/online-tools; CEDEFOP (2022[40]), Skills anticipation in Finland; Data Insights - - European Union https://www.cedefop.europa.eu/en/data-insights/skills-anticipation-finland#_skills_forecasts; CEDEFOP (2023[39]), "Skills in transition: the way to 2035", Luxembourg: Publications Office. http://data.europa.eu/doi/10.2801/438491;European Commission (2021[41]), Education and Training Monitor – Finland https://op.europa.eu/webpub/eac/educatieuro on-and-training-monitor-2021/en/finland.html

Supporting the development of assessments that track competencies important for innovation, including cross-cutting competencies.

While monitoring the demand for skills through skills forecasting is essential, it is equally important to improve understanding of the supply side - the effectiveness of HEIs in cultivating key skills for innovation in students. As noted, traditional higher education assessments often focus on measuring what students can remember (Van Damme and Zahner, 2022[21]). Some emerging models of higher education assessment instead aim for authenticity – evaluating student's development of transversal skills and ability to apply knowledge in real-world contexts. Authentic assessment requires more resources to develop but shows promise for improving the employability of graduates, enhancing their readiness to solve problems and improving their contribution to innovation in the workplace (Villaroel et al., 2018[42]).

Governments and HEIs could actively champion and invest in new generations of assessment models that emphasise skills relevant for green and digital innovation within higher education degree programmes, such as those shown in Box 2. Such assessments, despite their complexity and operational challenges, offer unique insights into the competencies of higher education students and can provide a basis for measuring the impact of different teaching and learning approaches (Hoidn and Kärkkäinen, 2014[43]).

Box 2. Assessing higher education students' competencies in Ireland and Italy

The Human Capital Initiative and DCU Futures in Ireland

Dublin City University (DCU) aims to radically redesign undergraduate education through its **'DCU Futures'** project. This project is funded through the Irish **Human Capital Initiative**, a policy which aims to enhance skills provision in critical areas, future-proof graduates by providing them with industry-relevant capabilities, and promote transversal skills throughout higher education (HEA, 2024[44]).

Since its launch in 2021, DCU Futures has introduced ten new undergraduate programmes centred on critical competencies, with the goal of bridging the gap between academia and industry. The initiative aims to address common challenges of embedding these competencies within higher education, such as defining and operationalising each skill in a clear and transparent way, devising innovative methods for competency development, and ensuring that integrating these skills enhance rather than overshadow or compete with discipline-specific curricula. DCU has also developed a framework to assess and provide evidence of students' transversal skills gained during their education, which will result in a personalised skills profile for learners. The skills profile will enable graduates to provide more complete evidence of their competencies to employers (DCU Futures, 2024[45]).

Evaluating undergraduate skills in Italy using the TECO instrument

The **"TEst sulle COmpetenze"** (TECO) project, launched by the National Agency for the Evaluation of Universities and Research Institutes (ANVUR) in 2012, is designed to assess and enhance the quality of university education by evaluating the competencies of Italian undergraduate students (Anvur, 2024[46]). It consists of two components: TECO-T, which assesses transversal competencies (literacy, numeracy, problem-solving, and civic knowledge), and TECO-D, which evaluates discipline-specific skills. The assessment programme is conducted annually, and participation is voluntary. In 2022, the test was administered to 24 010 students in 40 universities, with a focus on students studying for the health professions (Anvur, 2024[46]).

Source: Higher Education Authority, Ireland (HEA, 2024[44]), "What is the Human Capital Initiative?" https://hea.ie/skills-engagement/what-is-human-capital-initiative-hci/; Dublin City University (2024[45]), "DCU Futures, Reimagining undergraduate education for an unscripted world", https://www.dcu.i e/ovpaa/dcu-futures;Agenzia Nazionale di Valutazione del Sistema Universitario e della Ricerca (Anvur, 2024[46]),TECO – TEst sulle COmpetenze - https://www.anvur.it/attivita/ava/teco-test-sulle-competenze/

2. Reviewing and updating curricula

Insights from evidence and experience

Adapting degree programmes to address emerging competency needs is a complex process that requires careful consideration, research and the management of challenges and trade-offs. HEIs operate with varying degrees of autonomy - decisions related to programme development are influenced not only by their internal capacities and resources but by external factors such as government policy, labour market trends and student demand. Conventional planning and strategic approaches followed by HEIs may be too rigid to be effective and remain relevant in a fast-moving environment (Eckel, 2023[47]). STEM occupations, for example, exhibit the highest rate of skills content evolution, leaving little room for extensive trial runs of curricula (Deming and Noray, 2020[48]).

Time lags are often encountered between recognition of needs or demands, decision-making about updates to curricula and programmes, implementation, and, finally, impact on student knowledge and skills (Desha, Hargroves and Smith, 2009[49]; OECD, 2018[50]). Developing and accrediting full degree programmes in most OECD countries is a lengthy, resource-intensive process, which must align with national standards and, in some cases, international agreements (such as the Bologna process in Europe). These standards are designed to ensure that the structure, content, teaching, and expected outcomes of degree programmes meet essential quality benchmarks, but they come at the expense of flexibility and adaptability. As a result, HEIs tend to be more agile and responsive to emerging needs when developing and updating their offer of shorter programmes, such as upskilling or reskilling courses.

HEIs must constantly balance between responding promptly to ever-changing market demands for discipline-specific skills and maintaining an enduring focus on evergreen competencies. Making space in curricula for new knowledge and competencies requires difficult choices. Competing demands for limited space in the curriculum can result in curriculum overload (when the curriculum becomes excessively lengthy) or imbalance (when disproportionate attention is given to certain competencies at the expense of others) (OECD, 2020[51]). This process becomes even more challenging when emerging competencies important for green and digital innovation are not closely related to traditional content taught within established programmes (for example, sustainability concepts or digital proficiency outside of STEM fields, or management and entrepreneurial competencies outside of business schools (OECD, 2015[52])).

