Education and innovation for the digital and green transitions: **How higher education can support effective curricula in schools**

The Education and Innovation Practice Community (EIPC)

This is the first 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 support knowledge exchange within an **Education and Innovation Practice Community (EIPC)**. EIPC is an action of the European Commission (DG EAC), implemented with the OECD under the New European Innovation Agenda, flagship 4 “Fostering, attracting and retaining deep tech talent”.

This analytical report examines how higher education institutions (HEIs) can support the integration of competencies for innovation into school curricula, drawing on research evidence and policy and practice examples from a wide range of education systems. It offers six options for consideration by education policy makers to strengthen HEIs’ role in supporting effective curriculum development in schools:

1. Develop structures to strengthen HEI involvement in **curriculum analysis and facilitating dialogue between teachers, schools and policy makers** to inform school curricular reforms.
2. Support HEIs to develop **educational resources** for schools – specifically, resources on digital and climate change literacy – and promote their use through guidance, translation and online platforms.
3. Mobilise the higher education sector to engage in collaborative and applied **educational research** on education for the digital and green transitions.
4. Explore the potential of **service learning** involving HEIs, schools and civil society to increase community-based learning to help secondary students develop competencies for innovation.
5. Support HEIs to engage in **science communication** with schools, to strengthen research-based teaching practices and raise students’ motivation and interest in science, research and innovation.
6. Examine the potential of **dual enrolment programmes** to establish structured collaboration between schools and HEIs for curriculum design and delivery in upper secondary education.

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1. Introduction

In 2022 and 2023, the earth experienced the hottest summers on record. The World Meteorological Organisation (WMO) predicts that the El Niño climate event could push earth's temperatures to even further extremes over the next five years (WMO, 2023[1]). Transitioning our economies and societies to net zero greenhouse-gas emissions, adapting to climate change and mitigating further consequences of global warming are urgent priorities, and education systems have an important role to play in supporting this. As the OECD argued in a major report on climate change policy released earlier in 2023, "innovation and skills development are key components of an accelerated transition to net zero [... and] educational institutions should provide the foundational knowledge and skills to identify and resolve environmental challenges, and shape attitudes and behaviours that lead to individual and collective action" (OECD, 2023, pp. 52, 156[2]). Education also plays a key role in helping citizens develop the digital competencies needed to live in an interconnected and increasingly digitalised world. The acceleration of digitally enabled economic and social activity, further spurred by the global COVID-19 pandemic, has opened up the risk of new forms of digital divide and an aggravation of existing ones (OECD, 2020, p. 2[3]). To ensure that the twin digital and green transitions occur in as fair and just a manner as possible, education systems must prepare citizens for the changes required and to use digital technologies as enablers of change (Muench et al., 2022[4]).

> Supporting governments to achieve a fair and just transition to a digital and climate neutral economy and society, through education, is a priority for both the OECD and the European Commission.

Supporting governments to achieve a fair and just transition to a digital and climate neutral economy and society, through education, is a priority for both the OECD and the European Commission. In their "Declaration on Building Equitable Societies through Education", Ministers and representatives of 41 OECD member countries and associate countries committed to "empowering all learners [...] to develop the knowledge, skills, attitudes and values to fulfil their potential [...] as they face constant change and sudden disruptions such as technological advancements or the transition to a green economy" (OECD, 2022, p. 5[5]). The digital and green transitions are also key priorities in the European Union's (EU) "Digital Education Action Plan (2021-2027)" (European Commission, 2023[6]) and Council Recommendation on "Learning for the green transition and sustainable development" (Council of the European Union, 2022, p. 5[7]). To advance the twin green and digital transitions and drive deep tech[1] innovation, the European Commission and OECD have joined forces to establish an Education and Innovation Practice Community (EIPC) as part of the "New European Innovation Agenda" (European Commission, 2022[8]). By boosting international dialogue among education policy makers, practitioners, students and businesses, EIPC seeks to develop talent for innovation in secondary and higher education, as well as adult upskilling and reskilling.

Building competencies to support innovation for the digital and green transitions in schools

School education must ensure that students develop competencies that will enable them to shape, and adapt to, the social and economic innovations needed for the digital and green transitions. Analysis by Broberg (2023[9]) and the *OECD Skills Outlook 2023* (OECD, 2023[10]) suggests that a wide range of competencies can support innovation for the digital and green transitions, although it is challenging to establish direct links between particular competencies and specific types of innovation. In this report, "competencies for innovation" is used to refer to a broad set of knowledge, skills, attitudes and values acknowledged in the research literature and various competency frameworks as essential for living and working in greening and digitalising economies (see Box 1).

Box 1. Foundational competencies to support innovation for the digital and green transitions

Based on a comparative analysis carried out by Broberg (2023[9]) of the knowledge, skills, attitudes and values included in different competence frameworks – both comprehensive frameworks (e.g. Education 2030 Learning Compass (OECD, 2019[13])) and frameworks with a specific focus on digital or climate change education (e.g. DigComp (Vuorikari, Kluzer and Punie, 2022[10]), GreenComp (Bianchi, Pisiotis and Cabrera Giraldez, 2022[11])) – the following set of competencies can be regarded as crucial for living and working in greening and digitising economies:

- ***Knowledge***: strong foundations in science and an understanding of how these subjects link to innovation and sustainability. Key knowledge domains include biology, physics and chemistry, as well as climate change and digital literacy.
- ***Skills***: social, digital and transversal cognitive skills to live and work effectively in a global and highly interconnected 21st century society. A distinction can be made between basic digital skills (e.g. proficiency in information and communication technology (ICT), and data literacy); behavioural, social and emotional skills (e.g. communication, collaboration); and higher order cognitive skills (e.g. creativity, problem solving, systems thinking, critical thinking, research skills, metacognition, digital cognition).
- ***Attitudes and values***: positive values and attitudes towards the environment (e.g. empathy, openness to change) and digital citizenship (e.g. digital etiquette, online behavioural norms).

Source: Adapted from Broberg (2023[9]), "Understanding the competencies needed for innovation in greening and digitalising economies: Insights from existing literature", *OECD Education Working Papers*, OECD Publishing, Paris (forthcoming).

Higher education can support schools to integrate competencies for innovation into curricula

This analytical report examines higher education's role in supporting the integration of competencies for innovation into school curricula. The school curriculum can be defined as "all the learning that goes on in schools, whether it is expressly planned and intended or is a by-product of our planning and/or practice" (Kelly, 2004, p. 6[9]). Curriculum development is one of the two major "connection points" or mechanisms – alongside initial teacher education (ITE) and the continuing professional learning (CPL) of teachers and school leaders – through which higher education has traditionally engaged with schools (Walsh and Backe, 2013[11]; RCUK, 2020[12]; OECD, 2022[13]; Reimers M. and Marmolejo, 2021[14]).[2] To help schools rethink what and how to teach, HEIs themselves will need to rethink how they support curriculum design. In many education systems, it is academic subject-matter experts who drive content-heavy school curricula, leaving schools with little room for broader competence development (OECD, 2020[17]).

To help governments across OECD and EU jurisdictions strengthen higher education's role in promoting effective school curricula, this report offers a review of the research literature as well as policy and practice examples of higher education-school collaboration in support of competencies for innovation. The primary focus is on examples that can help students develop climate change literacy and digital competencies, as this supports the work of EIPC (which focuses on developing talent for the digital and green transitions, and deep-teach innovation). The report draws on an extensive review of the scientific literature, expert interviews, and inputs from the EIPC network. The desk-based literature review informed the identification of inspiring policy and practice examples of higher education-school collaboration, and the establishment of a growing EIPC network (see Annex 1). Through an international online knowledge exchange event, the OECD team has convened the EIPC network to collaboratively develop key messages on higher education support for effective school curricula (see Annex 2), which have informed this report.

2. What challenges do schools face to integrate competencies for innovation into their curricula?

This section discusses key challenges facing school educators with the integration of competencies for innovation into school curricula. This is done by reviewing available evidence on the integration of innovation competencies in curriculum frameworks and school curricula, as well as the effectiveness of school curricula in supporting the development of students' competencies for innovation.

The school curriculum guides the teaching and assessment practices of teachers and how students learn. If competencies for innovation are recognised and embedded in school curricula, this would be expected to enhance students' capacity to develop these competencies across subjects, grades and ability levels. In curriculum analysis, a distinction can be made between the "written", "taught" and "attained" curriculum (OECD, 2020, p. 13[10]). The written (or intended) curriculum refers to the national, regional or local curriculum frameworks or guidelines, often included in official government documents, guiding the work of schools at different levels of education. The taught (or implemented) curriculum covers the teaching, learning and assessment practices implemented by school leaders and teachers: in other words, the way in which the written curriculum is interpreted at local school level in the teaching, learning and assessment practices and the learning materials used. The attained (or achieved) curriculum covers what learners have learned from the teaching and learning to which they have been exposed as part of the curriculum. Drawing on data from the OECD's Programme for International Student Assessment (PISA), the Teaching and Learning International Survey (TALIS), as well as curriculum analysis carried out by the OECD's Education 2030 project, the following sections review evidence on how competencies for innovation are integrated into the written and taught curricula of schools across OECD jurisdictions, and the impact of this on student learning.

Competencies for innovation are mainly integrated as cross-curricular themes in written curricula, rather than in individual school subjects

Across the OECD and EU, the work of teachers and school leaders is guided by subject-specific objectives, curriculum goals, and legislation that prescribe the intended outcomes of teaching and learning (OECD, 2022[16]). Competencies for innovation are often integrated as cross-curricular themes in these documents. Between 2018 and 2020, the OECD carried out a Curriculum Content Mapping exercise (CCM), which examined the extent to which the competencies included in the OECD's Learning 2030 Compass (OECD, 2019[17]) – several of which directly relate to those identified as crucial for living and working in greening and digitalising economies (see Box 1**Error! Reference source not found.**) – are integrated into the written curricula of 15 jurisdictions in lower secondary education.[3] The analysis found "environmental sustainability" to be the most frequently articulated cross-curricular theme (present in 57% of countries). ICT or digital literacy also had a strong presence (present in 40% of countries) (OECD, 2020[18]). **Norway**'s core curriculum, for example, is structured around three interdisciplinary topics: health and life skills, democracy and citizenship, and sustainable development, which "demand engagement and effort from individuals and local communities, nationally and globally. The pupils develop competence in connection with the interdisciplinary topics by working with issues from various subjects" (Norwegian Education Directorate, 2020[19]). Sustainability is also one of three cross-curricular themes in **Australia**, and digital literacy is one of seven general capabilities learners are expected to develop from Foundation to Year 10. The Australian curriculum is delivered in a digital format, which allows teachers to filter and see where digital literacy and sustainability can be taught most authentically to engage students (ACARA, n.d.[21]). The recently updated curriculum frameworks for primary and lower secondary education in the **Flemish Community of Belgium** are formulated around 16 key competencies, one of which is digital and media literacy. When designing their curricula, schools are free to decide in which subjects and how to support the development of these competencies (Flemish Department of Education and Training, 2023[20]).

One of the reasons for the cross-curricular integration of competencies for innovation in curriculum frameworks, especially digital and green competencies, is to address challenges of curriculum expansion and curriculum overload (OECD, 2020[18]). Research shows that when digital competencies are integrated into teaching and learning in a transversal way, this allows teachers to pay explicit attention to how learners use digital technologies in different discipline-related contexts, which is, in turn, a more effective way of developing these competencies than addressing them as part of a single subject (Grix, 2020[21]). The complexity inherent to climate change also requires a regular and in-depth examination of the topic in relation to different subjects, and offers opportunities to help learners establish links between subjects (Jorgenson, Stephens and White, 2019[22]).

While integrating competencies for innovation as cross-curricular themes can be a way to circumvent the challenge of curriculum expansion and overload, several experts interviewed for this report argued that it is important to carve out explicit time and space in the curriculum to ensure their effective development. Cross-curricular integration carries the risk of competencies being "buried" or "lost" in the content of existing subjects, with no teacher being given explicit responsibility to support their development. In this context, it will be important for governments to rethink how subject-matter experts from higher education are involved in curriculum development, because in many education systems they are the ones driving the content of curricula, leaving subject teachers with limited time and space to help students develop more transversal skills such as creativity, critical thinking or digital literacy (OECD, 2020[18]).

The OECD's CCM has found large differences between countries in terms of how present different competencies for innovation are across the content of lower secondary school curricula. For example, while the competency of "taking responsibility" (i.e. learners' capacity for creativity and taking responsibility for their own learning throughout life) was found to be embedded quite strongly in the Estonian (68%) and Chinese (54%) curriculum, it is barely present in the Portuguese curriculum (5%). Most countries reported that "creating new value" (i.e. the ability to add new value by contributing to the development of new solutions, products, services, or ways of thinking and living) was embedded in over 30% of countries' curriculum content, but there were again large differences between countries. While it is present in 63% of Estonia's curriculum, "creating new value" is present in only 3% of Greece's curriculum. "Co-operation/collaboration and teamwork" are more common in curricula, with levels ranging from 17% in Portugal to 71% in Korea. "ICT/digital literacy" is also embedded in more than 30% of countries' written curricula. "Environmental literacy/literacy for sustainable development" is typically embedded in more than 20% of countries' written curricula (OECD, 2020[18]). These findings suggest that there is scope to embed competencies for innovation more strongly and explicitly across different subjects in the curriculum in many education systems. This is an area where higher education can support schools, for example through the creation of educational resources that "anchor" competencies for innovation in different subjects and support "bridge building" between subjects and school years.

In some jurisdictions, curriculum frameworks also mention that school education should contribute to achieving broader social and economic goals (such as inclusion, employability, well-being), beyond the development of specific competencies or subject knowledge (OECD, 2022, p. 71[16]). This reflects the fact that education systems are increasingly asked to prepare young learners to adapt to and help find solutions for various economic and social challenges facing society. However, a review of the educational goals included in national and regional policy documents on education shows that, to date, only 18% of OECD jurisdictions focus on articulating educational goals more strongly around economic outcomes, and 17% around social outcomes such as increasing the participation and attainment rates of students with special educational needs, sustainability or citizenship. Articulating educational goals around future workforce needs such as capacity for lifelong learning, skills development or entrepreneurship was reported by only 13% of jurisdictions; and only 8% of countries reported environmental goals (OECD, 2022, pp. 71-72[16]). To ensure young learners are prepared to contribute to tackling key social and economic challenges facing society, it is likely that governments will need to pay greater attention to embedding social and economic goals in their curricula, in addition to holistic competence development and supporting student well-being.

School educators involved in curriculum update often lack curriculum design expertise

National or regional curriculum frameworks typically provide more guidance to schools on *what* to focus on in their curricula (i.e. broad educational goals as well as which subjects or competencies to prioritise) than on *how* to support and assess student learning (i.e. how to translate educational goals or curriculum content into lesson plans for different subjects or which educational resources or teaching methods to use). The area where teachers seem to have the greatest responsibility is the design of instruction and learning materials, with "a majority of principals report[ing] significant responsibility for teachers in choosing learning materials (75%) and determining course content (52%)" (OECD, 2020, p. 200[23]).

The OECD has argued that giving school leaders and teachers responsibility for designing their own educational goals, content, learning materials, pedagogies and assessments offers potential to adapt to students' individual learning needs as well as "greater responsiveness to local communities; and an improved potential for innovation" (OECD, 2022[24]). The TALIS 2018 survey has found that, on average across OECD countries, teachers who feel more control of the decisions regarding the classes they teach tend to report that they work in innovative environments (OECD, 2020, p. 205[23]). A move towards greater school autonomy for curriculum design can also address challenges of "implementation time lag" in curriculum reform processes (OECD, 2022, p. 50[16]). A 2018 study reviewing curriculum reforms in 11 jurisdictions found that a full national curriculum reform takes two years on average for decision making, and another eight years for full implementation (Van den Akker, 2018[25]). The frequency of curriculum renewal cycles typically ranges from every 2-5 years in some jurisdictions (e.g. Czechia, Hungary) to every 15-20 years in others (e.g. Québec, Canada) (OECD, 2022, p. 19[16]).

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While levels of school autonomy for curriculum design vary between OECD and EU jurisdictions and different levels of education,[4] more decentralised education systems face the challenge that school leaders and teachers may not have the expertise needed to design curricula which translates the educational goals included in the written curriculum into teaching practice (Van den Akker, 2018[25]). Highly centralised school education systems (i.e. where schools have limited autonomy for curriculum design) face the risk that "the curriculum content that children are learning in school [...] lags behind what they will be expected to know and do" and – importantly – does not respond to students' individual learning needs (OECD, 2022, p. 12.[16]). Experts interviewed for this report said that the integration of competencies for innovation into curricula requires renewal of teaching, learning and assessment practices – which, in turn, requires staff with the capacity to achieve this.