HEIs also need to grapple with the question of **how** to develop curricula targeting emerging competencies - through dedicated formal courses, integrating them within existing courses, or fostering them through practical experiences such as internships or experiential learning. For example, there is an ongoing debate about whether certain transversal skills, such as creativity and critical thinking are best nurtured in domain-specific or domain-general contexts (Saroyan, 2022[53]). Education strategies that incorporate interdisciplinary and multidisciplinary elements, such as problem-based learning, are being increasingly recognised for their potential to train future innovators (Hoidn and Kärkkäinen, 2014[43]; OECD, 2015[52]). This is based on the premise that complex global challenges are multidimensional in nature and cannot be understood or resolved from individual disciplinary perspectives (Jacob, 2015[54]). However, more research is needed to confirm and further explore the benefits of interdisciplinary approaches, and to ensure that interdisciplinary education does not hinder the acquisition of deep discipline-specific knowledge.

Finally, efforts to update curricula depend on widespread support and engagement from academic staff. The perceived complexity of curriculum updates, the time and resources required for their implementation, and (in the case of cutting-edge knowledge of emerging disciplines) lack of relevant knowledge and skills can all deter staff from being proactive in the change process (Chan et al., 2017[55]). Recent significant advancements in generative AI exemplify the challenges faced by higher education providers and governments, who need to make sound decisions in the face of the rapid advancement of the technology and its use cases, uncertainty regarding which competencies best promote “AI Literacy” and how to best teach them, and external pressure to act (Southworth et al., 2023[56]).

EIPC Reflections – assessing and updating higher education programmes and curricula

Speakers at the Strand 2 knowledge exchange event highlighted the distinction between discipline-specific education and educational approaches that integrate sustainability and digital education across disciplines. In an increasingly crowded and diverse landscape of education and skills providers, HEIs should reflect on their uniqueness – the particular value of a higher education degree in developing competencies and providing a distinct form of learning experience. Our economies and societies will need highly skilled specialists with deep field-specific knowledge to advance on green and digital innovation, and the right combination of disciplinary and pedagogical knowledge, technical and practical skills required to develop education programmes is in short supply.

> *"Quantum science is not something one can improvise - it requires deep knowledge. Experts are not found everywhere. It is therefore essential to ensure everyone collaborates. Working together, we can create a programme that is much stronger".*
>
> **Bruno Julia-Diaz,** Physics professor & MSc Quantum Science & Technology coordinator, University of Barcelona

Challenges such as staff resistance, disciplinary fragmentation and regulatory barriers were identified as key obstacles to developing innovative programmes and curricula. Strategies for overcoming disciplinary fragmentation include fostering interdisciplinary learning and adopting participatory and collaborative approaches to programme design and assessment.

> *"Interdisciplinary learning plays a pivotal role in enhancing our comprehension of complex, interdisciplinary issues such as sustainability. By integrating insights from a diverse array of disciplines, we can foster a more comprehensive and holistic understanding of sustainability challenges."*
>
> **Walter Leal,** Professor of Climate Change Management & Environment and Technology, Hamburg University of Applied Sciences and Manchester Metropolitan University

Regulatory and quality assurance frameworks (both internal and external), including assessments of the outcomes of higher education may need to be rethought to allow individual HEIs and systems to become more dynamic in developing education offers that respond to emerging and urgent needs for competencies.

> *"We follow up with our students in a shallow way. Measuring whether they are employed is insufficient. We should follow up longitudinally to assess the ongoing application of the competencies students have acquired."*
>
> **Teri Balser,** Professor and Former Provost, University of Calgary

> *"Designing a programme for students with diverse backgrounds and securing external evaluation and accreditation in less than nine months, while also navigating internal bodies are distinct challenges we faced."*
>
> **Elpida Keravnou-Papailou,** Computer Science Professor, MSc in Artificial Intelligence coordinator, University of Cyprus[2]

Note: *This information is derived from the presentations and discussions at the international online knowledge exchange 'Cultivating the next generation of green and digital innovators – the critical role of mainstream higher education' held on 11 January 2024. The event agenda is available in Annex A.*

Options for policy and practice

Gaining insight on the alignment of higher education curricula to knowledge frontiers

While ultimate responsibility for the development and update of educational programmes and curricula usually rests with HEIs, governments use a range of policy levers to promote performance improvements and incentivise desirable practices (OECD, 2019[57]). For example, governments can support the collection and dissemination of information that sheds light on the extent to which higher education curricula incorporate cutting-edge knowledge that is critical to green and digital transitions. Despite substantial public investment in higher education systems, there has been very limited research or policy debate into how knowledge is positioned within higher education curricula and the related understanding that students develop during their educational experiences (Ashwin, 2014[58]).

Governments can play a pivotal role by funding or directly conducting targeted research that sheds light on the content of higher education curricula. Despite being in early stages, some governments and researchers have already initiated promising projects to better understand the links between curriculum content and innovation, including green innovation (Box 3). Such knowledge-building initiatives not only provide insight into current curriculum development, but also signal to educational institutions the critical importance of, and national interest in, nurturing competencies for green and digital innovation.

Box 3. Innovative assessments of curriculum content in the United States and Denmark.

Measuring the "education-innovation gap" in higher education curricula in the United States

Biasi and Ma (2022[9]) introduced the concept of the "education-innovation gap" to quantify the disparity between HEI course content and cutting-edge knowledge. Using natural language processing, the authors analysed 1.7 million HEI course syllabi and 20 million academic articles and calculated the gap by comparing the content of a course to both older and frontier knowledge. The authors define the education-innovation gap as the ratio of similarities between a course's content and knowledge from research published decades ago and most recent research literature. The study examined approximately 540 000 courses taught at 800 four-year US institutions from 1998 to 2018.

The authors documented significant differences in the education-innovation gap across courses. The study highlights the substantial role of instructors in shaping course content, with those more active in research tending to teach more state-of-the-art knowledge. HEIs enrolling more socio-economically advantaged students generally offer courses with a smaller education-innovation gap, and students from HEIs with a narrower education-innovation gap are more likely to pursue a doctoral degree, generate more patents and earn higher incomes after graduation. While the authors caution that their results do not necessarily imply causation, their findings suggest that HEIs could make a greater contribution to innovative processes by incorporating more frontier knowledge into their courses and taking action to promoting widespread access to advanced knowledge.

[2] Note by the Republic of Türkiye The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Türkiye recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Türkiye shall preserve its position concerning the "Cyprus issue".

Note by all the European Union Member States of the OECD and the European Union The Republic of Cyprus is recognised by all members of the United Nations with the exception of Türkiye. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

Identifying green study programmes and learning outcomes in Denmark

In 2020, the Danish Agency for Higher Education and Science initiated a project to identify and map green study programmes within Danish HEIs as part of a wider strategy to invest in green research, technology, and innovation (Ministry of Higher Education and Science Denmark, 2020[59]). The framework defines green study programmes as those incorporating at least one key learning outcome related to seven green themes (sustainable energy production, energy effectiveness, agriculture and food production, transport, environment and circular economy, nature and biodiversity, and sustainable behaviour and societal consequences).

The mapping exercise, drawing on data supplied by the institutions themselves, found that 29% of standard study programmes had a core green learning outcome in 2021, while 22% included at least one compulsory course with a green learning outcome, and 14% offered an optional course with a green learning outcome. The most frequently addressed outcome across all study programmes was sustainable behaviour and societal consequences.

Case studies carried out for the project emphasised the complexity of distinguishing between green and non-green learning outcomes, highlighting the need for clear definitions and strategic alignment in fostering competencies that support green innovation (Ministry of Higher Education and Science Denmark, 2022[60]).

Sources: Biasi, B. and Ma,S, (2022[9]), The Education-Innovation Gap, NBER Working Paper 29853 http://www.nber.org/papers/w29853; Ministry of Higher Education and Science Denmark, (2020[59]), Green solutions of the Future Strategy for investments in green research, technology, and innovation, https://ufm.dk/en/publications/2020/filer/green-solutions-of-the-future; Ministry of Higher Education and Science Denmark (2022[60]), "Kortlægning af grønt læringsudbytte i uddannelserne", https://ufm.dk/uddannelse/videregaende-uddannelse/temaer/gron-omstilling-i-uddannelser/kortlaegning-af-gron-laeringsudbytte-i-uddannelserne

Providing supports and incentives for academic staff to proactively update curricula

Academic staff involved in curriculum design face the challenge of making informed choices in a context where rigorous evidence is limited, and where they may not personally feel prepared to effectively develop new competencies in students, especially in emerging areas of knowledge. Making space for academic staff to experiment with curricula is fundamental, as is ensuring that their efforts are recognised and rewarded.

It may be especially important to recognise and reward interdisciplinary collaboration, considering that current academic staff reward structures often prioritise research output and publication in high-impact journals, which are typically discipline-specific. Specifically encouraging and recognising efforts of staff to collaborate across faculties and departments and break down disciplinary silos can help to motivate these efforts, along with improving knowledge and research about frameworks and models that can best support the development of interdisciplinary approaches (Ashby and Exter, 2018[61]).

Effective supports and incentives can be developed at system or institution level. For example, national teaching awards, recognising outstanding individuals or teams, are present in around half of European higher education systems (Bunescu and Gaebel, 2018[62]). Dedicated supports for academics provided within HEIs can also be transformational. These can include greater investment in professional development and training and providing regular opportunities for higher education teachers to update their field knowledge (e.g. through sabbaticals and research conferences). Increasingly, leading HEIs are ensuring that academic staff have access to high-level specialist expertise in instructional design, learning technology and pedagogy (IMHE, 2012[63]).

Seeking dialogue, collaboration and alignment of policy and practice in emerging disciplines

Given the high costs of curriculum development and renewal, particularly in frontier fields where available expertise is severely limited, one way to make efficient progress with curriculum development is to collaborate and share educational resources. This can happen through institutional collaboration on education that is oriented around a particular societal challenge, such as advancing on climate goals. It can also entail working with partners - for example, firms or other institutions - to advance curriculum development in specific fields. Box 4 provides inspiring examples of interesting collaborative initiatives.

Box 4. Field-specific collaborative programmes in innovative disciplines

The **MSc. Artificial Intelligence** programme at the **University of Cyprus**, launched in 2022, focuses on human-centric, explainable, and responsible AI (University of Cyprus, 2022[64]). It includes mandatory courses on AI ethics and entrepreneurship and prioritises career counselling to help students start their business. The programme, co-funded by the EU's Connecting Europe Facility, was developed in partnership with the University of Bologna, University of Ruse Angel Kanchev, the CYENS Centre of Excellence, and technology businesses. These organisations are part of the Master's Programmes in Artificial Intelligence 4 Careers in Europe (MAI4CAREU) project, a partnership of European Universities that aims to enhance AI master's programmes and provide students with access to a wider range of course modules in industry-relevant areas. The development process for this programme needed to overcome significant challenges, including the requirement for rapid design, progression through accreditation processes and the co-ordination of shared online content among various partners.

The **University of Barcelona,** jointly with other institutions, offers a **Master's degree in Quantum Science and Technology**. This programme, developed in partnership with QuantumCat, Catalonia's Quantum Technologies Hub, promotes research in quantum technologies. It aligns with the European Quantum Flagship, a significant EU research initiative from 2018 aimed at driving the second quantum revolution in Europe (University of Barcelona, 2024[65]). Students interact with quantum technology companies through placements, seminars, and an annual symposium. The programme enhances its educational offerings by incorporating hands-on methods and transferable skills, equipping students for either research or industry-oriented careers. The development of the programme faced challenges such as fostering effective collaboration between different partners, maintaining the curriculum's relevance and currency – a task made difficult due to the intricate and innovative nature of the subjects being taught – and actively engaging with industry.

The **Research and Transfer Centre "Sustainability and Climate Impact Management" (FTZ-NK)** at the Hamburg University of Applied Sciences is an example of how HEIs can join forces to address global challenges (Molthan-Hill et al., 2019[66]; HAW Hamburg, 2024[67]). The Centre's International Climate Change Information and Research Programme (ICCIRP) and its "100 papers to accelerate climate change mitigation and adaptation" initiative encourage research and publication from doctoral students in critical areas of sustainability and climate change. The ICCIRP facilitates education and communication about climate change at universities, organises biennial conferences, and aims to develop a strong publication strategy on climate change adaptation. The FTZ-NK also hosts the Inter-University Sustainable Development Research Programme (IUSDRP) and the European School of Sustainability Science and Research (ESSSR).