Huizinga et al. (2013[26]) propose six areas of curriculum design expertise required by school educators: subject matter knowledge, pedagogical content knowledge, curricular consistency expertise, curricular design expertise, intra-personal skills, and inter-personal skills. Van den Akker's "curricular spider web" covers nine components: aims and objectives; learning content; learning activities; teacher role; materials and resources; grouping; location; time; and assessment. One of the main challenges for curriculum improvement, he notes, is "creating balance and consistency between the various components of a curriculum (i.e. plan for learning)" (Van den Akker, 2010, p. 39[27]). This is particularly relevant to competencies for innovation because, as noted earlier in this report, the development of competencies such as environmental awareness or digital literacy require an interdisciplinary and progressive approach to teaching and learning, across grades and subjects. HEIs can support schools to make the transition towards such practices by providing guidance, access to educational resources, training and peer learning.

Many school curricula fail to equitably support learners to develop the competencies needed to shape – and adapt to – innovation for the digital and green transitions

Assessing how effective schools are at equipping young learners with competencies that can help them shape, and adapt to, the social and economic innovations needed to digitalise and green our economies is not an easy task. There are several reasons for this. First, as noted there is limited empirical evidence that directly links distinct skillsets to specific social or economic innovations (Broberg, 2023[9]; OECD, 2023[10]). Second, the concept of innovation itself has often been narrowly focused on how innovation takes place in firms, understood as “the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method” (OECD, 2009, p. 11[28]). Not only can innovation be defined more widely to encompass all sectors of human endeavour, but the relationship between different competencies and various innovation outcomes is far from straightforward. Finally, reliable student assessment requires innovative approaches in the way assessment itself is carried out. A recent OECD report on *Innovating Assessment to Measure and Support Complex Skills* notes “a lack of systemic understanding in how to measure or capture the attainment of 21st Century competencies” (Foster and Piacentini, 2023, pp. 35-40[29]).

There have been attempts to develop more reliable and internationally comparable student outcomes data, including on more complex and hard-to-measure competencies. For example, the OECD’s Programme for International Student Assessment (PISA), first administered in 2000, has been collecting comparative data on the level and distribution of 15-year-old students’ performance in reading, mathematics, and science every three years. Since 2012, a series of innovative domains has been included in every PISA assessment cycle. The innovative domains assessed to date are: creative problem-solving (OECD, 2014[30]), collaborative problem solving (OECD, 2017[31]) and global competence (OECD, 2020[32]). The 2022 innovative domain was creative thinking (OECD, 2022[33]), with results expected in June 2024. In 2025, the OECD will assess students’ readiness for learning in a digital world (OECD, 2023[34]) and their environmental-science literacy and science identity (OECD, 2023[35]), with initial results expected to be published in December 2026. In addition to collecting information on students’ academic performance, the OECD has commenced work on assessing students’ social and emotional skills, with first results published in 2021 (OECD, 2021[36]). More recently, the OECD has carried out an examination of the PISA indicators covering environmental issues (between 2006 and 2018) to assess students’ readiness to take on environmental challenges (OECD, 2022[37]; Borgonovi et al., 2022[38]; Borgonovi et al., 2022[39]).

Table 1 groups key findings from this work around the three competency domains of knowledge, skills, attitudes and values identified in Box 1 as crucial living and working in greening and digitising economies. Looking at students’ performance on different knowledge domains, PISA data shows that nearly one-quarter of 15-year-old students had low performance in science and mathematics in 2018 on average across OECD countries, while the share of top performers in both domains was less than 15%. Supporting students to obtain higher proficiency levels in science and mathematics will be crucial to drive innovation, as both are key for careers in science, technology, engineering and mathematics (STEM), and research shows that STEM graduates are more likely to work in a highly innovative job after graduation than other students (Avvisati, Jacotin and Vincent-Lancrin, 2014[40]). The results also suggest a need to strengthen learners’ nuanced understanding of climate change science, as evidence shows a decline in student performance in environmental science between PISA 2006 and PISA 2015. Looking at performance levels in relation to different skills, evidence from PISA 2012 and 2015 suggests that, on average across OECD countries, one in five 15-year-olds cannot effectively solve straightforward problems (i.e. related to situations with which they are familiar), either collaboratively or individually. Data collected from students, parents and teachers also suggest that creativity and curiosity are lower among 15-year-olds than 10-year-olds, suggesting a decline in creativity as students enter adolescence. Finally, looking at students’ attitudes and values, evidence suggest that, on average across OECD countries, only 33% of students in 2018 achieved minimum benchmarks across all four environmental-sustainability competence areas of the European Commission’s GreenComp framework (Bianchi, Pisiotis and Cabrera Giraldez, 2022[41]).

Table 1. Students' readiness to shape and absorb innovations for the digital and green transitions: key findings from OECD and PISA datasets

Competency	Dataset	Summary of key results (OECD averages)
1. Knowledge		
Mathematics	PISA 2018	Close to one in four (24%) 15-year-olds did not attain a basic proficiency Level 2 in mathematics. At the highest performance Levels 5 and 6, only 10.9% and 2.4% of students respectively were able to complete tasks. Level 6 is defined as the ability to "conceptualise, generalise and utilise information based on their investigations and modelling of complex problem situations, and can use their knowledge in relatively non-standard contexts" (OECD, 2019, p. 105[42]).
Science	PISA 2018	Close to one in four (22%) 15-year-olds did not attain a basic proficiency Level 2 in science. At the highest performance Levels 5 and 6, only 6.8% and 0.8% of students respectively were able to complete tasks. Level 6 is defined as the ability to "draw on a range of interrelated scientific ideas and concepts from the physical, life, earth and space sciences and use content, procedural and epistemic knowledge in order to offer explanatory hypotheses of novel scientific phenomena, events and processes or to make predictions" (OECD, 2019, p. 113[42]).
Environmental science	PISA 2018	Student performance in environmental science declined between PISA 2006 and PISA 2015, and "students in 20 out of the 26 countries/economies with available data had more difficulties identifying short-term than long-term solutions to climate change: that is, distinguishing between combatting climate change and adapting to its effects" (OECD, 2022, p. 12[37]).
2. Skills		
Creative thinking	PISA 2022	The PISA 2022 assessment will include insights on creative thinking, which is defined as the capacity to "engage productively in the generation, evaluation and improvement of ideas that can result in original and effective solutions, advances in knowledge, and impactful expressions of imagination" (OECD, 2022[33]).
Social and emotional skills	OECD 2021	The social and emotional skills survey collected data from students, parents and teachers. The findings suggest that creativity and curiosity are lower among 15-year-olds compared to 10-year-olds. This suggests a decline in creativity as children enter adolescence. Boys also report higher emotional regulation, sociableness, and energy levels, while girls display higher levels of responsibility, empathy and cooperation. Socio-economically disadvantaged students report the highest levels of socio-emotional skills (OECD, 2021[36]).
Collaborative problem-solving	PISA 2015	In 2015, on average 28% of students could not solve straightforward collaborative problems, and only 8% were top performers in collaborative problem solving, which means that they could "effectively engage in a process whereby two or more agents attempt to solve a problem by sharing the understanding and effort required to come to a solution and pooling their knowledge, skills and efforts to reach that solution" (OECD, 2017, p. 47[31]).
Creative problem-solving	PISA 2012	In 2012, on average one in five students was able to solve only straightforward problems – if any – provided they refer to familiar situations. Only 11.4% of students were top performers in problem solving, meaning that they can solve problems at Level 5 or 6 in the assessment scale (OECD, 2014[30]).
3. Attitudes and values		
Environmental sustainability competence	PISA 2018	Following the Commission's GreenComp framework (Bianchi, Pisiotis and Cabrera Giraldez, 2022[41]) and using PISA data, the OECD has found that "in 2018, only 31% of 15-year-old students, on average, throughout EU countries and 33% throughout OECD countries […] demonstrated having achieved at least minimum benchmarks across all four environmental sustainability competence areas" (Borgonovi et al., 2022, p. 6[39]).
Global competence	PISA 2018	In 2018, around four in five students were enrolled in schools whose curriculum covered opportunities to learn about global issues and intercultural understanding. However, large differences between countries exist, and the number of learning activities covering global and intercultural topics are positively associated with students' attitudes and dispositions (OECD, 2020[32]). "The strongest associations were between coverage of climate change and global warming in the curriculum and students' awareness of these issues" (Schleicher, 2020[43]).
Learning in a digital world	PISA 2025	The PISA 2025 innovative domain will be learning in a digital world. It will assess students' capacity to "engage in a self-regulated process of knowledge building and problem solving using computational tools" (OECD, 2023[34]). The assessment framework will be published in November 2023.
Agency in the Anthropocene	PISA 2025	In 2025, the PISA science test will assess students' environmental-science competencies. The central construct for the PISA 2025 environmental-science competency is defined as "Agency in the Anthropocene". Students who demonstrate this competency are able to: "1. Explain the impact of human interactions with Earth's systems; 2. Make informed decisions to act based on evaluation of diverse sources of evidence and application of creative and systems thinking to regenerate and sustain the environment; 3. Demonstrate hope and respect for diverse perspectives in seeking solutions to socio-ecological crises" (OECD, 2023, p. 50[35]).
Science identity	PISA 2025	The PISA 2025 science test will include "science identity" as a major construct. It will assess: 1) students' readiness to value scientific perspectives and approaches; 2) students' scientific capital and willingness to engage with science; and 3) students' environmental awareness, concern and agency (OECD, 2023[35]).

Note: The evidence presented in this table is drawn from multiple OECD reports and PISA results published between 2005 and 2023.[5] The results are structured around the competencies identified in Box 1 as crucial for living and working in greening and digitising economies.

Several higher education experts interviewed reported that the results highlighted above suggest that school curricula are insufficiently adapted to equip learners with the broad range of knowledge, skills, attitudes and values needed to shape – and adapt to – innovation in the context of the digital and green transitions. Going forward, they underlined the need to develop a commonly agreed set of “Education and Innovation Indicators” to strengthen the evidence base on student outcomes, as well as to help design and implement public policies and institutional practices to promote competencies for innovation in schools. Such data development would ideally examine disparities in competency acquisition across school populations. One of the strongest gaps in educational performance measurements is between boys and girls, and between students with different socio-economic backgrounds. Boys and students from socio-economically disadvantaged backgrounds are more likely to be low achievers in reading, mathematics and science than their peers from better-off backgrounds. At the same time, however, boys are more likely to be top performers in mathematics and science (Encinas-Martín and Cherian, 2023[44]). In environmental sustainability matters, boys also report higher levels of awareness of challenges such as nuclear waste or the use of genetically modified organisms, while girls report higher levels of awareness of water shortage, air pollution and the extinction of plants and animals. Students from socio-economically disadvantaged backgrounds tend to care less about the environment than students from more advantaged households (Borgonovi et al., 2022[38]).

As noted, education systems in OECD and EU countries have not been successful at countering these gaps, which often surface early in formal education and tend to widen over time, with likely implications for study and career choices (Staring et al., 2021, p. 161[45]). At the level of public policy, documenting attainment gaps in competencies for innovation across different dimensions of diversity – as well as examining their causes, consequences and possible policy responses – will be an important part of future policy action to improve overall achievement levels in the population. The outputs from the OECD’s *Strength through Diversity* project can be used as a basis for this work. The project has identified six interrelated dimensions of diversity, noting many possible intersections between them: migration-induced diversity, ethnic groups, national minorities and Indigenous peoples, gender, gender identity and sexual orientation, special education needs, and giftedness (Cernie et al., 2022, p. 21[46]). It has also published a report which presents an initial set of guidelines to help governments and policymakers design, implement and monitor policies for equity and inclusion (OECD, 2023[47]), with the help of an “Education Equity Dashboard”, which contains 35 internationally comparable indicators on different aspects of equity in and through education (OECD, 2023[48]).

3. How do HEIs support the integration of competencies for innovation into school curricula?

This section discusses six mechanisms through which higher education institutions support the integration of competencies for innovation into school curricula. For each mechanism, the report reviews evidence on the impact of the support mechanism in question, key challenges facing HEIs in scaling and strengthening the impact of their support for schools, and how public policy can support institutional good practice.

HEIs support school curriculum development through six key mechanisms

Table 2 presents an overview of six mechanisms through which higher education institutions support the integration of competencies for innovation into school curricula. The table builds on a typology of mechanisms for integrating education for sustainable development (ESD) into school curricula,[6] developed by Tasiopoulou et al. (2022[49]).

Table 2. How can HEIs support the integration of competencies for innovation into school curricula?

Mechanism	Description	Objective
Supporting the development of curriculum frameworks and teaching materials		
1) Curriculum analysis and stakeholder dialogue	HEIs carry out specific studies and facilitate stakeholder dialogue to provide policymakers with evidence on the latest developments in educational research and practice and ensure the relevance of written curriculum frameworks guiding school practice.	Integration of competencies for innovation into *written* curriculum frameworks developed by national or regional policy makers
2) Educational resources	HEIs develop research-based lesson plans, worksheets, tests or learning activities to support educators with the integration of competencies for innovation in their classes.	Integration of competencies for innovation into the *taught* curricula developed by school leaders and teachers
Development of teaching and learning methods to promote competencies for innovation		
3) Educational research	HEIs engage in research on new educational approaches, and pilot new teaching and assessment methods in collaboration with schools and industry partners.	Integration of new or improved learning, teaching and assessment practices in pedagogical practice
4) Service learning	HEIs engage in service learning with schools to support educators with the development of place-based and community-based learning that provides learners with opportunities for applied learning, linked to real-world challenges and innovations.	Integration of real-world, applied and community-based learning into school curricula
Enriching school curricula to accelerate and deepen the development of competencies for innovation		
5) Science communication	HEIs organise (online) courses, summer camps, school visits or competitions to enrich school curricula and enable young learners, teachers and parents to develop a more in-depth understanding, interest and competencies in science, research and innovation.	Strengthening learners' motivation, interest and competencies in science, research and innovation
6) Dual enrolment programmes	Upper secondary schools and HEIs collaborate to develop and deliver dual enrolment programmes, providing learners with opportunities to develop competencies for innovation and accumulate learning to count towards a higher education degree.	Supporting gifted/talented and disadvantaged learners to develop competencies for innovation

Note: The categorisation of higher education support mechanisms for the integration of competencies for innovation in school curricula builds on the typology for ESD curriculum integration developed by Tasiopoulou et al. (2022[49]). It has been adapted based on a desk-based review of policies and practices across OECD and EU member countries, expert interviews and an online international knowledge exchange of the EIPC Network on 18 April 2023, focused on higher education support for the integration of competencies for innovation in school curricula.

Supporting development of curriculum frameworks and teaching materials

This section discusses the first two support mechanisms introduced above: 1) higher education's role in curriculum analysis and stakeholder dialogue to support curricular reforms; and 2) how higher education institutions develop educational resources to support curriculum design at school and classroom levels.

Mechanism 1: Curriculum analysis and stakeholder dialogue to inform curricular reforms

To support the development of competencies for innovation in school education, it is important for the written curriculum frameworks guiding the work of teachers and school leaders to integrate these competencies across subjects and within subject-specific guidelines. In recent years, several governments have started curriculum reforms to ensure curricula reflect societal developments and innovations (OECD, 2020[10]). Curricular reform involves a lengthy process of dialogue and negotiation with many stakeholders, which is crucial to strengthen the relevance and build ownership of the curriculum over the long term. This also creates challenges for policymakers who need to make informed decisions on which competencies to prioritise, and how to embed them in written curricula (Looney et al., 2022[50]). In this process, HEIs can provide independent advice to governments supplementing the (often highly politicised) inputs from various stakeholders (e.g. parents, teachers) or national bodies with formal responsibility for curriculum design.

Higher education can play a key role in identifying priorities for curriculum reform

As autonomous institutions operating independently from government, and due to their connection with teachers, HEIs are ideally positioned to convene actors from research, policy, practice and civil society to reflect on the competencies to be integrated into or strengthened within the written curriculum. Already in 1852, in his *Idea of the University*, John Henry Newman pleaded that institutions of higher learning should be a place "for the communication and circulation of thought [...] a place where inquiry is pushed forward, [...] discoveries verified and perfected, and [...] error exposed, by the collision of mind with mind, and knowledge with knowledge" (Newman, 1852[51]). A contemporary example of this is the public seminar series on "What are we educating for?", organised by the Department of Educational Research at the University of Lancaster in **England (United Kingdom)** (University of Lancaster, 2023[52]). Key questions explored include: *what* are the key competencies education should teach students? *Who* should determine what we are educating for? And how can the *connection* between policy, practice and research be improved? In a February 2023 seminar, experts noted that "the pre-16 school compulsory curriculum is nearly identical to that of 1904" and "a decline [in] students taking technical and creative subjects and those taking qualifications relating to digital and green industries [...] precisely the subjects that students need if they are going to be properly prepared to contribute to society" (University of Lancaster, 2023[53]).