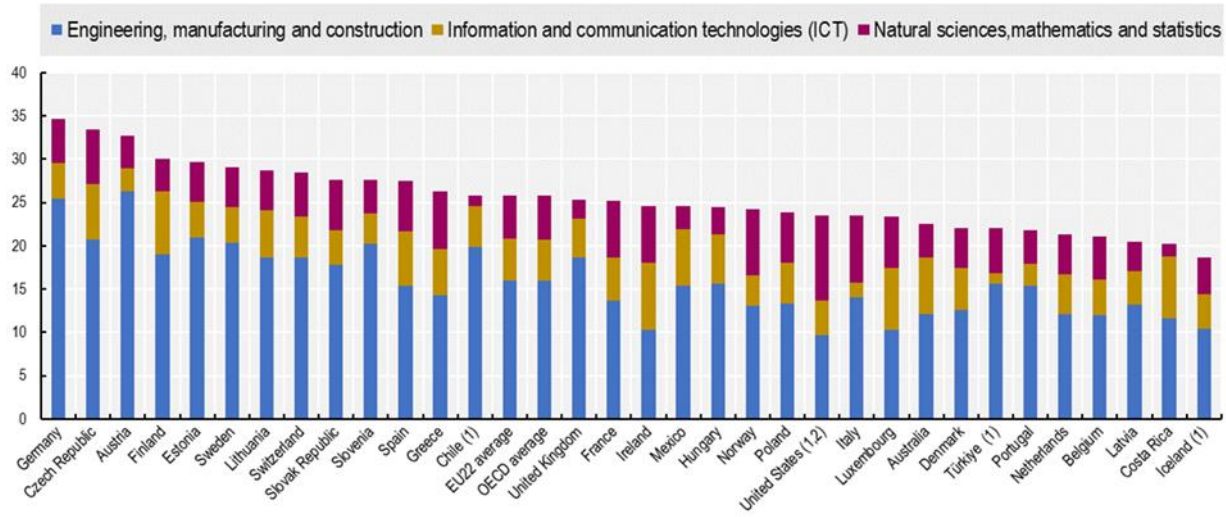
Sources: Adapted from presentations made by Elpida Keravnou-Papailou and Bruno Julia-Diaz during the EIPC International Knowledge Exchange Event in January 2024; University of Cyprus (2022[64]), "Master in Artificial Intelligence", https://www.cs.ucy.ac.cy/index.php/education/postgrad/master-in-artificial-intelligence; University of Barcelona (2024[65]), "Master in Quantum Science and Technology", https://web.ub.edu/en/web/estudis/w/masteruniversitari-MD70D, https://quantummasterbarcelona.eu/ HAW Hamburg (2024[67]) "Sustainable development and climate change management", https://www.haw-hamburg.de/en/ftz-nk/, Molthan-Hill et al. (2019[66]), "Climate change education for universities: A conceptual framework from an international study", Journal of Cleaner Production

3. Engaging and motivating learners

Insights from evidence and experience

Certain sets of knowledge and skills are closely associated with green and digital innovation. Graduates with STEM competencies, including ICT, are more likely to work in advanced scientific and engineering fields that drive innovation (Toivanen and Väänänen, 2016[68]; Bianchi and Giorcelli, 2019[69]). Graduates with competencies in science and technology disciplines also - on average - receive better rewards in the labour market, in terms of employment and earnings (OECD, 2022[18]). Despite these positive outcomes, and policy focus on increasing the flow of STEM graduates, across the OECD just one-in-four adults with higher education degrees have studied STEM subjects, with the highest share in Germany (Figure 4). Furthermore, the share of young STEM graduates across Europe has remained relatively static over the last decade, and even decreased in some countries (Eurostat, 2024[70]).

Figure 4. Population aged 25-64 with tertiary attainment in STEM subjects (2021)



Note: OECD calculations based on (OECD, 2022[18])
1. Year of reference differs from 2021: 2017 for Chile and the United States, 2016 for Iceland and Türkiye.
2. Data refer to bachelor's degree field, even for those with additional tertiary degrees.

Available evidence also indicates that students enrolled in mainstream higher education programmes may be interested in, and aware of, issues related to sustainability and technological innovation but may not be motivated to devote their careers to participating in it or even to engage in education programmes and courses focusing on the topic (Balser, forthcoming[71]). This reluctance may be driven by several factors. Learners may be less inclined to study STEM subjects in higher education because of failures at school level to build adequate foundational proficiency and positive attitudes towards careers in science and technology (OECD, 2023[22]). This can result in reluctance to engage with science and technology subjects due to their perceived difficulty. Students may also have limited understanding of how their chosen field of study can contribute to green and digital innovation, especially if they are studying in environments that prioritise memorisation of facts rather than those that focus on development of deep understanding and problem-solving skills (Hoidn and Kärkkäinen, 2014[43]).

Policy makers and practitioners may need to take further action to increase students' motivation to engage in education that builds competencies for green and digital innovation. This process starts with building stronger foundations at school level, where HEIs play a pivotal role in developing secondary school curricula and training teachers and school leaders (OECD, 2023[22]; OECD, 2023[72]), but also entails creating more engaging learning experiences within higher education programmes.

EIPC Reflections - engaging and motivating learners

At the Strand 2 EIPC International Knowledge Exchange event, speakers considered different possibilities that HEIs and policy makers can pursue to effectively motivate learners to participate in and drive forward innovation for the digital and green transitions. The dialogue underscored the importance of comprehensive study and career guidance and targeted communication strategies that aim to motivate students to pursue study and careers in disciplines and skill areas that contribute heavily to innovation, such as STEM disciplines. Students as well as employers need to be involved heavily in programme design and review.

> *"Students tend to see the world through the lens of programmes rather than skills. We need to work with them to understand their worldview. Additionally, it's important to construct a narrative that engages them in the development of transversal skills. They should also be able to reflect on their development and articulate them compellingly to an external audience."*
>
> **Ciarán Dunne,** Transversal Skills Director, Dublin City University

Students themselves are also increasingly aware of the need to focus on skills, attitudes and values in their education, as a means to help increase awareness of important global challenges and improve their understanding of how to contribute to solving them. Governments and institutions can also work to promote greater visibility and validation of the experiences, skills and achievements of students in study programmes that are oriented towards green and digital transformation, as a mechanism to motivate future learners.

> *"We echo the call to open curriculum ownership and cross-disciplinary dialogue - we encourage HEIs to break free from disciplinary silos (...) We call for educational approaches that impart knowledge but also instil values essential for responsible global citizenship."*
>
> **Tamara Ciobanu,** Executive Committee, European Students' Union

The potential of using the higher education campus as a "living lab" and active learning space was also highlighted as a way to promote experiential learning and problem-solving related to real-world challenges. Here, HEIs can learn from the experiences of the digital transition that many institutions experienced during the COVID pandemic, where digital infrastructure upgrades rapidly introduced to support the continuation of education were later harnessed to promote deeper embedding of digital competencies across education programmes on a more permanent basis.

> *"HEIs could do more to leverage the campus as a living lab to engage students in experiential learning, problem solving, and critical thinking that uses the physical plant of the university. A living lab can provide tangible, real-world examples for students to foster a deeper understanding."*
>
> **Teri Balser**, Professor and Former Provost, University of Calgary

Note: *This information is derived from the presentations and discussions at the international online knowledge exchange 'Cultivating the next generation of green and digital innovators – the critical role of mainstream higher education' held on 11 January 2024. The event agenda is available in Annex A.*

Options for policy and practice

Designing engaging educational experiences that focus on green and digital innovation.

One way that HEIs can improve learner understanding and stimulate their interest in issues related to green and digital innovation is to create educational offers specifically with this objective in mind. Many institutions have experimented with diverse initiatives to foster student engagement in solving real-world challenges and contributing to innovation, including the development of industry apprenticeships, introducing transdisciplinary programmes, or encouraging students to cultivate a creative and entrepreneurial mindset (Box 5). Students can be further motivated to take up these offers if they are provided with academic credit and/or other forms of recognition for their experience.

Box 5. Initiatives supporting student engagement in entrepreneurship and interdisciplinarity

In Malta, the **Malta College of Arts, Science and Technology (MCAST)** has implemented two initiatives to foster student engagement. The Institute of Information and Communication Technology (ICT) Student Apprenticeships initiative bridges the gap between academic study and industry experience in the digital sector, allowing students to earn 12 ECTS credits through a 1 096-hour apprenticeship in a workplace setting (Bonnici et al., 2022[73]). MCAST also incorporates a mandatory Community Social Responsibility (CSR) programme into its curriculum, providing students with diverse experiences in areas like entrepreneurship, arts, sports, social and environmental initiatives, and culture (MCAST, 2022[74]). This programme, in collaboration with various NGOs, social partners, and educational institutions, aims to enhance students' skills, attitudes, and values for real-world application.

In Belgium, **KU Leuven's Transdisciplinary Insights Honours Programme** is an innovative, one-year interdisciplinary course for Bachelor's, Master's, and PhD students, designed to tackle complex global issues such as climate change and AI (KU Leuven, 2024[75]). It encourages research and entrepreneurship through teamwork, coaching, and workshops. Despite facing challenges such as diverse academic levels among participants, unequal engagement and the complexity of evaluating interdisciplinary competencies, the programme has made significant strides. Its external position to university structures poses challenges in recognition and financial support, and its non-contribution to degree credits may impact student motivation. However, to date, the programme has equipped over 300 students with cutting-edge transdisciplinary skills and created 30 challenge teams focused on the development of groundbreaking solutions. These accomplishments underscore the potential role of such programmes in addressing global challenges and shaping future leaders and innovators.

The **Hungarian Startup University Program (HSUP)** is an initiative aimed at promoting entrepreneurship among students by engaging 10 000 students over a period of three years (HSUP, 2024[76]). The programme, funded by the Hungarian Innovation Agency, includes a two-semester course on entrepreneurship. In the second semester, students receive financial support to encourage them to start their own startups. Over three academic years, the programme has involved 32 educational institutions, with 474 project teams completing the course. The programme is supported by 50 professional partners and 72 active mentors.

Sources: Adapted from EIPC case studies received from MCAST, KU Leuven and HSUP
Bonnici, J., Farrugia, M., Zammit, E., and De Raffaele, C. (2022[73]), "IICT Student Apprenticeships", https://doi.org/10.5281/zenodo.5914514
MCAST (2022[74]), "Fostering Social Responsibility through MCAST", https://doi.org/10.5281/zenodo.5914498
KU Leuven (2024[75]), "Institute for the Future, Transdisciplinary Insights", https://rega.kuleuven.be/if/education-training/tdi/transdisciplinary-insights; HSUP (2024[76]), "Hungarian University Startup Program", https://hsup.nkfih.gov.hu/

As well as recognising the efforts of learners to engage in competency development for green and digital innovation, governments and other stakeholders could also find ways to highlight the efforts of HEIs themselves in developing and delivering programmes that deliver cutting-edge learning on sustainability and technology issues. Examples of promising policy directions include recognition of institutions' effort in comparative assessments of performance, and in external quality assurance processes (Box 6).

Box 6. Bringing visibility to institutions' efforts for sustainability education

NVAO's Special Feature for Sustainable Higher Education

The Accreditation Organisation of the Netherlands and Flanders (NVAO) offers a special feature for accrediting sustainable higher education, allowing higher education programmes to be included on a voluntary basis for a special assessment in the field of sustainability. The process first involves a self-evaluation by the institution followed by a review by an independent panel of experts and a site visit. The panel's judgment on the programme's alignment with sustainability criteria forms the basis of NVAO's decision to grant the special feature. The assessment framework used can either be NVAO's own or other sustainability frameworks, such as the Sustainability Higher Education (SHE) assessment framework. The latter is a comprehensive framework developed for HEIs aiming to integrate Sustainable Development Goals (SDGs) into their programmes, and a programme must achieve a minimum grade within it to pass the assessment (NVAO, 2019[77]).