HEIs are sometimes also directly tasked by governments to support curriculum reviews. For example, in **Australia** the Australian Curriculum and Assessment Reporting Authority (ACARA) is responsible for developing and reviewing the Australian school curriculum every six years. In 2020, ACARA tasked the University of Queensland to carry out independent analyses of public consultation data collected by ACARA to support the review (University of Queensland, 2021, p. 7[54]). This included three reviews focused digital technologies (University of Queensland, 2021[54]), cross-curriculum priorities (University of Queensland, 2021[55]) and general capabilities (University of Queensland, 2021[58]). These supported ACARA's review of the curriculum "from Foundation to Year 10 to ensure it is still meeting the needs of students and providing clear guidance on what teachers need to teach" (University of Queensland, 2021, p. 7[55]). In **Poland**, the Ministry of Development commissioned the University of Poznan to evaluate how effective schools are at developing competencies for innovation, using a definition developed by the research team. Based on a non-representative survey of 15 400 teachers, covering the 18 regions of Poland, the study found that "schools are not well suited for 'intellectual rebels', and the current curricula and teaching methods do not offer sufficient conducive conditions for intellectual development that would enhance curiosity of the world" (Fazlagić, Kaczmarek and Connolly, 2022[56]).

HEIs' curriculum analysis is not always considered in policy making

Despite HEIs' activity in analysing educational policy and practice, including in the area of school curricula, "using [educational] research systematically and at scale in education policy making [...] remains a challenge for many countries and systems" (OECD, 2022, p. 11[13]). Educational research can be defined as "a form of systematic investigation of educational and learning processes with a view to increasing or revising current knowledge" (OECD, 2022, p. 18[13]). A recent OECD policy survey on research use in policy and practice has found that, across 37 education systems representing 29 countries,[7] "only 22% of respondent systems reported having a system-wide strategy for facilitating research use in policy" and "around 40% of systems do not synthesise and disseminate educational research findings through user friendly tools" (OECD, 2022, pp. 111, 240[13]). A recent case study from the **Netherlands**, reconstructing and reflecting on how scientific research was used in the ongoing curricular reform process (see Box 2), notes that there was "no structure or mechanism in the ministry for systematically gathering, accumulating and weighing all the relevant pieces of knowledge" in a knowledge infrastructure consisting of multiple actors. It also identified a "need to invest in strategic human resources", notably hiring content specialists able to effectively engage with and use research (Rouw and van der Hoeven, 2023, pp. 92-3[57]).

Only 22% of respondent [OECD] systems reported having a system-wide strategy for facilitating research use in policy.

Another reason why the curriculum analyses produced by HEIs do not always inform policymaking is because "ministries solicit a large number of different types of organisations in matters of research" (OECD, 2022, p. 96[13]). In addition to this, higher education's role in curriculum design and review is often less formalised. In most education systems, school inspectorates bear formal responsibility for the external evaluation and quality assurance of schools, providing national ministries and the public with information on the state of play in relation to the quality and relevance of the school curriculum. For example, in **England (United Kingdom)** the Office for Standards in Education, Children's Services and Skills (Ofsted) is responsible for inspecting the services providing education and skills to learners of all ages. In 2019-20, Ofsted carried out a large-scale inspection of schools across England, which yielded insights on areas of modernisation to the English school curriculum (Ofsted, 2020[58]). In **France**, the General Inspectorate for Education, Sport and Research (*Inspection Génerale de l'Éducation, du Sport et de la Recherche*) is responsible for analysing how specific government priorities are implemented in practice. Recent reports have covered topics such as achieving equity between boys and girls in the development of mathematics competency, or the teaching of digital competencies (IGÉSR, 2023a[59]; IGESR, 2023[60]). In **Belgium (Flemish Community)**, in addition to publishing annual status reports on the quality of education (Flemish Education Inspectorate, n.d.[61]), the Education Inspectorate (*Onderwijsinspectie*) is responsible for monitoring the implementation of the government's digital education strategy (*DigiSprong*), including how schools are developing digital competencies (Flemish Education Inspectorate, 2022[62]).

Establishing links between policy and research can increase the impact of HEIs' curriculum analysis on decision making

Ensuring that the curriculum analyses conducted by subject and curriculum design experts from higher education feed into curriculum reform processes led by policymakers is crucial. To achieve this, researchers must be trained to produce research that is more directly relevant to the work of decision makers. Likewise, education policymakers must be trained and supported to engage with educational research on a more regular basis. To this end, and to improve collaboration between policymakers and researchers, the European Commission has launched two competency frameworks (one for researchers, one for policymakers), which are relevant to policymaking. The competence framework for "Innovative Policymaking" consists of 36 competencies, divided into seven clusters: advise the political level; innovate; work with evidence; be futures literate; engage with citizens and stakeholders; collaborate; and communicate. The “Science for Policy” competence framework consists of 27 competencies, divided into five clusters: understanding policy; participating in policymaking; communication; engaging with citizens and stakeholders; collaboration (European Commission, 2023[63]).

Another approach involves establishing more structured connections between formal bodies responsible for school education and experts from higher education. In some OECD and EU jurisdictions, governments include representatives from the higher education sector in the activities of agencies, committees or working groups that bear formal responsibility for developing and reviewing the school curriculum. These bodies operate as brokerage agencies “to increase effective communication regarding the research and policy/practice interface, evaluate proposed changes and recommendations, [... and] collaborate with an as wide community of researchers, practitioners and policy makers as possible to broaden the relevance of their work and findings” (OECD, 2022, p. 61[13]). For example, **New Zealand**’s Curriculum Design Advisory Group includes representatives from primary, secondary and higher education advising the national Curriculum Centre (*Te Poutāhū*) on an ongoing basis on strategic, whole-of-system curriculum issues. The group provides advise on the education system from early learning to senior secondary school (New Zealand Ministry of Education, n.d.[64]). In the **Netherlands**, a committee of higher education experts was set up in 2020 to inform the ongoing curriculum reform (see Box 2).

Box 2. Scientific Curriculum Commission in the Netherlands

In November 2014, the Ministry of Education, Culture and Science in the Netherlands launched a review of the existing set of curriculum frameworks at national level for primary and secondary education. In January 2016, a first proposal on how to reform the national curriculum frameworks was prepared by the Platform Education 2032. However, this was met with heavy criticism as it was felt to insufficiently reflect the views of school practitioners. Inspired by the bottom-up curriculum reform process in British Columbia (Canada), the Ministry decided to put teachers and school leaders in the lead of further development work. Between March 2018 and September 2019, nine teacher design teams – each supported by a curriculum design expert from SLO (the national expertise centre for curriculum) – developed an overall rationale, “what matters” statements and “building blocks for knowledge and skills” for nine subject areas (SLO, 2019[65]). Parliamentary debates on the proposals in March 2020 – which involved curriculum experts from higher education – found issues with the development process, the feasibility of introducing everything the design teams considered to be “core knowledge and skills” in curricula (i.e. curriculum overcrowding), and the absence of an overarching vision, which would lead to too many differences in the interpretation of the curriculum at the regional and local school levels.

For these reasons, the Ministry set up an independent scientific Curriculum Commission in 2020 (*Curriculumcommissie*), including curriculum experts from HEIs across the country, to formulate recommendations on how to proceed and make an overall judgement about the quality of the set of “building blocks for knowledge and skills” developed by the nine design teams (Dutch Curriculum Commission, 2020[66]). Building on the advice of the Curriculum Commission, SLO was asked to organise a second consultation round, bringing together school leaders, teachers as well as curriculum design and subject experts from higher education to jointly revise the national curriculum frameworks. The process started in September 2022, with first proposals expected to be released by the summer of 2023 for the subjects of Dutch language, mathematics, citizenship and digital literacy (SLO, 2022[67]).

Source: Adapted from Nieveen and Kuiper (2021[68]), “Integral curriculum review in the Netherlands: In need of dovetail joints”, In Priestley et al. (Eds.), *Curriculum making in Europe: Policy and practice within and across diverse contexts*, Emerald, Bringley pp. 125-150, https://www.emerald.com/insight/publication/doi/10.1108/9781838677350.

Mechanism 2: Educational resources to support the cross-curricular integration of competencies for innovation

The cross-curricular integration of competencies for innovation in school curricula (see section 2) means that, to a certain extent, every teacher has a role to play in developing learners' digital and green competencies, as well as their creativity and critical thinking skills. However, stakeholders interviewed by the OECD team mentioned that many teachers face challenges in integrating competencies for innovation into their lesson plans. First, as noted earlier, written curricula typically provide limited guidance on how to teach different competencies. For example, while creativity is included as a cross-curricular topic in the curriculum frameworks of most PISA-2022 participating jurisdictions, they offer limited guidance on how to teach and assess it (OECD, 2023, p. 27[69]). Second, not all teachers have the specialised knowledge or expertise on topics such as climate change or digitalisation to choose or develop relevant lesson plans, activities or tests that can support the development of these competencies. Finally, regularly updating teaching materials and resources to stay in line with the latest developments in scientific research is time-consuming and, once again, requires in-depth thematic expertise. Many school educators would therefore welcome "ready-to-go materials and handbooks" and "categorisation by classifying materials according to themes, education levels, target users and type of resource" (Tasiopoulou et al., 2022, p. 55[49]).

HEIs develop open educational resources (OER) in support of competencies for innovation

In several OECD and EU jurisdictions, HEIs are involved in the development of research-based lesson plans, teaching materials, and tests to support the development of competencies for innovation. Often, these materials are made freely available to school educators as open educational resources (OER).[8] For example, in the **United States** several universities develop lesson plans and other types of educational resources to support primary and secondary schools with the integration of climate change literacy across subjects (Stanford University, n.d.[70]; Michigan University, n.d.[71]; Columbia University, n.d.[72]). The Massachusetts Institute of Technology (MIT) has developed an online platform that contains learning units on Responsible AI for Social Empowerment and Education (RAISE) in schools (MIT, n.d.[73]). Cambridge University in **England (United Kingdom)** has developed a series of "Digital Literacy Activity Cards" (Cambridge University, 2022[74]), and Sorbonne University in **France** has developed more than 70 freely downloadable lesson plans on education for sustainable development (OCE, n.d.[75]).

> The increasing use of digital devices by teachers and learners [...] offers opportunities to integrate research-based educational resources [...] into the school curriculum.

Several factors limit the use of research-based OER in school education

While internationally comparable evidence on the use of OER in school education is not yet widely available, the research literature suggests that the use of OER is more common in higher education than in schools. Whereas an increasing number of HEIs uses OER as their primary instructional materials, in schools such resources are primarily used to supplement existing materials or to facilitate more personalised or interactive learning (Ball and Saucedo, 2019[76]). However, the increasing use of digital devices by teachers and learners both inside and outside of the classroom, accelerated by the COVID-19 pandemic, has made the use of digital learning materials more common (UNESCO, 2021[77]). This offers opportunities to integrate research-based educational resources developed by academics and professionals into the school curriculum. However, in many education systems schoolteachers still use physical textbooks, which in some cases are only updated every 5-10 years (OECD, 2022[16]). This entails a risk that the content to which learners are exposed at school is not in line with the latest developments in scientific research. In many jurisdictions, the educational textbook sector is also dominated by a small number of publishers which dictate the content taught in classrooms (OECD, 2022[16]). The transition to digital textbooks should make the regular updating of educational content easier in future.

In addition to increasing the relevance of the educational content included in textbooks, it is important to stimulate educators to “teach beyond the textbook”, which is not common for all teachers (OECD, 2022[16]). First, not all teachers are aware of the rich array of free and easy-to-access OER available to them, many of which are developed by HEIs. Second, many OER are primarily available in English. For example, the OER Commons library contains over 50 000 openly licensed resources, 92% of which are in English (UNESCO, 2023, p. 3[79]). Coupled with the dominance of English as the language of science, this further limits the integration of the latest findings from scientific research into the classroom, especially for teachers with lower levels of English-language proficiency and research skills. A growing body of scientific research argues that the dominance of English as the language of science has insulated science from those with lower levels of English-language proficiency, with some researchers now advocating for “a multilingual way of doing science that could help to address the inequities in who gets to do science and what science is recognised” (Ferrari, 2019[80]). For example, based on a screening of 419 679 peer-reviewed papers on the effectiveness of biodiversity conservation interventions, researchers from the University of Queensland identified 1 234 non-English language studies compared to 4 412 English language studies, suggesting that a significant minority of scientific knowledge is not tapped into (Amano et al., 2021[81]). Increasing the development of educational resources in national languages as well as support for translation and the development of guidance might increase the use of (English-language) OER by schools.

A growing body of research argues that the dominance of English as the language of science has insulated science from those from those with lower levels of English-language proficiency.

Finally, even if schoolteachers have the necessary language proficiency and opportunities to access OER, many teachers prioritise preparing learners for end-of-year or -semester summative assessments, which are often based on the content in textbooks. They might therefore prioritise searching for OER that develop competencies tested in high-stakes exams rather than experimenting with educational resources that have the potential of developing competencies for innovation as a complement to the core curriculum. This might especially be the case in education systems that have external assessments at the end of primary, lower and/or upper secondary education (Maxwell and Staring, 2018[82]; Santos, 2023[83]).

Targeted funding, platforms and guidance can support the development and effective use of OER in support of competencies for innovation

Some systems have adopted strategies and offer targeted funding to HEIs to develop OER for the school education sector. For example, Aalborg University in **Denmark** has received funding from the Ministry of Education’s Innovation Fund to develop an online platform with teaching materials on the principles of the circular economy, adapted to different subjects (e.g. geography, physics, social sciences) and linked to the national curriculum (Aalborg University, n.d.[84]). In **Canada**, York University’s Faculty of Environmental Studies has been active as early as the late 1990s in developing (online) learning materials to support primary and secondary school teachers to embed climate change literacy across subjects. Growing interest and use of the learning materials by schools, as well as recognition and funding from Ontario’s Ministry of Environment and Climate Change, have led to the establishment of the national Eco-Schools programme (York University, 2018[85]; EcoSchools Canada, n.d.[86]). In **Austria** and **Germany**, the federal governments have issued strategies to support the integration of OER in education, although there is no explicit focus on higher education (Ebner et al., 2016[87]; BMBF, 2022[88]).

In addition to support for the development of OER, HEIs will need to be supported and incentivised to develop guidance complementing educational resources, to increase their take-up and effective use by teachers. In some systems, the use of OER by school educators is encouraged through online platforms that collate and categorise OER developed by different educational content providers (including HEIs) and guidance on how to use them in practice. Examples of such platforms are discussed in the next section of this report (mechanism 3), which covers higher education's role in conducting research on new pedagogies and assessments, which can also be disseminated through such platforms.

The digitalisation of curricula is another strategy that can support the integration of online materials into classrooms. According to the OECD's Education 2030 definition, a digital curriculum includes "digital content or organisational features to implement curricular elements, online materials, tools, depositories, hardware, software and other applications" (OECD, 2022, p. 50[16]). It has the following four features:

- ***Interactivity***: A digital curriculum is offered on a digital platform that enables dynamic interactions between students and teachers within and across different schools and school networks;
- ***End-user participation***: A digital curriculum gives end-users (i.e. school leaders, teachers and students) the flexibility to choose which educational materials to use or replace with other materials, as well as how to sequence the materials in function of students' abilities and interests;
- ***Integration***: A digital curriculum allows for the integration of curated online content, e-textbooks, tools and assessments into the curriculum; and
- ***Cross-grade and cross-subject learning progression***: A digital curriculum makes "conceptual learning progressions that cut across grades and disciplines more explicit and accessible" (OECD, 2022, p. 55[16]), making it easier for students and teachers to understand and compare the content and learning outcome requirements across different disciplines and grades, and fill in learning gaps with additional learning materials, activities or assessments as needed.

Examples of fully interactive and digital school curricula can be found in Australia, Belgium (Flemish Community) and Estonia, some of which include links to and translations of recommended educational resources. **Australia**'s national school curriculum is published online and accessible in multiple view modes. The application allows school leaders and teachers to filter the curriculum by grade and subject and provides content descriptions and assessment standards for each grade, as well as understand how content relates to general capabilities (one of which is digital literacy) and cross-curriculum priorities (one of which is sustainability). The platform also includes a repository of resources to support educators with the implementation of the curriculum (ACARA, n.d.[89]). In **Belgium (Flemish Community)**, the Department of Education and Training has funded the development of an online platform (i-Learn) which gives primary and secondary schoolteachers access to personalised digital education content based on pre-defined and modifiable learning tracks, aligned with the Flemish curriculum. The project started in September 2019, was piloted in 12 schools in 2020-21, and was implemented in collaboration with experts from KU Leuven. To ensure teachers can use the digital education content on the platform, the i-Learn Academy offers coaching and guidance delivered by teacher trainers based in Flemish HEIs (Flemish Department of Education and Training, n.d.[90]). In **Estonia**, *Opiq* is a government-funded online platform for school educators providing educational resources developed by experts in their field. All educational materials on the platform have been fact-checked, copy-edited and peer-reviewed, and are aligned with the Estonian curriculum (Opiq, n.d.[91]).

However, the OECD Policy Questionnaire on Curriculum Redesign (PQC)[9] has found that digital curricula are not yet common in many education systems. Out of all 34 jurisdictions that participated in the survey, less than half (43%) reported that they have some digital version of their curriculum and only a few (16%) are on the way to developing a fully interactive digital curriculum. Few systems (14%) have already implemented a fully interactive digital curriculum (OECD, 2022, p. 54[16]).

Development of teaching and learning methods to support competencies for innovation

This section discusses the third and fourth mechanisms introduced at the start of this section. They cover ways in which HEIs can support school educators to adopt teaching, learning and assessment methods in support of innovation competencies: 3) producing and disseminating research on new approaches to teaching, learning and assessment, and 4) service learning to support place-based and community-based learning.

Mechanism 3: Educational research to support new approaches to teaching, learning and assessment

Closely related to the development of educational resources (mechanism 2) is higher education's role in producing and disseminating educational research on teaching, learning and assessment methods that support competencies for innovation. Among six "drivers for innovation" in education, Vincent-Lancrin et al. (2019, p. 32[92]) note the importance of investment in and the use of educational research by practitioners to improve and change practices in the education sector.

Some HEIs conduct educational research on teaching and assessing innovation competencies

The OECD policy survey on the use of educational research in policy and practice cited earlier (OECD, 2022[13]) has found that HEIs, teacher-education institutions and networks directly involved in academia (e.g. research networks and HE-school partnerships) are the most active organisations in research in the field of education (Hill, 2022, p. 79[93]). Four-fifths (81%) of jurisdictions believed that HEIs – and within those, faculties of education – were "active" or "very active" in the production of educational research – more so than teacher-education institutions (identified by 59% of jurisdictions), and HE-school networks (38%). Public investment in pedagogical experiments, systematic reviews and other forms of primary and secondary research have increased in some OECD countries (Hill, 2022[93]).

Four-fifths (81%) of jurisdictions believed that HEIs [...] were "active" or "very active" in the production of educational research.

Some HEIs conduct educational research to identify and develop specific pedagogies and assessment methods in support of innovation competencies. For example, the University of **Latvia's** Interdisciplinary Centre for Educational Innovation co-operates with local schools and businesses to develop "educational activities and contribute to innovation in the education system [...] including different sub-sectors of science" (University of Latvia, n.d.[94]). Michigan State University's Centre for Excellence in STEM Education in the **United States** carries out research and promotes quality STEM education for teacher-education students, K-12 students and families, and in-service teachers and schools (Michigan State University, 2023[95]). Tallinn University's Centre for Innovation in Education runs a technology-supported laboratory to collaboratively develop, test and research innovative technological solutions and methodologies to enhance learning and teaching from pre-primary to vocational and higher education in **Estonia** (Tallinn University, n.d.[96]). The University of South-Eastern **Norway** has a specific research centre on Learning and Teaching for Sustainability (LET'S) (University of South-Eastern Norway, n.d.[97]). The University of Oslo has recently completed a project which included the development of a toolkit for "open schooling" (see Box 3). Open schooling is a form of challenge- or place-based learning whereby teachers and students use tools to collaborate with out-of-school actors to tackle local challenges and bring science into the classroom. As will be discussed in the next section (mechanism 4), such teaching methods have significant potential to support the development of students' climate change and scientific literacy.

Box 3. Support for science-based open schooling, University of Oslo (Norway)

Science Education and Action for Engagement towards Sustainability (SEAS) was a project coordinated by the University of Oslo (Norway). The project, funded by the EU's Horizon Europe programme, ran from 2019 to 2022 and involved collaboration among six open schooling networks in Austria, Belgium, Estonia, Italy, Sweden and the United Kingdom. As part of SEAS, the University of Oslo developed a wide range of tools, resources and teacher training activities for schools and out-of-school actors to collaborate on sustainability challenges facing their local community. While the project took sustainability as the point of departure, "the principles and tools developed will be of relevance for bringing closer school and society through other subjects and topics" (University of Oslo, 2023[98]). One of the key project outputs is an "Open Schooling Assessment Framework", which has been developed to support educators, school leaders, researchers and policy makers to assess and further develop their open schooling approaches (Mueller, Jornet and Knain, 2022[99]).

Source: Adapted from University of Oslo (2023[98]), *Science Education for Action and Engagement towards Sustainability (SEAS)*, https://www.seas.uio.no/.

HEIs can also support the creation of stimulating learning environments exploiting digital technologies

The school closures resulting from the COVID-19 pandemic in March 2020 required educators across the globe to continue delivering education in fully remote and online settings. This has triggered an emergence of studies on the impact of online learning, showing that without careful course design, fully online and hybrid education models risk increasing existing inequalities between learners and negatively impacting student learning (OECD, 2023, pp. 71-2[100]). However, when used effectively, digital technologies can have positive impacts and create stimulating learning environments.

For example, evidence shows that digital technology can bring simulations of real-world situations into the classroom to help learners better understand the concepts they are learning (Molderez and Fonseca, 2018[101]). Digital platforms also offer spaces for collaboration and exchange between teachers, students and the wider community (Harris and Jones, 2017[102]; Gourlay, 2021[103]; Mu et al., 2018[104]). Further benefits include greater student-centred learning and support for learners with special educational needs or learning difficulties (Wyeth et al., 2023[106]). Finally, one of the benefits most oft-cited by educators is that digital technology can help reduce their workload. Virtual Learning Environments (VLE) or Learning Management Systems (LMS) can automate administrative tasks and provide students with instant (possibly automated) feedback, thereby freeing up teachers' time to develop more innovative teaching strategies and supports for students (Alam, 2021[106]).

Evidence also shows that digital tools and resources can support the development of several key competencies for innovation, although more research is needed. First, by bringing in vast amounts of information from different sources, OER and "serious games" can help learners to develop critical thinking, data-analysis skills and media literacy (Schiele and Chen, 2018[107]; Wells, 2018[108]). Digital tools such as virtual reality (VR) and augmented reality (AR) also have the potential to visualise abstract concepts, thereby enhancing students' comprehension of more abstract learning content, such as the inner workings of an atom (York et al., 2019[109]). Finally, digital technology can promote self-directed learning and student autonomy by providing personalised learning, access to online resources, collaboration opportunities, and immediate feedback and assessment (Pawson and Poskitt, 2019[110]).

Lack of time, opportunities and capacity to access and engage with research lowers the use of new approaches to teaching, learning and assessment by school educators

Despite HEIs' activeness in the development of new approaches to teaching, learning and assessment, as well as evidence of their potential to create stimulating and innovative learning environments, there has only been "a moderate level of innovation in educational practices in primary and secondary education in the OECD" (Vincent-Lancrin et al., 2019, p. 17[92]). Vincent-Lancrin et al (2019[92]) found that use of digital technologies, independent knowledge acquisition and active learning practices were the main innovations introduced in OECD school systems over the decade to 2019. Teachers' openness to educational innovation also seems to vary between countries, with TALIS 2018 finding "openness to innovation [...] to be lower in many European countries than in other parts of the world" (OECD, 2020, p. 74[111]).

One of the main reasons for the limited pedagogical innovation cited by school educators is a lack of time, incentives and support to experiment with new approaches to teaching and learning, notably due to overloaded curricula and pressures to prepare learners for final examinations. This is especially reported to be the case by educators in systems that have high-stakes exams at the end of primary, lower secondary and/or upper secondary education, which determine students' later transitions and pathways in education and the labour market (Maxwell and Staring, 2018[82]; Santos, 2023[83]). HEIs also tend to be more active in *producing* than actively *disseminating* or promoting the use of educational research by teachers. The OECD has found that only 65% of jurisdictions responding to the 2021 policy survey cited earlier believed that HEIs were "active" or "very active" in facilitating the use of educational research in practice. Despite their closer connection to educational practice, HE-school networks and teacher-education institutions appear to be even less active in promoting the use of educational research in practice according to ministries of education. Only 57% of teacher-education institutes and 38% of HE-school networks were believed to be doing so (Torres and Steponavičius, 2022, p. 21[112]).

HEIs [...] tend to be more active in *producing* educational research than actively *disseminating* or promoting its use by teachers.

A third reason for the limited innovation in teaching practice, which was highlighted in section 2, is teachers' limited skills and capacity for research engagement in the field of education (i.e. research literacy) and apply this research in practice (i.e. research use) (Hill, 2022[93]). The research literature also notes that not all the innovative teaching and learning methods developed by HEIs meet the sometimes highly specific needs of practitioners. Hence, co-designing, developing and evaluating the effectiveness of new teaching and learning methods with educational practitioners should be a key priority for further development by HEIs engaged in educational research (OECD, 2022[13]).

Support for educational research on competencies for innovation, practitioner-led research, and online platforms could incentivise the use of educational research in practice

To tackle these challenges, some OECD and EU jurisdictions have made targeted investments to increase HEIs' engagement in educational research on pedagogies that can support competencies for innovation. For example, the **Norwegian** University of Science and Technology has received funding from the Ministry of Education to establish a research centre to enhance IT education across the country. During the first funding period (2017-21), the university's Centre for Excellence in IT Education (Excited) organised different activities for secondary school students to develop their knowledge, awareness and interest in IT. As a result of these activities, several educational resources have been developed, such as a serious game to raise students' awareness of privacy issues or materials to support the development of computational thinking (Norwegian University of Science and Technology, 2020[113]). In **Canada**, the Sustainability Education Policy Network (SEPN), located at the University of Saskatchewan, has received funding from the Canadian Social Sciences and Humanities Research Council (SSHRC) – the federal research funding agency that promotes and supports research and training in the humanities and social sciences – to collect and analyse approaches to education for sustainable development (ESD). As part of its work, SEPN has examined ESD policies and practices across primary, secondary and post-secondary curricula in all Canadian provinces (SEPN, n.d.[114]).

To encourage the use of educational research in practice, some countries or jurisdictions have invested in the creation of online platforms to collate and facilitate the use of educational research and OER (see mechanism 2) by school educators (OECD, 2022[13]). The What Works Clearinghouse in the **United States**, the Evidence for Policy and Practice Innovation Centre (EPPI Centre) in **England (United Kingdom)** and the **Netherlands**' National Initiative for Educational Research (NRO) are three examples of national platforms that have been established with government funding to provide educational practitioners with access to educational research and resources (WWC, n.d.[115]; EPPI, n.d.[116]; NRO, n.d.[117]). In some systems, the government has played a role in ensuring that the resources on these platforms respond to the needs of educators. For example, during the COVID-19 pandemic, KlasCement – a resource network run by the Department of Education and Training in the **Flemish Community of Belgium** – curated teaching and learning resources from the network to support teachers in adapting to remote teaching and organised webinars with pedagogical experts on topics such as the use of ICT tools for distance education (Mineea-Pic, 2020[118]; OECD, 2021, p. 13[119]).

Finally, in some systems, public investment targets structures that facilitate practitioner-led and industry-supported educational research and innovation as a way to enhance the overall effectiveness and use of new pedagogical approaches by educators through collaborative design and research. For example, in **Belgium** the Flemish Department of Education and Training has been funding "imec" – an independent research centre – since 2017 to run the Smart Education programme. The initiative supports the development of school- and company-driven innovations with educational technology. Imec "brings together academic expertise in the field of ICT across all major HEIs in Flanders and supports collaboration with businesses and other local actors [including education]" (European Commission, 2022, p. 18[120]). Through annual calls for proposals, imec supports teachers from kindergarten, primary and secondary education to develop tailored educational-technology solutions that can help improve the effectiveness and inclusiveness of teaching and assessment practices and develop 21st-century competencies (IMEC, 2017[121]). In the **Netherlands**, the government has allocated EUR 332 million to a National Development Programme (*Ontwikkelkracht*) for primary and secondary education (Dutch Ministry of Education, Culture and Science, 2022[122]). The project will run from 2022 until 2032 and aims to build a knowledge infrastructure both in and around schools by: 1) enhancing knowledge dissemination; 2) establishing co-creation labs between researchers and educational practitioners; 3) establishing collaborative school networks, led by "Research and Development Schools" (*O&O-school, onderzoek & ontwikkelscholen*); and 4) strengthening schools' research and improvement culture.

Mechanism 4: Service learning to support place-based and community-based learning

School curricula should ideally give learners the time and opportunities to apply their knowledge and skills in practice by offering them authentic learning experiences (OECD, 2020[18]; Broberg, 2023[9]). In this context, challenge-based learning (CBL), entrepreneurship education (EE) and place-based education (PBE) are three pedagogical approaches which are recognised in the research literature as having the potential to support practical and authentic learning and develop competencies for innovation. Specifically, such approaches are found to encourage students to "make connections between content areas" (Foster and Piacentini, 2023, p. 34[29]) and engage competencies such as critical thinking, creativity, collaboration and problem-solving (Hargreaves, 2008[123]; Tilbury and Galvin, 2022[124]).

Authentic, place-based and community-based learning can support competencies for innovation

The CBL and EE methodologies consist of three steps. The first step of CBL or EE asks learners to identify an actionable challenge, linked to the curriculum and society. The second and third steps ask learners to develop an actionable solution for the challenge they have formulated and reflect on its future implications, thereby fostering an iterative learning process of anticipation, action and reflection (OECD, 2019[125]). Such learning is different from project-based learning (which confronts students with pre-defined problems for which a solution is required) and problem-based learning (which presents students with an often fictional problematic situation for which no real solution is needed) (DCU, n.d.[126]). PBE is a pedagogical approach that "emphasises the connection between a learning process and the physical place in which teachers and students are located" (Yemini, Engel and Ben Simon, 2023[127]). What connects the three approaches is that students and teachers are required to identify, investigate and mobilise resources to tackle challenges facing their local community by collaborating with actors from different disciplines across the school (i.e. other students, teachers, school leadership and support staff) and the wider community (i.e. parents, neighbours, local businesses and government actors). HEIs are situated in the heart of (often urban) communities and can play an important role as local change agents. Together, schools and HEIs can form a "strategic sub-system in society, one which perhaps more than any other has the capacity to influence the functioning of society as a whole" (Hartley and Huddleston, 2010, p. 24[128]).

While it is difficult to establish a causal link between these three pedagogies and innovation – as actual "entrepreneurial [and innovative] behaviour occurs years after the educational intervention" (OECD, 2015, p. 15[129]) – there is some evidence that correlates EE graduates and acting entrepreneurially. A systematic literature review in EE has found that it can impact students' intentions or likelihood of becoming an entrepreneur, but it is unclear to what extent EE enables them to become more effective entrepreneurs (Pittaway and Cope, 2007[130]). A more recent study, examining 1 290 questionnaires from students enrolled at three HEIs in **Portugal** has also found that students enrolled in EE are more likely to "use prior knowledge and alertness to recognise new business opportunities and align their motivations toward starting a new venture than other students" (Adeel, Daniel and Botelho, 2023, p. 176[131]). If centred on an environmental challenge, evidence shows that CBL can have a positive impact on developing learners' pro-environmental attitudes and behaviour (Bramwell-Lalor et al., 2020[132]). An evaluation of six PBE programmes representing more than 100 schools found that PBE helps student learning and invites them to become active citizens. It can also energise teachers, transform school culture, connect students with their local communities, and increase the likelihood of students becoming local change agents for their environment (PEEC, 2020[133]). In a recent interview, Rachel Bolstad, Chief Researcher at **New Zealand**'s Council for Educational Research, said that "the purpose of learning is to empower action, and through action, learning" (Education Gazette, 2022[134]).