Promoting Sustainability in Higher Education: AASHE's STARS Programme and Colorado State University's Experience

The Association for the Advancement of Sustainability in Higher Education (AASHE) is a network of HEIs established in 2005 to promote sustainability. It has over 900 members across 48 US states, one US Territory, nine Canadian provinces, and 20 countries (AASHE, n.d.[78]). AASHE developed the Sustainability Tracking, Assessment & Rating System (STARS) to help HEIs track their sustainability progress. STARS is a voluntary tool for self-assessment which promotes continuous improvement. One component of the STARS assessment is the sustainability literacy assessment, which requires institutions to conduct a pre- and post-assessment of a representative sample of the entire student body or, at the very least, of the institution's main student body, to earn full points.

Colorado State University (CSU) is an example of an institution achieving Platinum rating in STARS and a perfect score in the sustainability literacy assessment. CSU conducts this assessment biennially, using the results to shape its sustainability curriculum and contribute to STARS reporting (CSU, n.d.[79]). The 2021 assessment covered various sustainability topics and gauged students' understanding of these topics. The results are used to guide curriculum development and set sustainability priorities.

Source: NVAO (2019[77]), "Special feature sustainable higher education, https://www.nvao.net/en/procedures/the-netherlands/special-feature-sustainable-higher-education,, The association for the advancement of sustainability in higher education (n.d.[78]), The Sustainability Tracking, Assessment & Rating System - STARS Participants & Reports - https://reports.aashe.org/institutions/participants-and-reports/ Colorado State University (CSU, n.d.[79]) – Sustainability Assessment - https://green.colostate.edu/assessment/

Providing access to "peripheral" experiences that can help stimulate learners' engagement

An advantage of traditional mainstream higher education over many alternative providers is the immersion of students in an environment that is designed specifically to promote their education and skills development – the physical higher education campus. This means that mainstream HEIs, particularly larger ones, have unique opportunities to raise students' awareness of important challenges related to the twin transitions outside of the immediate teaching and learning experience, by providing an immersive physical environment. For example, the concept of the campus as a "living lab" has been increasingly

assimilated by HEI leaders as an opportunity to provide experiential learning, particularly with respect to developing sustainability problem-solving capacities (Zen, 2017[80]).

Innovation challenges and contests are also increasingly being used to cultivate skills for innovation, particularly in topics relating to technology and sustainability. Well-designed challenges, using an evidence-based approach, can help to develop and maintain a focus on important societal challenges, such as environmental issues. They can also motivate learners to develop disciplinary knowledge as well as important transversal skills, such as teamwork, design and communication skills (Adamczyk, Bullinger and Möslein, 2012[81]). Game-based and challenge-based learning through contests show promise in building competencies vital for the digital transformation (Raman, Vachharajani and Achuthan, 2018[82]) and for sustainable development. HEIs could work to provide access to relevant challenge and game-based experiences on campus. Involving the business sector in developing challenges and contests can further increase their attractiveness to students, as discussed in the next section.

4. Promoting partnership with business and industry

Insights from evidence and experience

Co-operation between HEIs and business and industry on the development of degree-programme curricula and their delivery can take many forms (Elsevier, 2021[83]). It can include co-development of course modules within programmes, time spent by students in business or industry settings as part of degree programmes and providing opportunities for students to engage with professional experts, through guest lectures or with industry practitioners directly engaged in teaching students (European Commission, 2018[84])

Effectively engaging business and industry in the development of higher education degree programmes can be challenging. HEIs and private businesses tend to have differing priorities and organisational cultures – HEIs will place a high priority on theoretical knowledge, academic freedom, long-term educational outlook and learning outcomes of their students, while businesses tend to focus on practical skills and the immediate commercial interests of their sector and organisation. In the most innovative industries, rapidly evolving trends require continuous integration of new knowledge and adaptation of skills training. As noted, degree programme structures are often too static to quickly adapt to emerging needs for knowledge and skills. As a result, HEIs may be more likely to partner with the private sector on shorter, more adaptable tailored programmes rather than on degree programme curricula.

Resource availability can also pose a challenge to collaboration on more holistic degree programmes, compared to developing shorter programmes, such as micro-credentials. Collaborations on education design and delivery require a substantial commitment of time, ability to establish and maintain co-ordination and common ground on the design of education, and, often, some commitment of financial resources. At the same time, there are many enabling contextual factors that support renewed efforts for collaboration between HEIs and business on developing degree programmes, including a growing recognition that partnerships provide one of the best prospects for reducing skills mismatches and providing high-level expertise and knowledge for innovative and rapidly evolving business sectors. Companies are also increasingly seeking to display their social responsibility credentials, and partnering with HEIs on education supporting green and digital innovation can align with this objective.

Governments have a role to play in facilitating dialogue between a range of stakeholders, including public sector bodies, HEIs, and local industry partners, to promote curriculum designs that are effective and relevant in the context of green and digital transitions (Dowling, 2015[85]; European Commission, 2018[84]). This “triple-helix” of university-industry-government interactions has long been recognised as vital for knowledge-based innovation and economic development (Etzkowitz and Zhou, 2017[86]).

EIPC Reflections – collaboration with business and industry

At the Strand 2 EIPC International Knowledge Exchange event, the importance of synergies between higher education, industry, and government was underscored, with a call for academic programmes and curricula to be more responsive to industry needs. The potential of public policy to act as a catalyst for these collaborations was also recognised, with an emphasis on the role it can play in encouraging HEIs and businesses to co-create innovative, skill-focused educational offerings.

> *"Making entrepreneurship and innovation a mandatory part of our curriculum underscores our belief that even the brightest minds in Quantum Science and Technology need to be prepared for the fast-paced, practical realities of the industry. It's not just about advancing science, but also about turning ideas into viable businesses."*
>
> **Bruno Julia-Diaz**, Professor of Physics & Master in Quantum Science & Technology coordinator, University of Barcelona

The discussions highlighted the eagerness of employers to be more involved in shaping educational programmes, and the need for HEIs to further capitalise on this willingness to help make their programmes more innovative, learner-centred and relevant to business and industry. Industrial PhDs where candidates are co-supervised by HEIs and industry provide an inspiring example of deep collaboration on education programmes that promote advanced competencies (although they may also raise challenges linked to the innovation process, such as ownership of intellectual property developed during the collaboration).