Service learning can be a powerful tool to promote place-based and community-based learning in schools, but is not yet widespread in Europe

HEIs can support place-based and community-based learning in schools by mobilising higher education students in service learning with schools to carry out community projects. Service learning is seen as a valuable method for school students – and higher education students who work with them – to develop key learning outcomes such as interpersonal skills, applied disciplinary knowledge, as well as curiosity and social responsibility (Coelho and Menezes, 2021[135]). Service learning, also referred to as "involved learning" and "community learning" (OECD, 2019[136]), is commonly defined as:

> *A course-based, credit-bearing educational experience in which students (a) participate in an organised service activity that meets identified community needs and (b) reflect on the service activity in such a way as to gain further understanding of course content, a broader appreciation of the discipline, and an enhanced sense of personal values and civic responsibility (Bringle and Hatcher, 1999, p. 180[137]).*

There is no comparative international data on the extent to which and how HEIs and schools in different education systems engage in service learning, but it is most common in the **United States**. A *National Student Service-Learning and Community Service-Learning Survey* shows that "community service and service-learning are rooted in the U.S. public primary and secondary education system" (NCES, 2003[138]). Already in 1984, 27% of all upper secondary schools were reported to have community service, and 9% reported to have service learning, which in many cases includes collaboration with HEIs. In 1998-99 (when the survey took place), these percentages were 83% and 46% respectively, with most service learning taking place in upper secondary schools (46%), followed by lower secondary (38%) and primary schools (25%). Some HEIs have specific programmes for service learning with schools. For example, the University of Pennsylvania's Netter Center for Community Partnerships offers 70-80 Academically Based Community Service (ABCS) courses, enrolling close to 2 000 higher education students each year. The focus of ABCS courses ranges from giving students a theoretical foundation on how to carry out research with schools (e.g. course on "University-School-Community Research Partnerships") to giving students practical work experience in schools (e.g. West Philadelphia tutoring project) (University of Pennsylvania, n.d.[139]).

In Europe, service learning has been much slower to spread than in the Americas.

In **Europe**, service learning has been much slower to spread than in the Americas. In Ireland, for example, service learning first appeared in the late 1990s; in Spain, it first appeared in the early 2000s; and in Italy, the first service-learning model appeared in 2015 (Sotelino-Losada et al., 2021[140]; EOSLHE, 2020[141]). The European Observatory for Service Learning in Higher Education (EOSLHE) has been collecting service-learning experiences from HEIs across Europe and found that, in 2019, at least 29 European countries have had some level of activity in service learning (EOSLHE, 2020[141]). However, a research study has found that service-learning in Europe tends to be "a series of isolated institutional experiences and practices" rather than common across the system (Aramburuzabala, McIlrath and Opazo, 2019, p. 4[142]). In Europe, service learning is most often found in teacher-education programmes as part of students' practical training in schools. One article on service learning in **Austria**, for example, notes that service learning is "anchored in several strategic documents [of HEIs], however, not nationally organised" (Resch et al., 2020, p. 3[143]). In **Lithuania**, Vilnius University's Students' Representation (VU SR) has recently completed a project on "Applying Best Foreign Practices to the Implementation of the Social Dimension in Lithuanian Higher Education". As part of this project, VU SR set up a network of student ambassadors involving 45 students from Vilnius University and 22 schools in the region, to explain to school students how the Lithuanian higher education system works, as well as point them to opportunities for student funding to access higher education (Vilnius University, 2023[144]).

Evidence shows positive impacts of service learning on students, teachers, and the wider community, but substantial challenges related to equity and inclusion remain

Empirical research on the impact of service learning shows positive results for students, teachers, schools and the wider community. For both higher education and school students, studies show positive impacts on academic outcomes, including disciplinary knowledge, problem-solving skills, critical thinking, creativity, citizenship and cognitive development (Center for Community Engagement, 2023[145]; Losser et al., 2018[146]). The same studies show that service learning can increase retention, engagement, and graduation rates for higher education and school students. For teachers, one of the major benefits of service learning is that it can broaden the curriculum and create a richer context for learning, giving students responsibility for their learning and placing teachers in new roles as mentors. It also stimulates the use of formative assessment methods and collaboration among schoolteachers (American Psychological Association, 2009[147]; Coelho and Menezes, 2021[135]; Augsburg College, n.d.[148]). For schools and HEIs, service learning can enhance the relevance of the curriculum and community-based approaches. It allows them to respond to societal needs more rapidly and, due to the focus on local challenges, secure the buy-in and participation of community actors (including parents) in students' education. For example, one study based on interviews with teacher educators in **Austria** notes the following benefits of service learning for HEIs: connecting theory and practice; community engagement; responding to local needs; developing higher education students' job-related skills; and learning outside the classroom (Resch and Schrittesser, 2021[149]). Since service learning seeks to respond to community challenges, it can support the social capital building of both learners and community actors, and stimulate joint responsibility and collaboration of educational and community actors around shared goals (Intercultural Community Intervention Project, 2013[150]; Center for Community Engagement, 2023[145]).

Despite numerous benefits of service learning, the scientific literature notes substantial challenges to its further development. Lack of time and access to resources, in particular financial resources, is identified as perhaps the most important barrier for higher education and school staff to engage in service learning. Academic staff often report that they do not see how they can develop service learning on top of an already overwhelming workload. Additionally, the academic timetables of schools and HEIs do not always align. Coupled with crowded curricula, this limits opportunities for more extended service-learning projects. A second challenge relates to identifying opportunities for service learning within the content of curricula. This is reported to be a major challenge for academic staff in the hard sciences, such as mathematics or biology. A third challenge relates to a lack of incentives and opportunities to set up service-learning projects (Lewis, 2014[151]; Losser et al., 2018[146]). Finally, evidence shows that service learning might primarily involve high-performing school students, and not always reach its intended objectives of supporting equity and inclusion in schools. For example, the NCES survey of service learning in the **United States** shows that over 50% of high-school students involved in service learning were in tracks preparing them for higher education studies, and that more than 80% of students participating in service learning got "A" and "B" grades (NCES, 2003[138]).

In addition to strengthening schools and HEIs' financial resources and time to engage in service learning, the research literature notes the importance of building the capacity of higher education and school staff through ITE and CPL. Evidence shows that more experienced teachers and teachers with personal service-learning experience are more likely to recognise its importance (Losser et al., 2018[146]).

The impact of climate change on local communities can [...] be a powerful challenge around which to anchor service learning, and higher education-school collaboration more broadly.

The impact of climate change on local communities can also be a powerful challenge around which to anchor service learning, and higher education-school collaboration more broadly. According to interviewees from Lancaster University in **England (United Kingdom)**, a place-based approach centred on finding solutions to protect the environment in the Morecambe Bay region can work as a powerful lever to bring students, teachers, researchers and community actors together to develop a "Morecambe Bay Curriculum". The partnership, established in 2020, is managed by researchers from the University of Lancaster and seeks to develop a locally-anchored and progressive curriculum which, "from early years to postgraduate, provide[s] the green skills, knowledge and behaviours required by industry to respond to the climate emergency" (Lancaster University, n.d.[152]). Chatsworth International School in **Singapore** also notes that economic, social, environmental and other real-world problems can be powerful levers for collaborative service learning (Chatsworth International School, 2022[153]).

Public policy can embed service learning in social inclusion and engagement strategies, and incentivise a focus on environmental sustainability

Embedding service learning in higher education social inclusion strategies, coupled with the provision of dedicated resources, can be an effective way for governments to scale HEIs' engagement in service learning with schools. Evidence shows that many education systems in **Europe** already have dedicated strategies or policies related to equity or inclusion in higher education. In 2020-21 "nearly all European countries have at least one strategy or major policy plan related to equity in higher education" (Eurydice/EACEA/EC, 2022, p. 21[154]). The only countries where no strategy on equity or inclusion in higher education was identified are the Flemish and German-speaking Communities of Belgium, Denmark, Germany, Luxembourg, Bosnia and Herzegovina, Liechtenstein and Montenegro. However, internationally comparable evidence on whether such strategies include a specific focus on service learning is not available. In **Austria**, one of the measures under action line 2 (Outreach activities) of the 2017 social inclusion strategy for higher education is to "expand the cooperation between higher education and schools, with particular attention to underrepresented groups and increased involvement of teachers, who may have a compensatory effect with respect to the social dimension when it comes to educational decisions" (BMBWF, 2017[155]). In **Hungary**, since 2019 all HEIs are required to offer mentoring programmes to disadvantaged primary and secondary school students in their region as part of the "Let's Teach for Hungary" programme. Article 52 on "Fostering Talent, Academic Student Workshops and Colleges" in the National Act on Higher Education states that all HEIs "shall provide assistance to developing the talent of disadvantaged students within the framework of a mentoring programme" (Government of Hungary, 2011[156]; Mandiner, 2018[157]). In 2011, **Romania**'s Ministry of Education introduced the "Doing School Differently" programme (*Scoala altfel*), which seek to develop learners' socio-emotional skills from kindergarten to high school. The programme requires all schools in Romania to organise social engagement activities (lasting at least five working days) in partnership with parents and representatives of local institutions, authorities, companies or non-profit organisations. In many cases, these collaborations also include HEIs (Romanian Ministry of Education, 2016[158]).

Another approach can be to embed service learning in strategies or initiatives aimed at strengthening the "third mission" of HEIs. Based on a systematic review of 134 peer-reviewed articles on the "third mission" of HEIs, Compagnucci and Spigarelli (2020[159]) note a growing body of research and government pressure on HEIs to include "contribution to society" in their programme syllabi. Comparative international data on higher education systems' third mission strategies is limited, and much of the available internationally comparable data focuses on the engagement of higher education with business (OECD, 2019, p. 382[136]). Civic university models are common in **Finland**, **Ireland**, the **Netherlands**, the **United Kingdom** and the **United States**, but they differ significantly in terms of "the way teaching and research is funded and evaluated, and the connections (or lack of connection) to science and innovation policy and territorial development" (Goddard et al., 2016, p. 13[160]).

Finally, in recent years several private, non-governmental and international organisations have been active in supporting schools and HEIs with the development of service-learning projects specifically focused on environmental sustainability. According to higher education experts interviewed by the OECD team, to develop community-based service-learning projects focused on sustainability, the external expertise provided by such organisations was effective to establish more structured higher education-school partnerships, and collaboration with community actors. Two highly active organisations in this field have been the Foundation for Environmental Education (FEE) and UNESCO (see Box 4). The **United States** Environmental Protection Agency (EPA) has also developed a booklet containing several service-learning projects that focus on fostering environmental sustainability (EPA, 2015[161]). The European Teacher Academy and UNESCO have also developed a professional development course for teachers to examine the possibilities and potential of service learning to engage themselves in practical ways with their local communities on environmental challenges (Teacher Academy, 2023[162]; UN, 2017[163]).

Several private, non-governmental and international organisations have been active in supporting schools and HEIs with the development of service-learning projects specifically focused on environmental sustainability.

Box 4. Support for the implementation of service learning on environmental sustainability

Foundation for Environmental Education (FEE)

The Foundation for Environmental Education (FEE) is the world's largest environmental education organisation. Through a large network of national operators, the organisation supports primary, secondary and higher education institutions in more than 80 countries around the world to engage in education and research on environmental education. Through its Eco-Schools programme, FEE helps schools to implement CBL and give school students opportunities to collaborate with their local community to protect the environment. As part of the programme, FEE supports school leaders and teachers to link environmental education projects to the curriculum and facilitate students' interdisciplinary and systems thinking. EcoCampus is an award programme that provides a framework to guide HEIs on how they can model sustainability as an integral part of campus life.

Regional Centres of Expertise (RCE) on Education for Sustainable Development (ESD)

In 2003, the United National University Institute for the Advanced Study of Sustainability (UNU-IAS) launched a global education for sustainable development (ESD) project, with funding from the Ministry of Environment in **Japan**. One of the activities focused on establishing a global multi-stakeholder network of Regional Centres of Expertise (RCEs) on ESD. RCEs are national networks of existing formal, non-formal and informal organisations that facilitate learning for sustainable development and involve schoolteachers and higher education professors. In January 2023, over 170 RCEs have been officially acknowledged by the United Nations University worldwide. In several countries, HEIs are leading the national RCE. For example, **RCE Denmark** is jointly headquartered at VIA University College and University College Copenhagen, the two largest university colleges in Denmark. In **Ireland**, the RCE Secretariat is located at Dublin City University, and in **France**, the RCE Secretariat is located at Bordeaux Polytechnic Institute.

Source: Adapted from FEE (n.d.[164]), *Eco-Schools Global*, Foundation for Environmental Education (FEE), https://www.ecoschools.global/; RCE (n.d.[165]), *Global RCE Network: Education for Sustainable Development*, Regional Centres of Expertise (RCE), https://www.rcenetwork.org/portal/.

Enriching school curricula to accelerate the development of competencies for innovation

This section discusses the fifth and sixth mechanisms introduced at the start of this section. They cover ways in which higher education institutions can enrich school curricula to deepen and accelerate the development of competencies for innovation: 5) science communication to raise students' interest in science, research and innovation, and 6) dual enrolment programmes to strengthen students' competencies for innovation.

Mechanism 5: Science communication to raise students' interest in science, research and innovation

Increasing young learners' awareness and interest in science, research and innovation is crucial for their educational journeys and future professional careers (Broberg, 2023[9]), potentially as future scientists or innovators (Bell et al., 2018[167]). In many OECD and EU jurisdictions, HEIs organise guest lectures, campus visits, summer schools and competitions specifically aimed at stimulating interest in science, further study and research among school students. In addition to giving first-generation students the opportunity to "experience higher education without a large commitment of time or money [... and] explore fields of study before committing to a degree programme" (OECD, 2023, p. 15[168]), these programmes seek to raise students' interest in science, and equip them with competencies to access and successfully complete higher education. For example, Utrecht University's "Honours Trajectum Utrecht" (HTU) in the **Netherlands** targets disadvantaged learners studying at affiliated schools to develop their academic language proficiency in Dutch and develop an interest in science (Utrecht University, n.d.[169]).

Science communication with schools is a core activity for many HEIs, with evidence suggesting that HEIs have increased their civic engagement activity during the pandemic

For many HEIs, science communication with schools is a core part of their mission and part of their civic engagement activity (OECD, 2019, pp. 412-13[136]). Collaboration with schools has also increased during the COVID-19 pandemic. A recent survey of HEIs in 21 countries found that "most respondents see engagement with pre-collegiate education a part of their mission" (Reimers, 2021, p. 3[170]). This is confirmed in a larger survey by the International Association of Universities (IAU) covering 111 jurisdictions, with 45% of respondents saying that they had increased their public outreach activity during the pandemic (Marinoni, Van't Land and Jensen, 2020, pp. 35-7[171]).

This trend builds on earlier efforts by HEIs to incentivise and support academic staff and students to engage in science communication and collaboration with schools. In some HEIs, a specific unit is responsible for supporting higher education staff in their collaborative projects with schools. The aim is to bundle resources and to facilitate collaboration. One example is the High School Student Academy (*Scholierenacademie*) at Groningen University in the **Netherlands**. The centre organises a wide range of professional development activities for schoolteachers and students, mobilising and co-ordinating relevant academic expertise across the university (Groningen University, n.d.[172]). At Dublin City University (DCU) in **Ireland**, science communication with schools is coordinated by the Institute of Education (DCU, 2009[173]). Science communication can also be coordinated at institutional level or organised by individual faculties or departments. Examples of the latter approach include Durham University's Science Communication and Outreach Department in **England (United Kingdom)**, which is affiliated to the Faculty of Physics. In addition to supporting academic staff to engage and establish partnerships with local and global actors, businesses, government and civil society, it has a specific unit that supports academic staff to implement science communication projects for schools (Durham University, n.d.[174]). Leiden University's Centre for Innovation in the **Netherlands** also supports academic staff to organise digital guest lectures in schools (Leiden University, 2021[175]). Cornell University in the **United States** has recently established a specialised unit tasked with leading public engagement on mathematics and science (Glaser, 2023[176]).

Competitions are another way in which HEIs seek to raise school students' interest in science, research and innovation. For example, the University of Duisburg-Essen in **Germany** organises an annual physics competition targeting all pupils in grades 5 to 13 in North-Rhine Westphalia. Each year, the university sends a physics challenge to all schools in the region. Interested pupils then have three months to work on the challenge and present their result to professors from the Department of Physics during a university visit. Attractive prizes are awarded to the most creative and original solutions, and a supporting programme with laboratory tours, lectures and science experiments complements pupils' visit to the university (Duisburg-Essen University, 2023[177]). In the **Flemish Community of Belgium**, HEIs and industry collaborate to organise competitions ("Olympics" – *Olympiades*) targeting upper primary and lower secondary school students (and their teachers) to drive excellence in teaching and learning in different disciplines. For example, the "Flemish STEM Olympics" (*Vlaamse STEM Olympiade*) has been organised each year since 2010-11 (VSO, 2023[178]). There are also competitions in the fields of mathematics (VWO, 2023[179]), natural sciences (VONW, 2023[180]) and languages (NO, 2023[181]). A report from the Commission for Better Education (*Commissie Beter Onderwijs*) notes that these competitions can be highly effective in raising the attractiveness of – and student competencies in – different subjects. However, it also notes that the students most likely to participate and succeed in these competitions typically come from more academically oriented education tracks, and that there is therefore a need to redesign existing competitions and create new initiatives that focus on raising excellence in more vocationally or professionally-oriented education tracks (Commission Better Education, 2021[182]). In response to this, the Flemish Department of Education and Training has launched an Excellence Fund of EUR 1.5 million in 2023. The fund targets employer organisations, companies and education providers to develop new competitions and redesign existing ones to support excellence in more professionally-oriented education tracks (Flemish Department of Education and Training, 2023[183]).

While systematic monitoring and impact evaluations are limited, science communication can raise school students' interest in science, research and innovation

Systematic monitoring and evaluations of the impact of science communication are limited (Marcinkowski and Kohring, 2014[184]; Weingart and Joubert, 2019[185]). One of the reasons for this is that HEIs' science communication activities are often project-based (e.g. one or two visits by a school to a HEI per year). As a result, available evidence on the impact of science communication is often based on evaluations which cover only a small number of projects or activities and based on feedback surveys involving a small sample of school students, teachers and researchers. Furthermore, there has been a tendency of telling "success stories" instead of an open and constructive approach to evaluation. This is partly due to challenges with the methods employed, as practitioner-led evaluations of science communication lack precision in terms of their intended objectives and target groups, as shown in a recent review of 55 evaluations of science communication projects in **Germany** (Ziegler, Hedder and Fischer, 2021, p. 3[186]). The reliance on self-reported data from beneficiaries introduces a high level of subjectivity, which is augmented by asking teachers to judge the effects of an activity on their students. More structural collaboration between HEIs and schools could help to advance systematic monitoring and impact analysis.

The findings from evaluation reports on individual science communication projects with schools suggest positive impacts for the learners, school educators, and researchers involved. For example, an evaluation of school visits organised in 2021-22 by Trieste's International School for Advanced Studies in **Italy,** based on feedback from 15 teachers and 170 pupils participating in 17 online and in-person events, showed that 87% of lower and upper secondary students felt that the visits had made them "learn new things" and 62% felt that the visits had made them "want to learn more about science" (Busato et al., 2022, p. 24[187]). The researchers volunteering in the school visits reported that communicating about their research with children allowed them to "answer questions that [they] would have never imagined [and] explain [their] discipline in an accessible way" (Busato et al., 2022, p. 33[187]). To improve the programme, researchers highlighted the need for training on how to communicate their research to different age groups, and to link the topic of school visits to what students are learning at school (Busato et al., 2022, p. 34[187]). Building stronger links between science communication activities and the school curriculum was also highlighted as key priority by the schoolteachers responding to the survey.

Research confirms that exposure to a research environment of only two weeks can boost take-up of STEM courses in upper secondary and higher education and achievement in STEM. An independent interim evaluation of the Nuffield Research Placements (NRP) programme in the **United Kingdom** (Cilauro and Paull, 2019, p. 55[188]) shows that students who participated in the programme are more likely to choose STEM A-levels (0.2 A-levels more), to obtain a higher mean point score in their GPA (7 points higher), and to enrol in a STEM course in higher education (8 percentage points higher) than non-participating students. The NRP programme supports more than 1 000 secondary school students (Year 12 – the penultimate year of secondary school) each year to spend a short time (4-6 weeks) working in a higher education institution or research organisation (including 2-3 weeks of independent study ahead of the placement).

> Even as little as "a one-hour in-class exposure to a woman scientist can improve students' perceptions of science careers" (Breda et al., 2020, p. 1806[189]).

Researchers involved in science communication can be powerful role models for school students. A recent meta-level analysis of 55 articles on the effects of role models on students' motivation identified four recommendations for the educational research and practice community to consider when exposing learners from diverse backgrounds to role models in STEM fields (Gladstone and Cimpian, 2021[190]):

- ***Identify competent and successful role models***. Role models should be competent and successful in their field;
- ***Involve meaningfully similar role models***. Role models need to be perceived as belonging to the same social group as learners;
- ***Prioritise role models from underrepresented groups***. Prioritise exposure to role models who belong to groups that are traditionally under-represented in STEM fields, as this is "likely to have the broadest positive effects on students, regardless of students' own social identities" (Gladstone and Cimpian, 2021, p. 15[190]). Evidence from a large-scale randomised field experiment involving 56 female role models and close to 20 000 upper secondary school students found that even as little as "a one-hour in-class exposure to a woman scientist can improve students' perceptions of science careers, and significantly increase female participation in STEM fields of study at college enrolment" (Breda et al., 2020, p. 1806[189]);
- ***Make visible the career paths of role models***. Provide clear information on the career path of models and presenting it as an attainable goal.

Building structural capacity for HEIs to expand their science communication with schools

Despite the increasing prevalence of science communication with schools and indications of benefits for different stakeholders, HEIs face several barriers to increasing the scale of these activities. First, not all HEIs have dedicated support units for school engagement and, where they exist, the staff working in them often do not have the capacity to respond to all the requests for support they receive from academic staff and schools. As a result, not all researchers are equally prepared or supported to communicate effectively about their research to younger audiences and school educators. Training researchers on how to conduct science communication with schools, as well as engaging in more frequent and longer projects, were cited by experts interviewed for this report as crucial to increase the effectiveness and impact of science communication projects (Boeskens, Nusche and Yurita, 2020[191]).

A second challenge is the lack of time and incentives for academic staff to engage in science communication with schools on top of their other responsibilities (i.e. teaching, research, administration, among many other tasks). Higher education experts interviewed by the OECD team mentioned that the staff engaged in science communication with schools are often those working in institutes responsible for teacher training. Incentivising researchers from other departments to engage in science communication is challenging. A survey of more than 7 000 full-time academics at HEIs in 13 countries[10] across the world has found that, in practice, full-time academics spend only 7% of their time on service and engagement on average. 30% of their annualised hours are spent on teaching, around 40% on research activities, and about 15% on administration (Bentley and

Kyvik, 2012[191]). Moreover, in recent years it seems that an increasing proportion of academics' working hours is spent on research, especially in highly ranked and research-oriented institutions (OECD, 2023[193]).

Finally, as noted, science communication projects often have limited direct connection to the school curriculum, which further limits their potential to support competence development among young learners. To overcome this challenge, experts interviewed by the OECD team for this report recommended designing science communication projects in close collaboration with schoolteachers, as well as giving more flexibility to students and teachers to choose which activities they wish to attend.

Guidelines, funding and peer-learning networks can support HEIs to develop their science communication with schools

Guidelines, coupled with dedicated resources, can help HEIs to allocate resources and set institutional priorities to develop their science communication activity with schools. In the **United Kingdom** and the **Netherlands**, for example, public authorities have funded the development of guidelines for HEIs on how to support and reward scientists who work structurally on science communication (RCUK, 2020[12]; KNAW, 2022[193]). In **Romania**, HEIs can apply for government funding to organise summer bridge programmes for upper secondary students as part of the Romania Secondary Education Project (ROSE), which runs from 2015 to 2024 and is funded (EUR 200 million) by the International Bank for Reconstruction and Development. To date, more than 12 000 high school students have been able to participate in courses, seminars, counselling activities, sports or socio-cultural activities (typically lasting two to three weeks) organised by 21 HEIs, to familiarise themselves with the academic environment and develop foundational skills for success in higher education. The wider objectives of ROSE are to reduce early school leaving in upper secondary education and improve transitions to higher education in 1 110 low-performing state high schools (accounting for 80% of all state high schools in the country). The programme also seeks to reduce drop-out rates in the first year of higher education, primarily among disadvantaged learners. Interim results (from mid-2021) show that drop-out rates in participating high schools have decreased from 6.5% to 2% on average, and that retention rates in the first year of higher education have increased from 79.4% to 81.6% on average (Romanian Ministry of Education, 2015[194]).

Several systems have also set up national support centres for science communication to promote peer learning among academics engaged in science communication. Examples include the Science in Dialogue centre (*Wissenschaft im Dialog*) in **Germany**, which is funded by the Federal Ministry of Education and Research and was established in 2000 (Wissenschaft im Dialog, n.d.[195]) and the National Centre for Science Communication, which the Ministry of Education, Culture and Science in the **Netherlands** has recently announced to set up (Dutch Ministry of Education, Culture and Science, 2022[196]). In the **United Kingdom**, 12 HEIs worked closely with National Co-Ordinating Centre for Public Engagement (NCCPE) between 2013 and 2017 to establish structured school engagement partnerships (see Box 5). The **Australian** government funds the Australian Academy of Technology and Engineering to implement the national STELR initiative (Science and Technology Education Leveraging Relevance). The Academy is an independent body of more than 800 Australian scientists and engineers. Through STELR, the body has developed a range of curriculum resources for teachers and students as well as professional learning sessions and videos to inspire girls (and boys) to pursue STEM careers and boost enrolments of girls in STEM subjects in senior years of schooling (ASTE, 2023[197]).

Several international networks also exist which seek to support collaboration between national and institutional centres for science communication. One example is the European Children's Universities Network, located at Vienna University's Children's Office in Austria. The network, established in 2006, has developed a range of guidance materials and facilitates peer learning between HEIs (primarily in Europe) that have support units to connect academic staff with schoolteachers and students (EUCUNET, n.d.[197]). The European Science Engagement Association (ESEA) is co-funded by the EU and acts as a knowledge-sharing platform and accelerator of innovation in the fields of public engagement (EUSEA, n.d.[198]).

Box 5. School-University Partnership Initiative (2013-17), United Kingdom

Following a competitive awards process, Research Councils UK (RCUK) – the predecessor body to UK Research and Innovation (UKRI) – funded 12 universities to set up long-term school-university partnerships as part of its *School-University Partnerships Initiative* (SUPI). SUPI started in 2013, and over the course of four years the programme benefited from GBP 2.4 million RCUK funding, matched by contributions from the participating universities and schools. NCCPE was appointed to coordinate the SUPI network, provide support for the development of the projects, and draw key lessons from the initiatives to support further practice development across the UK. Through 900 school engagement initiatives, SUPI engaged 600 schools, 2 000 academics, 3 800 teachers and 40 000 school students. For universities, one of the major benefits of the initiative was the RCUK start-up funding and guidance received from NCCPE to help them develop a coherent and long-term institutional system for school engagement, many of which are still running today. The guidance and best practices collected as part of the project cover the following areas: 1) Bringing contemporary research into formal and informal learning contexts; 2) Working with secondary school students from a diversity of backgrounds and abilities; 3) Offering high-quality professional development for researchers; and 4) Creating structured and sustainable school-university engagement.

Source: Adapted from NCCPE (2017[199]), *School-University Partnerships: Lessons from the RCUK-funded School-University Partnerships Initiative (SUPI)*, National Co-Ordinating Centre for Public Engagement (NCCPE), https://www.publicengagement.ac.uk/sites/default/files/publication/nccpe_supi_lessons.pdf.

Mechanism 6: Dual enrolment to strengthen the development of competencies for innovation

In some education systems, students can already earn higher-education credit as part of their secondary school studies and accumulate this learning to count towards their first higher education degree. Depending on the education system, different terms are used to describe such programmes. Terms used include concurrent enrolment programmes, dual enrolment programmes, early college high school programmes or dual credit. The College in High School Alliance (CHSA), a Washington-based centre supporting HEIs in the United States to develop dual enrolment programmes, has developed a definition of the core elements shared by all early college high school programmes. They are defined as “partnerships between school districts and accredited institutions of higher education that provide high-school-age students an intentionally designed authentic postsecondary experience leading to officially transcripted and transferable college credit towards a recognised postsecondary degree or credential” (College in High School Alliance, 2022, p. 1[200]).

In this analytical report, the term “dual enrolment” is used to refer to all types of programmes that seek to offer some form of higher education credit to secondary school students. Structural differences between programmes include where the instruction is offered (online, at school or the higher education institution, or a mix), who offers the instruction (schoolteacher, HEI faculty staff, industry, or a mix), the type of credential earned (from individual course credit to associate degree), the ISCED level of the credential earned, the audience targeted by the programme (e.g. open to all learners or specifically targeting disadvantaged learners), the cost of the programme (free or tuition-based), and whether the programme is offered in addition to or integrated into the school curriculum (College in High School Alliance, 2022, p. 2[200]). Box 6 describes the key features of three different types of dual enrolment programmes.

Box 6. Three types of dual enrolment programmes

Drawing on examples of different types of dual enrolment included in the College in High School Alliance glossary, as well as the U.S. federal definitions, three types of dual enrolment programmes are:

- ***Concurrent or dual enrolment programme***: Dual or concurrent enrolment programmes are offered by a partnership between at least one HEI and one secondary school. In this model, students can enrol in one or more higher education courses and earn credits that can be accumulated towards the completion of a higher education degree. The courses are followed in addition to the school curriculum, and when students complete their studies at high school, they have not yet acquired a higher education credential.
- ***Early college high school programme***: In early college high school programmes at least one HEI and one secondary school collaborate to offer an accredited higher education programme as part of the school curriculum. The qualification obtained by the student is no less than 12 higher education credits and up to an associate degree and counts towards the requirements for obtaining the upper secondary school qualification. In many cases, these programmes focus on attracting under-represented groups in higher education.
- ***P-TECH schools***: First launched by IBM in 2011, P-TECH programmes allow upper secondary school students to obtain a higher education qualification upon completing secondary school. In addition to the programme being delivered in partnership between a school (or school district) and an accredited higher education institution, employers are involved in the delivery of the programme to allow learners to acquire practical skills as part of their degree.

Source: Adapted from College in High School Alliance (2022[200]), *Glossary: Understanding College in High School Programmes*, College in High School Alliance (CHSA), https://collegeinhighschool.org/wp-content/uploads/2022/10/CollegeinHighSchoolProgramsGlossary.pdf.

Dual enrolment programmes are very common in the United States, and slowly emerging in some other OECD and EU education systems

Dual enrolment programmes, especially early college high school programmes (ECHS), are most common in the **United States (U.S.)**. The first ECHS in the U.S. was launched in 1966 and the programme was significantly expanded in the early 2000s with funding from the Bill & Melinda Gates Foundation. National estimates suggest that, today, about 1.4 million high school students in the United States – or 9% of all high school students – are enrolled in college courses (Taylor et al., 2022, p. 5[201]). Dual enrolment programmes also exist in **Australia** and **New Zealand**, where P-TECH programmes have been piloted (i.e. Australia) and schools can access funding to form partnerships with HEIs and employers to provide vocational education and work experience (Australian Department of Education, n.d.[202]; New Zealand Ministry of Education, n.d.[203]). In **Europe**, dual enrolment is less common. However, in recent years secondary schools in several European jurisdictions have started to offer P-TECH programmes. They now exist in Czechia, France, Ireland, Italy, Poland, the Netherlands and the United Kingdom (P-TECH, n.d.[204]). In Ireland, for example, P-TECH is coordinated by the National College of Ireland (NCI). An ongoing pilot initiative is currently supporting five Dublin-based schools to deliver P-TECH modules on "Skills for the Digital World" and "Skills for Business & Employment, Computer Science". The initiative targets disadvantaged learners and is offered as a three-year programme, starting in the transition year between lower and upper secondary education, delivered in addition to the upper secondary school curriculum. When the first cohort of P-TECH students graduate in 2024, they will obtain both their Leaving Certificate and an accredited Level 6 Special Purpose Award (P-TECH, 2023[205]).

Dual enrolment can enrich school curricula as well as positively impact access and completion rates in higher education

The Bill & Melinda Gates Foundation has funded several evaluations of early college programmes in the **United States**, all of them indicating positive effects on participating students (Berger, Adelman and Cole, 2010[206]; Song and Zeiser, 2021[207]). A recent study has found that secondary school students enrolled in dual enrolment programmes are more likely to complete upper secondary education, as well as access and complete higher education. The study also noted broad support for dual enrolment programmes among higher education and school educators, especially regarding their potential for bringing more challenging coursework to students (Taylor et al., 2022[201]). These findings were confirmed in an evaluation of the P-TECH pilot in **Australia**. For students, the evaluation results showed increased interest in STEM studies and careers (Social Compass, 2019, p. 1[208]). Positive effects on teachers' practices were also found. Notably, the direct access to industry partners allows them to better understand current labour market needs and circumvent the time lag in between current requirements and formal curriculum updates. If well designed, dual enrolment programmes also have the potential to support learners from under-represented groups. For example, Maynooth University in **Ireland** has received multi-year government funding to develop a module on "Introduction to 21st century STEM skills", targeting disadvantaged girls in secondary schools to strengthen their interest and competencies in STEM fields. Results show positive outcomes on how girls approach STEM fields, even if the effects might be lower due to the self-reporting methodology underpinning the assessment (see Box 7).