> *"There is a strong interest from employers in being more involved in the design and updating of programmes to ensure their relevance, as well as in the delivery. Industry exposure for both teachers and learners, increasing the number of industrial PhDs, and promoting apprenticeships can all be effective ways to support the development of higher technical skills."*
>
> **Robert Plummer**, Senior Advisor, Social affairs, Business Europe

Additionally, the benefit of industry exposure was recognised in the context of education programmes that aim to develop advanced competencies in frontier disciplines. The importance of mobilising local industry ecosystems to infuse dynamism and innovation into higher education was stressed, along with the need for this exposure to be recognised and credited within the student's learning record.

> *"We want students to get the taste of a real AI work environment by doing internships in research centres and different companies and get credits for that. Career counselling and fostering strong links with industry add significant value to their experience and help them acquire necessary soft skills to pursue a successful AI-related career or set up their own startups."*
>
> **Elpida Keravnou-Papailou**, Professor of Computer Science and coordinator of the Master in AI, University of Cyprus

Note: *This information is derived from the presentations and discussions at the international online knowledge exchange 'Cultivating the next generation of green and digital innovators – the critical role of mainstream higher education' held on 11 January 2024. The event agenda is available in Annex A.*

Options for policy and practice

Introducing or strengthening dual education in technological and environmental fields

Recent OECD research highlights the vital importance of focusing on collaboration between academia and business in key areas of innovation for the green and digital transition, such as AI (OECD, 2023[1]). One of the most important forms of collaboration in this area has been in the development of co-operative "dual" education, such as dual degree programmes or degree apprenticeships. Dual education, properly designed and implemented collaboratively, is demonstrably effective - enhancing graduate employability and accelerating career advancement compared to graduates from more traditional university programmes (Kocsis and Pusztai, 2021[87]). In the United Kingdom, for example, the introduction of dual "degree apprenticeships" has been found to have positive impact on productivity of firms, and improved social mobility of learners (Nawaz et al., 2022[88]).

Dual education may be especially advantageous in sectors and disciplines with relevance for green and digital innovation. This relevance stems from the heightened motivation of companies and HEIs to participate, driven by the alignment of these initiatives with national strategic priorities, and, consequently, potential sources of public funding and incentives. Dual education development can therefore be a "win-win model" of university-business partnership (Pogatsnik, 2018[89]).

Diversifying approaches to strengthening ties between academia, research, and industry in cutting-edge fields

The development of degree-level dual training is a complex undertaking, requiring the development of new mechanisms for co-operation between employers and higher education providers. Employers and higher education providers need to be sufficiently motivated to participate and invest in the process. Dual education also requires tailor-made operational procedures, including assessment and quality assurance processes. For this reason, the development of full dual education may tend towards a longer time horizon, while the needs for competencies to support green and digital innovation are current and urgent. Therefore, HEIs, governments and businesses could explore a diversity of means to collaborate, building bridges between education programmes, research and business activity. Box 7 provides some examples of interesting recent initiatives involving HEIs across Europe.

Box 7. Initiatives in Europe building bridges between higher education, research and industry.

The **European Institute of Innovation and Technology (EIT)** has launched several schemes to encourage innovation through linking higher education and industry. **The EIT Manufacturing Doctoral School** is a two-year international programme that assists PhD students in turning their research or patents into marketable solutions, with a focus on manufacturing innovation. The programme has supported students to progress to associate professorship, link their research with large firms and tech startups, and participate in international research collaboration (EIT Manufacturing Doctoral School, 2024[90]). Self-reported challenges include the need for more manufacturing expert involvement and mentorship on intellectual property rights issues.

Another EIT initiative is the **Innovation Capacity Building for Higher Education project**, which aims to equip HEIs with expertise, coaching, access to the EIT innovation ecosystem and funding. This initiative has backed projects like **EuroSpaceHub**, which digitally links the European space ecosystem (EuroSpaceHub, 2024[91]). The project has created entrepreneurship-oriented courses for deep-tech participants, particularly from the space sector, and has trained around 500 engineers and scientists.

Many **initiatives funded by the European Union's Erasmus+ programme** seek to integrate innovation with education by developing educational resources. The **Ethical Food Entrepreneurship project (EFE)**, led by Savonia University of Applied Sciences in Finland and involving the Polytechnic Institute of Bragança in Portugal among other partners, aims to drive global change in the food industry (EFE, 2023[92]). The project focuses on enhancing the skills of food educators within HEIs, with the goal to support the growth of ethical food enterprises. Activities of the EFE project include creating guides, manuals, open educational resources, and a mentoring platform.

The **EXPAND project**, another Erasmus+ project spearheaded by Impact Shakers Labs, collaborated with various stakeholders to boost social innovation skills of learners in higher education. The initiative launched two idea accelerator pilots at ESSEC and ESADE Business Schools, focusing on homelessness. The project applied Design Thinking methodology to stimulate creative problem-solving, encapsulated its approach in a toolbox for future use. Project activities included research, curriculum co-design, and running accelerators. Key outcomes were a challenge-based accelerator curriculum, the execution of two programmes involving 55 students and 11 social enterprise ideas, and the widely disseminated toolbox. The project underscored the importance of academia-business collaboration, time management and fieldwork preparation (Expand, 2024[93]).

As a nationally focused example, in Hungary the government has launched a **Cooperative Doctoral Programme** to increase the number of employees in research, development, and innovation, particularly in mathematics, natural science, engineering, IT and agricultural sciences The programme encourages doctoral students to collaborate with businesses within the institutional framework of higher education doctoral schools, fostering innovation ecosystems within universities. The programme is governed by the Ministry of Culture and Innovation and operated by the National Research, Development and Innovation Office operates it. From 2020 to 2023, the programme supported 516 doctoral students, their schools, and business partners (NRDI Office, 2023[94]).