Box 7. STEM Passport for Inclusion, Maynooth University (Ireland)

The STEM Passport for Inclusion is a five ECTS-credit module on "Introduction to 21st century STEM skills", targeting transition year (TY) girls enrolled in socio-economically disadvantaged schools (DEIS schools). It is delivered by Maynooth University in partnership with Microsoft Dreamspace and Munster Technological University. Since the start of the programme in 2021, the university has supported 1 250 DEIS girls in 38 schools to strengthen their interest and competencies in STEM, with evidence showing a positive impact on girls' STEM intentions and skills. 96% said that the programme had changed their view of STEM; 79% said they were now considering studying a STEM subject; and 76% that they were considering a career in STEM. However, the study also found that "schools often 'select' students to participate in outreach programmes [...] leaving STEM engagement to those who are deemed 'good enough'" (Maynooth University, 2023[209]). For the next three years, the university has received a further EUR 1.5 million of government funding to expand the programme across TY girls in DEIS schools.

Source: Maynooth University (2023[209]), *STEM Passport for Inclusion*, https://www.maynoothuniversity.ie/all-institute/all-projects/stem-passport-inclusion.

More research and public policy support is needed to identify key design features and advance equity and inclusion in dual enrolment programmes

Evidence suggests that dual enrolment programmes often reach students who are already performing well at school or are interested in pursuing higher education. Students of colour, low-income students, male students, lower achieving students, students speaking a different home language, students with disabilities, foster youth, and students experiencing homelessness are less likely to participate in dual enrolment programmes than their peers (Taylor et al., 2022, p. 11[201]). To further advance the practice of dual enrolment programmes, the research literature underlines the need for further research to identify design features that can increase participation and positively impact student learning. For example, the literature identifies student support as a key design principle of successful dual enrolment programmes, as many school students "lack the maturity and behavioural dispositions needed for participation in college [higher education] classes" (Taylor et al., 2022, p. 82[201]). In the **United States**, dual enrolment is one of four key pillars of the U.S. Department of Education's *Unlocking Career Success* initiative, which was launched in January 2023 to raise the share of the population that possesses a higher education credential, even if they have never enrolled or completed a full higher education (see Box 8).

Box 8. Raise the Bar: Unlocking Career Success, United States

On 23 January 2023, the U.S. Department of Education launched a new strategy for education: *Raise the Bar: Lead the World*. The strategy seeks to unite actors across all levels of education and training and the labour market to promote equity and inclusion in education. The strategy is centred on three pillars, one of which is: *Creating Pathways for Global Engagement.* The actions under this pillar seek to "ensure every student has a path to postsecondary education and training, including by establishing and scaling innovative systems of college and career pathways that integrate high schools, colleges, careers, and communities and lead to students earning industry-recognised credentials and securing in-demand jobs" (U.S. Department of Education, 2023[210]). This includes dedicated support for States and districts to expand dual enrolment programmes, thereby increasing the share of the population that possesses a higher education credential, even if they have never enrolled or completed a full higher education programme. The motivation for investing in dual enrolment is because the government estimates that, by 2027, 70% of jobs will require education beyond upper secondary education.

Source: Adapted from U.S. Department of Education (2023[211]), *Raise the Bar: Lead the World*, https://www.ed.gov/raisethebar/; (2023[210]), *Unlocking career success: Blurring the lines between high school, college and career*, https://cte.ed.gov/unlocking-career-success/home.

4. Conclusions and options for further policy and practice development

This section summarises key findings from the report and highlights options for further policy and practice development to strengthen higher education's role in supporting the integration of competencies in support of innovation for the digital and green transitions into school curricula.

Countries face challenges to integrate competencies for innovation into school curricula

This report has reviewed available evidence on the integration of competencies for innovation into schools' written (or intended), taught (or implemented) and achieved (or attained) curricula – with a specific focus on competencies that can support innovation for the digital and green transitions. It shows that, across OECD and EU education systems, policy makers and practitioners face three main challenges to integrate competencies for innovation into school curricula.

Challenge 1 – In many education systems, competencies for innovation are insufficiently embedded in national and regional curriculum frameworks

National and regional decision makers are often not aware of how and in which subjects to anchor different competencies for innovation in the curriculum frameworks that guide the work of teachers and school leaders. Specific challenges relate to how to avoid curriculum overload, the risk of competencies being "buried" or "lost" in the curriculum as cross-curricular themes and the difficulty of capturing lessons from effective practice in schools and sharing these across the education system.

Challenge 2 – Many teachers and school leaders involved in updating curricula lack curriculum design expertise

In many OECD and EU education systems, teachers and school leaders have significant responsibility for determining curriculum content and the educational resources, teaching and assessment practices they use. To integrate competencies effectively into school and classroom settings, school educators would benefit from research-based educational resources and guidance on effective teaching, learning and assessment methods that can support the development of competencies for innovation, and raise students' motivation and interest in science, research and innovation more broadly.

Challenge 3 – School curricula are unable to support all learners to develop competencies needed to shape, and adapt to, innovations for the digital and green transitions

An analysis of available student outcomes data from PISA suggests that school curricula are currently not adapted to equip learners with the broad range of knowledge, skills, attitudes and values needed to drive forward – and adapt to – innovation for the digital and green transitions. For example, in 2018 one-quarter of 15-year-old students in OECD jurisdictions were classed as low-performing in science and mathematics (OECD, 2019[43]). And only one-third of students surveyed in PISA 2018 achieved minimum benchmarks across all four environmental sustainability competence areas of the European Commission's GreenComp framework (Bianchi, Pisiotis and Cabrera Giraldez, 2022[41]). Evidence also shows that education systems face challenges with achieving equity in student learning outcomes. For example, boys and students from socio-economically disadvantaged backgrounds are more likely to underperform in reading, mathematics and science than their peers from better-off backgrounds (Encinas-Martín and Cherian, 2023[44]). Socio-economically disadvantaged learners also tend to care less about the environment than their peers from more advantaged backgrounds (Borgonovi et al., 2022[38]). The results suggest a need to strengthen the evidence base on how well students perform in relation to different competency domains that can support innovation for the digital and green transitions, and to design, implement and monitor public policies and institutional practices that can support the *equitable* acquisition of competencies for innovation in schools.

Options to strengthen higher education's role in supporting effective school curricula

The report identifies six "mechanisms" through which higher education institutions can support the integration of competencies in support of innovation for the digital and green transitions into school curricula. For each of these, the report examines a wide range of inspiring policy and practice examples from across OECD and EU jurisdictions, including available evidence on the impact of these policies and practices on student learning and teachers' professional practice. For each mechanism, this analytical report has reflected on how public policy can support higher education institutions and schools to engage in more structured and sustained collaboration around school curriculum development. Six options for further policy and practice development can be identified.

Option 1 – Develop formal structures to strengthen higher education's role in leading independent curriculum analysis and stakeholder dialogue to inform curricular reforms

Higher education institutions can support the integration of competencies for innovation into school curricula by engaging in curriculum analysis and facilitating stakeholder dialogue to inform decision makers on how and where to embed competencies for innovation in written curriculum frameworks – thus guiding the work of teachers and school leaders. To ensure the curriculum analysis and advice provided by higher education institution is considered by decision makers, some education systems have sought to establish more structured connections between experts from higher education and formal bodies responsible for monitoring or reviewing the relevance of national/regional curriculum frameworks.

Option 2 – Support higher education institutions to develop educational resources for schools and promote their use through guidance and platforms

Higher education institutions can develop research-based lesson plans, materials and assessments to incentivise teachers to "teach beyond the textbook" and support the development of competencies for innovation. Many of these resources are available to teachers as freely downloadable OER, but not all teachers know where to access them or how to integrate them effectively in their lessons. Many teachers prioritise educational content focused on preparing learners for end-of-year or end-of-semester summative assessments, rather than experimenting with the possibilities of integrating new or additional content from OER in their lessons. Finally, most OER are available in English, which can hinder their use by teachers with lower levels of English-language proficiency or research skills – or who teach students with different proficiency levels in English. Governments can support the integration of OER in school curricula by funding higher education institutions to develop specific educational resources for schools, supporting translations of resources, developing (international) online platforms and guidance to increase their take-up and effective use, and digitalising curricula to facilitate the integration of curated online materials.

Option 3 – Mobilise the higher education sector to engage in collaborative and applied educational research on education for the digital and green transitions

Some higher education institutions engage in research on new teaching and assessment methods that can foster the development of foundational competencies in support of innovation for the digital and green transitions, such as digital literacy, climate change literacy or critical thinking. However, the use of new pedagogies and assessment methods that result from such research by educational practitioners has remained limited, in particular due to a lack of funding to support their scaling and limited transferability of certain practices to schools' often highly specific and individual contexts and needs. In some jurisdictions, public authorities fund higher education institutions to act as national or regional centres of expertise on how to teach certain subjects or competencies (e.g. centres of expertise on digital competencies, education for sustainable development or STEM), or to engage in practitioner-led and industry-supported educational research and innovation to increase the relevance of outputs for school educators and use of these outputs.

Option 4 – Explore the potential of service learning involving higher education institutions, schools and civil society organisations to increase place-based and community-based learning in schools

By engaging higher education students and staff in service-learning projects with local schools, higher education institutions can encourage school educators to adopt place- and community-based approaches to teaching and learning. Evidence shows that such approaches can give learners opportunities to apply their knowledge and skills in practice, which is crucial to develop higher order cognitive skills such as creativity, critical thinking and collaboration. Focusing service-learning projects on the impact of climate change on local communities is also identified as a powerful lever for strengthening higher education-school collaboration. To incentivise higher education institutions to strengthen their service-learning activity with local schools, public authorities can consider making service learning a required component of institutional social inclusion and/or “third mission” policies or strategies, coupled with the provision of dedicated resources and supports.

Option 5 – Support higher education institutions to engage in science communication with schools, to strengthen research-based teaching practices and raise students’ motivation and interest in science and innovation

Science communication with schools is a core activity for many higher education institutions and can range from the organisation of guest lectures, campus visits and summer schools to national/regional competitions aimed at stimulating interest in science, further study and research among school students. Science communication can have a positive impact on increasing students’ interest in specific study fields (including learners from under-represented groups), especially when powerful role models are involved, students have longer exposure to science and research, and science-communication activities are aligned with school curricula. To strengthen higher education institutions’ capacity for science communication, public authorities in some jurisdictions have funded the development of guidelines or national support centres to build the capacity of scientists who structurally work on science communication. Several international networks seek to foster collaboration between national and institutional centres for science communication.

Option 6 – Examine the potential of dual enrolment programmes to establish structured collaboration between schools and higher education institutions for curriculum design and delivery

In some education systems students have access to dual enrolment programmes, which allow them to already earn higher education credit as part of their secondary school studies and accumulate this learning for their first higher education degree. Such programmes can help broaden the school curriculum, creating a richer environment for student learning, and support the development of teachers’ pedagogical practices. Students enrolled in dual enrolment programmes are more likely to complete upper secondary education as well as access and complete higher education. If designed appropriately, such programmes can also support learners from under-represented groups. Some jurisdictions are funding national programmes or pilot projects to support higher education institutions and schools to collaborate for the development of dual enrolment programmes.

About this analytical report

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Annexes: Qualitative evidence underpinning the development of the report

Annex 1: Expert interviews

To supplement the desk-based review and analysis of the research literature and inspiring policy/practice examples, the OECD Higher Education Policy Team carried out 45 semi-structured expert interviews between November 2022 and February 2023. These included policymakers, practitioners and researchers coming from 21 OECD and EU jurisdictions: Austria, Belgium (Flemish Community), Canada, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Japan, Latvia, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, United Kingdom and the United States. The interviews were conducted by François Staring and Andrea-Rosalinde Hofer.

The expert interviews have been instrumental for the identification of inspiring policy and practice examples of HE-school collaboration in support of innovation competencies, and to establish the growing EIPC network.

Annex 2: International online knowledge exchange on how higher education can support effective curricula in schools

Agenda of the international online knowledge exchange

On 18 April 2023, the OECD Higher Education Policy Team organised an international online knowledge exchange (IKE) for the EIPC network on key mechanisms through which higher education can support the integration of innovation competencies into school curricula. The IKE featured presenters from ten OECD and EU jurisdictions and focused on the following three questions:

1) What are practical examples of the **different mechanisms through which higher education can support schools** to update and enhance their curricula to support the development of foundational competencies for innovation?
2) What is the **added value of higher education support** for school curriculum innovation?
3) What are **policy options to scale institutional good practice** and support a more structured collaboration between the school and higher education sectors for curriculum innovation?

Table 3 presents the agenda of the IKE.

Table 3. Agenda international online knowledge exchange on 18 April 2023

13:30 – 13:45	*Welcome and introduction* • **Paulo Santiago**, Head of Policy Advice and Implementation Division, Directorate for Education and Skills, OECD • **Ingrid Rigler**, Deputy Head of Unit, Unit C1 “Innovation and EIT”, Directorate-General for Education, Youth, Sport and Culture, European Commission
Session 1 – THE INNOVATION IMPERATIVE: How the digital and green transitions are asking us to rethink education	
13:45 – 14:20	*Presentation: “Fostering students' curiosity, spirit of adventure and innovation: what is the potential of introducing a Math 101 course in school curricula?”* • **Steven Strogatz**, Jacob Gould Schurman Professor of Applied Mathematics, Cornell University (United States) Respondents: • **Helle Hallik**, Chief Expert on Mathematics and Digital Skills, Department of General Education Policy, Ministry of Education and Research (Estonia) • **Anna Weinrich**, Organising Bureau of European School Student Unions (OBESSU)
14:20 – 14:30	*Questions from the audience*

Session 2 – CURRICULUM DESIGN: Integrating digital and climate change literacy in curriculum frameworks	
Introduction & Moderation: **François Staring**, Analyst, Higher Education Policy Team, Directorate for Education and Skills, OECD	
14:30 – 14:50	*Presentation: "Updating the national curriculum frameworks in the Netherlands"* • **Nienke Nieveen,** Professor of Curriculum Design in STEM Education at Eindhoven University of Technology (TU/e), Member of the Scientific Curriculum Commission (*Curriculumcommissie*), Netherlands Respondent: • **Saskia Heunks**, Programme Leader, Trion Research-Practice Partnership in Education, Schoolteacher at City College Eindhoven, Co-Leader PLC Challenge-Based Learning/Sustainability Education (Netherlands)
14:50 – 15:10	*Presentation: "Anchoring challenge-based learning in school curricula"* • **Pramod Kumar Sharma**, Senior Director of Education, Foundation for Environmental Education (FEE) Respondent: • **Lewis Molot**, Professor Emeritus and Senior Scholar, Faculty of Environmental and Urban Change, York University (Canada)
15:10 – 15:30	*Presentation: "A new pathway for learning: the P-TECH initiative in Ireland"* • **Ita Kennelly**, Lecturer in Education & P-Tech Programme Director, National College of Ireland (Ireland) Respondent: • **Alex Perry**, Policy Advisor, College in High School Alliance (United States)
15:35 – 15:45	*Plenary reporting*
15:45 – 16:00	*Comfort break*
Session 3 – CURRICULUM DELIVERY: Supporting schools to develop digital and climate change literacy	
Introduction & Moderation: **Andrea-Rosalinde Hofer**, Analyst, Higher Education Policy Team, Directorate for Education and Skills, OECD	
16:00 – 16:30	*Presentation: "imec Smart Education: from research to impact"* • **Lien De Bie** and **Ine Windey**, imec Smart Education programme, imec & itec - KU Leuven (Belgium) Respondent: • **László Munkácsy**, Head of Pedagogical Development Unit, Office of the Secretary-General of the European Schools Questions from the audience
16:30 – 17:00	*Presentation: "Enriching school curricula through science outreach and engagement"* • **Lorraine Coghill**, Deputy Director of Science Outreach & Engagement. Durham University (United Kingdom) Respondent: • **Kuniaki Sato**, Chair of the Group of National Experts on Higher Education (GNE-HE), Vice President for University Reform & Planning, Tohoku University (Japan) Questions from the audience
17:00	*Closing remarks & next steps* • **Loredana Lombardi**, Policy Officer, Unit C1 "Innovation and EIT", Directorate-General for Education, Youth, Sport and Culture, European Commission • **François Staring**, Analyst, Higher Education Policy Team, Directorate for Education and Skills, OECD

Key messages emerging from the international online knowledge exchange

The sections below present the key messages emerging from the presentations and discussions with members of the EIPC network during the IKE on 18 April 2023. The inputs provided by the EIPC network have provided the basis for the analysis and conclusions presented in this analytical report.

1) How can higher education support innovation in school curricula?

Through six presentations, the IKE explored practical examples of different mechanisms through which HEIs can support policy makers and school practitioners to develop and deliver innovative school curricula that support the development of innovation competencies. Key messages emerging from the presentations are presented in Table 4.

Table 4. Key messages from EIPC network on how higher education can support schools

Mechanism	Presenter	Key messages
1. Rethinking the purpose of education	Steven Strogatz (Cornell University)	Steven Strogatz (Cornell University) urged policymakers and educational practitioners to rethink what we are educating learners for. Education, he believes, is too narrowly focused on developing students' *knowledge and technical skills* (i.e. teaching the "how"), rather than teaching them to be brave, curious and innovative (i.e. teaching the "why"). Building on his experience of teaching a Math 101 course at Cornell University, he believes that pedagogical approaches that link disciplinary content to innovations in society are crucial to enhance student learning outcomes, and to foster innovative *attitudes and mindsets*, in addition to technical knowledge and skills.
2. Supporting macro-, meso- and micro-level curriculum design	Nienke Nieveen (Eindhoven University of Technology)	Nienke Nieveen (Eindhoven University of Technology) explained how, in the Netherlands, curriculum and subject experts from higher education support the government with macro-level curriculum reform (to tackle key challenges such as coherence, curriculum overload, equity, and a clear national vision). Due to high levels of school autonomy in the Netherlands, HEIs also support school leaders and teachers to develop their curriculum design expertise (including subject matter knowledge, pedagogical content knowledge, curricular consistency expertise, curricular design expertise, intra-personal skills, and inter-personal skills).
3. Implementing challenge-based learning	Pramod Kumar Sharma (Foundation for Environmental Education)	Pramod Kumar Sharma (Foundation for Environmental Education) explained how the global EcoSchools programme supports schools and HEIs around the world to implement challenge-based learning (CBL) and develop students' pro-environmental attitudes. He advocated for more time and space in curricula to develop such approaches, and that HEIs are key partners for schools to build the necessary community partnerships, train (prospective) teachers, and evaluate approaches to CBL.
4. Development and delivery of joint curricula	Ita Kennelly (National College of Ireland)	Ita Kennelly (National College of Ireland) presented the P-TECH pilot, a Level 6 Special Purpose Award (10 ECTs) offered to upper secondary school students in three schools in Dublin. The Award is offered to students in addition to the courses they must complete to obtain their upper secondary Leaving Certificate. The programme seeks to develop learners' digital and professional competencies through personalised and applied teaching, learning and assessment practices, thereby also preparing learners to access and successfully complete higher education. Initial results of the pilot are promising, and reflections are currently taking place on if (and how) to expand the programme to more schools in Ireland.
5. Piloting, scaling and evaluating pedagogical innovation	Ine Windey and Lien De Bie (imec & itec – KU Leuven)	Ine Windey and Lien De Bie (imec & itec – KU Leuven) presented the Smart Education Programme in the Flemish Community of Belgium. This government-funded initiative brings together expertise from industry and higher education to develop tailor-made and innovative educational technology (EdTech) solutions – in close collaboration with schools – to help schoolteachers and leaders tackle key challenges, and adopt teaching and assessment practices that support the development of new competency requirements in the curriculum (e.g. computational thinking, self-regulated learning).
6. Science communication and engagement	Lorraine Coghill (Durham University)	Lorraine Coghill (Durham University) shared how the University of Durham's Science Communication and Outreach Department collaborates with local schools around science, highlighting multiple benefits for all actors involved: for students, teachers, researchers, the university, and the wider community (see Table 5 for more details on the different benefits). She also discussed several challenges moving forward including time and the recognition of researchers' partaking in such initiatives for career progression.

Note: This table was prepared by the OECD Higher Education Policy Team. It summarises the key messages from the six main presentations during the IKE on 18 April 2023.

2) What is the added value of higher education support for curriculum innovation in schools?

In the discussions, presenters and discussants all recognised the role of higher education as a crucial partner in supporting schools in designing and delivering innovative school curricula, and in incorporating digital and climate change literacy. However, evidence on the concrete impact of higher education support for curriculum innovation is often limited. Table 5 provides a summary of the assumed benefits of higher education support for school curriculum innovation, highlighted by the presentations and discussions.

Table 5. Key messages from EIPC network on the added value of higher education support

Benefits and impact	Key messages
1. Strengthening the evidence base for educational policy and practice	Presenters argued that collaboration between higher education institutions engaging in fundamental and strategic research, private sector actors and school education practitioners is crucial for ensuring that education policy is informed by the latest developments in both research and practice. Likewise, by collaborating with industry and schools – as is the case in the Smart Education Programme in the Flemish Community of Belgium – HEIs can play a key role in ensuring that educational practice is informed by the latest developments in scientific research and society.
2. Providing an umbrella for inter-school collaboration	Higher education institutions can offer an umbrella under which different school districts can cooperate and align their practices, discuss common challenges and seek funding for initiatives they identify as important in their local context. As highlighted in Lewis Molot's intervention on the experience of establishing EcoSchools in Canada, HEIs make good lead institutions thanks to their considerable experience managing large sums of research funding and launching their own initiatives.
3. Improving transitions between upper secondary and higher education	Strengthening collaboration between schools and HEIs has the potential to improve transitions between upper secondary and higher education. Anna Weinrich (OBESSU) felt that establishing greater connections between HEIs and upper secondary schools could enhance the development of key skills such as critical thinking and problem solving, which students will eventually need to access and complete higher education. Other examples of initiatives through which higher education has sought to help students complete upper secondary education are the government-launched initiative in Estonia at the beginning of the COVID-19 pandemic, during which HEIs helped upper secondary school students prepare for their final exams. Evidence on dual enrolment programmes in the United States, such as those discussed by Alex Perry from the College in High School Alliance (CHSA), also have the potential to enhance student access and completion in higher education.
4. Enhancing student motivation and interest in learning, science and innovation	Several presenters and discussants highlighted the potential of higher education in enhancing the depth and richness of school curricula. By bringing examples from research and society into the classroom (including role models), HEIs can help make the overall school curriculum more engaging, applied and research-based, increasing students' motivation for learning in general, and their interest in science and innovation specifically.
5. Benefits for all stakeholders involved in higher education-school collaboration	Lorrain Coghill (Durham University) argued that engaging in higher education-school collaboration brings multiple benefits to all stakeholders involved: for students (deeper and more authentic learning experiences, as well as access to role models), teachers (broadening the school curriculum through regional links), researchers (developing new ways of working and thinking about their own research), the university (increasing the impact of education and research activities) and the wider community (fostering a sustainable ecosystem and network with a positive impact on regional development).
6. Impact of dual enrolment programmes on higher education participation and attainment rates	Alex Perry (College in High School Alliance) shared research from the United States (U.S.) on the various impacts of dual enrolment programmes (Taylor et al., 2022[1]).[1] In dual enrolment programmes, upper secondary school students attend tertiary level courses and obtain higher education credits while in upper secondary school. Using rich U.S. State level data, the study shows strong positive effects on a wide range of students, in particular students who are typically under-represented in higher education. Students who are exposed to the relatively unsupervised college experience while in high school are more likely to access and complete higher education as well as persist between the first and second year of higher education. Mr Perry highlighted that the positive impact of these experiences and their strong impact on students from backgrounds, who are less represented in higher education, means that in future more attention should be paid to how ensure equitable access to these kinds of programmes.

Note: This table was prepared by the OECD Higher Education Policy Team. It summarises the main takeaways from the discussions on the benefits and impact of higher education support for curriculum innovation, higher education collaboration with secondary education more broadly.

[1] Taylor et al. (2022[1]), *Research Priorities for Advancing Equitable Dual Enrollment Policy and Practice*, University of Utah, https://cherp.utah.edu/publications/research_priorities_for_advancing_equitable_dual_enrollment_policy_and_practice.php.

3) What are key considerations for scaling institutional good practice?

The IKE also asked presenters and discussants to reflect on key considerations for scaling collaborative practice between HEIs and schools around curriculum innovation. Key messages emerging from those discussions are presented in Table 6.

Table 6. Key messages from EIPC network on key considerations for policy makers and practitioners

Considerations	Key messages
Key considerations for policymakers	
1. Develop shared system-wide vision and curriculum awareness	The need for a clear vision of what education should seek to achieve and what is to be evaluated was highlighted by several presenters and discussants, including Ita Kennelly (National College of Ireland) and Nienke Nieveen (Eindhoven University of Technology). Successful replication of innovative educational practice across different school contexts requires the creation of framework conditions for collaboration between HEIs and schools, including system-wide curriculum awareness and the articulation of clear values and a shared vision for all actors involved in the process to feel empowered to collaborate. Steven Strogatz mentioned that HEIs could help foster this shared vision by promoting alternative goals or "metrics of success" in higher education admission requirements.
2. The importance of sustained financial support and government involvement	Sustained financial resources and government support to scale projects was emphasised by several presenters and discussants (e.g. government funding and involvement is crucial for the roll-out of the Smart Education programme in the Flemish Community of Belgium; and in Japan, the government funds several programmes that seek to enhance the quality and depth of science education in secondary education, e.g. Super Science High School programme).
3. Training teachers matters	Initial teacher training (ITE) and continuing professional learning (CPL) were mentioned as perhaps the single most important set of policy levers to support the development of learners' innovation competencies. HEIs, in their role as providers of ITE and CPL in many OECD and EU systems, have a key role to play in this. As mentioned by Steven Strogatz, in the short run, training teachers to implement new pedagogies might call for significant additional resources from governments to support HEIs in achieving this task.
4. Strengthen evidence-based work and develop networks to share best practices	Presenters and discussants highlighted the importance of strengthening the evidence base on the impact of different pedagogical practices and higher education-school collaboration, to inform government and school-level decision making and scaling. Discussions following Ine Windey and Lien De Bie's presentation highlighted the importance of innovations stemming from higher education and secondary school partnerships to be grounded in evidence for such innovations to be brought in a timely manner and work positively in the right context. In the United States, too, Alex Perry highlighted that evidence on the positive impact of dual enrolment programmes (see Table 5 above) has led to conversations on if (and how) to scale such programmes at the level of the federal government.
Key considerations for practitioners	
1. Identifying talented and motivated individuals	In his discussion on the establishment of the EcoSchools programme in Canada, Lewis Molot stressed the importance of identifying motivated and talented people – both in higher education and schools – that are willing and capable to dedicate time and resources to engaging in structural collaboration for educational innovation.
2. Time, incentives, support and recognition	Both schoolteachers and academic staff need time, incentives and recognition for engaging in collaboration and implementing innovative approaches. Both Lewis Molot and Lorraine Coghill stressed the importance of creating systems (at national and institutional level) that reward time and effort by academic staff to develop HEI and secondary education collaboration in an environment otherwise typically characterised by high pressures to publish for career progression.
3. Ensure a clear link to the school curriculum	When discussing challenges faced by European Schools seeking to develop more innovative practices and collaboration with HEIs, Lászlo Munkacsy emphasised that HEIs and schools should ensure a strong link of their innovations with national school curricula given the strict schedules and requirements schools are required to meet.
4. Keep the size of higher education-school partnerships manageable	Presenters and discussants also discussed whether there might be an "optimal size" for higher education-school partnerships. The discussions highlighted that it is important to keep initiatives at a scale where stakeholders on both sides – in school and higher education – can make a valuable contribution. Saskia Heunks (Trion University-School Partnership) said that no more than 20 schools per partnership might be the optimal size to ensure strong relations between the different stakeholders involved in the partnership.
5. Collaboration is a two-way street	Both Lewis Molot and Pramod Kumar Sharma highlighted the importance of HEIs seeing themselves as *partners* when working with schools. While HEI professors can contribute to curriculum innovations in secondary school, and act as coordinators to bring different schools together for peer learning (see Table 5), it is important that higher education staff realise that they can also learn a lot from schoolteachers.

Note: This table was prepared by the OECD Higher Education Policy Team. It summarises the main takeaways from the discussions on key considerations for scaling higher education-school collaboration for curriculum innovation.

Notes

[1] "Deep-tech" innovation can be defined as bringing together insights from the natural sciences and digital technologies to provide new and cross-disciplinary solutions to global challenges. Among the key skills needed are the ability to manage projects with long time horizons and high risk (Broberg, 2023[9]).

[2] Higher education's role in supporting teachers and school leaders through ITE and CPL is discussed in a separate analytical report prepared by the OECD (OECD, 2023[217]).

[3] Australia, British Columbia (Canada), Estonia, Greece, Israel, Japan, Korea, Lithuania, Northern Ireland (United Kingdom), Portugal, Saskatchewan (Canada), Sweden, and partner countries: China, Kazakhstan and Russian Federation.

[4] An OECD report dating back to 2011 (drawing on data from countries participating in PISA 2009) found that lower secondary schools in Czechia, the Netherlands and the United Kingdom had the greatest levels of autonomy over their curriculum and assessment practices, as well as their financial and human resource allocation. In Japan, Korea and New Zealand too, more than 80% of students participating in PISA 2009 were attending schools that had significant autonomy or responsibility over their student-assessment policies, but they had less autonomy over resource allocation. Greece and Türkiye granted the least autonomy to schools (OECD, 2011[214]).

[5] The evidence presented in Table 1 draws on the following sources: OECD (2019[42]), *PISA 2018 Results (Volume I): What Students Know and Can Do*, OECD Publishing, Paris, https://www.oecd.org/pisa/publications/pisa-2018-results-volume-i-5f07c754-en.htm; OECD (2022[33]), *Thinking Outside the Box: The PISA 2022 Creative Thinking Assessment*, OECD Publishing, Paris, https://www.oecd.org/pisa/innovation/creative-thinking/; OECD (2021[36]), *Beyond Academic Learning: First Results from the Survey of Social and Emotional Skills*, OECD Publishing, Paris, https://www.oecd.org/education/ceri/social-emotional-skills-study/beyond-academic-learning-92a11084-en.htm; OECD (2017[31]), *PISA 2015 Results (Volume V): Collaborative Problem Solving*, OECD Publishing, Paris, https://www.oecd-ilibrary.org/education/pisa-2015-results-volume-v_9789264285521-en; OECD (2014[30]), *PISA 2012 Results: Creative Problem Solving: Students' Skills in Tackling Real-Life Problems*, OECD Publishing, Paris, https://www.oecd.org/pisa/keyfindings/PISA-2012-results-volume-V.pdf; OECD (2023[34]), *PISA 2025 Learning in the Digital World*, OECD Publishing, Paris, https://www.oecd.org/pisa/innovation/learning-digital-world/; OECD (2022[37]), *Are Students Ready to Take On Environmental Challenges?*, OECD Publishing, Paris, https://www.oecd-ilibrary.org/education/are-students-ready-to-take-on-environmental-challenges_8abe655c-en; OECD (2020[32]), *PISA 2018 Results (Volume VI): Are Students Ready to Thrive in an Interconnected World?*, OECD Publishing, Paris, https://www.oecd-ilibrary.org/education/pisa-2018-results-volume-vi_d5f68679-en; Schleicher (2020[43]), "Are students ready to thrive in an interconnected world? The first PISA assessment of global competence provides some answers", *OECD Education and Skills Today*, OECD Publishing, Paris, https://oecdedutoday.com/students-ready-thrive-interconnected-world-first-pisa-assessment-global-competence/; OECD (2023[35]), *PISA 2025 Science Framework (Second Draft)*, OECD Publishing, Paris, https://pisa-framework.oecd.org/science-2025/assets/docs/PISA_2025_Science_Framework.pdf; Borgonovi et al. (2022[39]), "The environmental sustainability competence toolbox: From leaving a better planet for our children to leaving better children for our planet", *OECD Employment, Social and Migration Working Papers No. 275*, https://www.oecd.org/publications/the-environmental-sustainability-competence-toolbox-27991ec0-en.htm.

[6] Tasiopoulou et al. (2022[49]) identified five mechanisms of EES curriculum integration: 1) developing a new standalone subject; 2) embedding in existing subjects (some or all); 3) project-based integration; 4) focusing on teaching and learning methodologies; and 5) co/extra-curricular activities.

[7] OECD member countries: Austria, Belgium (Flemish and French Communities), Canada (Quebec, Saskatchewan), Chile, Colombia, Costa Rica, Czechia, Denmark, Estonia, Finland, Hungary, Iceland, Japan, Korea, Latvia, Lithuania, Netherlands, New Zealand, Norway, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland (Appenzell Ausserrhoden, Lucerne, Nidwalden, Obwalden, St. Gallen, Uri, Zurich), Türkiye, United Kingdom (England), United States (Illinois). Non-member countries: Russian Federation, South Africa.

[8] Open Educational Resources (OER) are "learning, teaching and research materials in any format and medium that reside in the public domain or are under copyright that have been released under an open license, that permit no-cost access, re-use, re-purpose, adaptation and redistribution by others" (UNESCO, 2019[214]).

[9] The OECD Education 2030 Policy Questionnaire on Curriculum Redesign (PQC) provides data (from 2020) on the frequency of curriculum reform of 34 OECD countries/jurisdictions and partner countries (upper and lower secondary education).

[10] Australia, Canada, United Kingdom, United States, Finland, Germany, Italy, Norway, China, Hong Kong, Malaysia, Argentina, Brazil.

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

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