Source: Adapted from EIPC case studies shared by EIT Manufacturing, EuroSpaceHub and the Hungarian Ministry of Culture and Innovation; EIT Manufacturing Doctoral School (2024[90]),” The Doctoral School: Turn your thesis into a startup”, https://www.eitmanufacturing.eu/what-we-do/education/education-programmes/empower-programme/doctoral-school/ EuroSpaceHub (2024[91]), “The European Innovation Ecosystem to digitally connect the Space Academic, Research, Industry and Startups to leverage Innovation Together”, https://www.eurospacehub.com/about/; National Research, Development and Innovation Office, Hungary, “Cooperative Doctoral Programme Doctoral Scholarship 2023 call for applications”, https://nkfih.gov.hu/english/nrdi-fund/funded-institutions-kdp-23; EFE (2023[92]), “Ethical Food Entrepreneurship Project Information”, https://www.savonia.fi/en/rdi-projects/rdi-project-list/?id=1605; EXPAND (2024[93]), “A challenge-based accelerator”, https://expandaccelerator.eu/

Encouraging students to engage in industry-led or sponsored innovation activities

Private businesses run various innovation-related activities involving students, such as hackathons, workshops, student conferences, job simulation competitions and innovation contests. These activities can serve several purposes - raising the profile of the company, generating new ideas to solve business challenges, and connecting with students who have strong skills and a propensity for innovation. Participation in industry-led innovation activities also offer advantages to students, giving them the opportunity to apply academic knowledge in real-world scenarios, enhance their professional skills, and establish contacts within their chosen industry.

Innovation-related competitions and contests, including contests addressing “grand challenges”, such as sustainable development and achieving technological breakthroughs (Box 8), have been found to have positive economic and social impacts, and to generate favourable spillovers after their conclusion (Liotard and Revest, 2018[95]). Therefore, governments and HEIs can work to find ways to encourage learners to participate in company activities that aim to stimulate green and digital innovation - for example, providing funding or academic credit for participation.

Box 8. Examples of industry-sponsored innovation competitions and partnerships across OECD countries.

The **Bridgestone World Solar Challenge** is an international event for solar-powered cars that takes place every two years since 1987 (World Solar Challenge, n.d.[96]). The race spans 3 022 kilometres through the Australian Outback, from Darwin to Adelaide, and was created to promote the development of solar-powered vehicles. The vehicles are engineered and built by the students themselves, mostly from universities or secondary schools, and the competition attracts teams from around the world.

The **Imagine Cup**, a global technology competition by **Microsoft**, invites student entrepreneurs to develop AI-based solutions for societal issues, offering a robust entrepreneurial ecosystem with mentorship and AI technology access (Microsoft, n.d.[97]). The top three teams showcase their startups at Microsoft's annual Build conference, with the winners receiving USD 100 000 and a mentoring session with the Microsoft CEO.

Airbus, the leading European multinational aerospace corporation, has a long tradition of fostering partnerships with HEIs. In 2022 and 2023, the company signed numerous Airbus Academic Partnership agreements (AAP) with universities aimed at developing the next generation of aerospace professionals (Linkedin, 2023[98]). These partnerships aim to foster collaboration on curriculum development, continuous training, recruitment, inclusion and diversity, entrepreneurship, education for students, sustainability, technology, and innovation (Cranfied University, 2022[99]). Airbus also runs a dedicated internship programme and **"Airnovation"** summer academies for students from partner universities (Airbus, 2018[100]).

In partnership with **UNESCO**, **Airbus** organises **'Fly Your Ideas',** a global competition that encourages students worldwide to innovate for the future of aerospace (Airbus, 2019[101]). The competition, which has been held since 2008, involves three rounds: ideation, idea development and mentoring, and a live final. It challenges students to submit proposals to tackle aerospace challenges in areas such as electrification, data services, and artificial intelligence.

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Higher Education Policy

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For more information

Contact: Gillian Golden (gillian.golden@oecd.org)

Website: https://www.oecd.org/education/higher-education-policy/

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Annex A. Education and Innovation Practice Community International Online Knowledge Exchange Agenda

Thursday 11 January 2024, 14:30 – 16:15 CET

14:30 – 14:40	***Welcome*** • **Simon Roy**, Team Lead, Higher Education Policy, Policy Advice and Implementation Division (PAI), Directorate for Education and Skills (OECD) • **Luca Perego**, Head of Unit, C1 "Innovation and EIT", Directorate-General for Education, Youth, Sport and Culture (European Commission)
Session 1 – Identifying key competencies to support the green and digital transition	
14:40 – 14:55	***What are the most pressing needs for the business sector and what can be done to meet them?*** • **Robert Plummer,** Senior Advisor, Business Europe *Audience Q&A*
Session 2 – Motivating students and designing education for green innovation	
14:55 – 15:25	***Educating the sustainability leaders of the future: interdisciplinary best practice*** • **Walter Leal,** Professor of Climate Change Management & Environment and Technology, Hamburg University of Applied Sciences and Manchester Metropolitan University ***Mainstreaming sustainability education in higher education institutions: challenges and options for progress*** • **Teri Balser,** Professor of Sustainability Education, University of Calgary, Alberta, Canada **Respondent:** Tamara Ciobanu, Executive Committee, European Students' Union *Audience Q&A*
Session 3 – Fostering key competencies in tomorrow's innovators – bridging policy and practice	
15:25 – 15:40	***The DCU Futures programme within Ireland's Human Capital Initiative*** • **Ciaran Dunne,** Professor and Transversal Skills Director, Dublin City University, Ireland *Audience Q&A*
Session 4 – Developing education programmes for the digital frontier	
15:40 – 16:10	***Developing AI Education at the University of Cyprus and collaboration on Master programmes in Artificial Intelligence 4 Careers in Europe (MAI4CAREU) project*** • **Elpida Keravnou-Papailou**, Professor of Computer Science, Programme coordinator of the Master in AI, University of Cyprus

	What does it take to develop degree programmes for deep-tech fields? The case of quantum science and technology at the University of Barcelona • **Bruno Julia Diaz,** Professor in the Department of Quantum Physics and Astrophysics, Coordinator of the Master in Quantum Science and Technology, University of Barcelona **Respondent:** Caroline Paunov, Head of Secretariat for the OECD Working Party on Innovation and Technology Policy, Directorate for Science, Technology, and Innovation, OECD *Audience Q&A*
Closing remarks	
16:10 – 16:15	• **Loredana Lombardi**, Policy Officer, Unit C1 "Innovation and EIT", Directorate General for Education, Youth, Sport and Culture (European Commission)

This Education Policy Perspective has been authorised by Andreas Schleicher, Director of the Directorate for Education and Skills, OECD.