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The Twin Transitions: Digital and Sustainability Learning in Schools

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1. Introduction

> 'In the digital transition, the European Union aims to harness digital technologies for sustainability and prosperity, and to empower citizens and business. Successfully managing the green and digital 'twin' transitions is the cornerstone for delivering a sustainable, fair, and competitive future. There is no time to waste, and the twin transitions must be achieved together.'
>
> '*Towards a Green and Digital Future, 2022*'[i]

Much has been written about the twin tracks of digital and green innovation and the potential for EU Member States to combine their efforts in these areas through shared transition pathways. Both agendas call for changes in the way we presently live, learn and work as well as how we consider our future. Pathways leading to the green and digital transitions are multifaceted and often interconnected[ii]. Indeed, the European Commission has underlined that an environmentally sustainable, circular, and climate-neutral economy cannot be attained without harnessing new technologies[iii].

Policy measures, investment and actions could be aligned across the two agendas and in ways that enable a more sustainable future. Of note is the Commission's '*Towards a Green and Digital Future'* (2022) study that examined how the green and the digital transitions can be mutually reinforcing. It noted, however, that the two agendas are not entirely complementary and pointed to some incompatabilities that add a layer of complexity to twinning efforts[iv].

Synergies and tensions, between the green and digital transitions, are emerging across the education sector as it begins to embrace this challenge. An overview of developments in schools point to some successes but also to complications and disparities in the way Member States have engaged with these agendas. It is within this context that the Commission's annual *Strategic Foresight Report* (2023)[v] turned its attention to education and training as one of its ten priority actions. It calls for Member States to focus on aligning efforts in digital and sustainability provision in education to give effect to the joint transitions.

This input paper explores what we mean by the digital and green transitions in the context of education and learning. Numerous documents exist that outline the EU-level policy goals and priorities for the twin transitions and set a course for the education sector's engagement with these agendas. Informed by these documents and a series of examples, the paper looks closely at how both agendas could be mutually supportive and where complementaries already exist in schools. These common points include: a quest for eduational innovation; a commitment to whole-school approaches; efforts to extend learning beyond the classroom; and, the opportunities offered for learner participation and competency based learning. The paper also examines tensions such as those relating to the carbon burden and e-waste, equality of access, wellbeing, security and safeguarding; teacher engagement and student preparedness. It proposes ways in which we can harness digital technologies to advance learning for sustainability in schools and in ways that can contribute to improving learner outcomes. Specifically, it seeks to offer insights on how to combine educational policy, action and investment in these areas.

2. What do we mean by the green and digital transitions in the context of education?

Accompanying a growing global concern for the environment, is the increased use and significance of digital technologies across society. When we refer to digital technologies we mean *electronic tools, systems, devices and resources that generate, store, process or communicate data or physical information.* Examples include social media, online games,

multimedia and mobile technology, the Internet of Things, Geographic and Information Systems (GIS), augmented reality, robotics and automated mobility.

The parallels between the green and the digital agendas are recognised and valued: Member States seek to harness digital technologies for sustainability, prosperity and to empower citizens[vi]. To accelerate the use of green digital technologies for the benefit of the environment, 27 Member States as well as Norway and Iceland signed the Declaration on a Green and Digital Transformation in which they commit to leading the green digital transformation at national level[vii]. In addition, the Council adopted the conclusions of "Digitalisation for the Benefit of the Environment" establishing the *European Green Digital Coalition* and bringing together technology business and enterprises in support of these venture. A similar coalition is needed and could be established with a focus on education.

The term 'twin transitions' has been adopted to refer to these priority agendas given that they are concurrent transformational agendas that are increasing influencing how we live our lives. There is a view that uniting them would accelerate the necessary changes. In eduation, they offer platforms, processes and contexts that can help learners engage with contemporary issues, build competences and aspire to a more sustainable future.

A commitment was made by EU Member States for students to ***learn for sustainability*** and for educational environments to become sustainable[viii]. The agenda is about creating opportunities to *experience* as well as *learn* sustainability in schools, colleges and universities. This requires investment in buildings and infrastructure as well as the development of competences so that students can contribute to the green transition. Key features include creating opportunities for collaborative, participatory, inquiry-based, empowering, connected, future-facing, action/change oriented learning (*see Figure 1*).

The Digital Education Action Plan 2021-2027[ix] is a key European Commission document which calls for education and training to be 'reset' for the digital age. The Action Plan recognises the potential these advancements offer to learning environments and learning experiences as well as the need for all citizens to be digitally literate. In schools, ***digital education*** looks at ways in which digital tools and technologies can create interactive, collaborative, accessible, flexible, inquiry-based, interactive, collaborative and networked learning (*see Figure 1*).

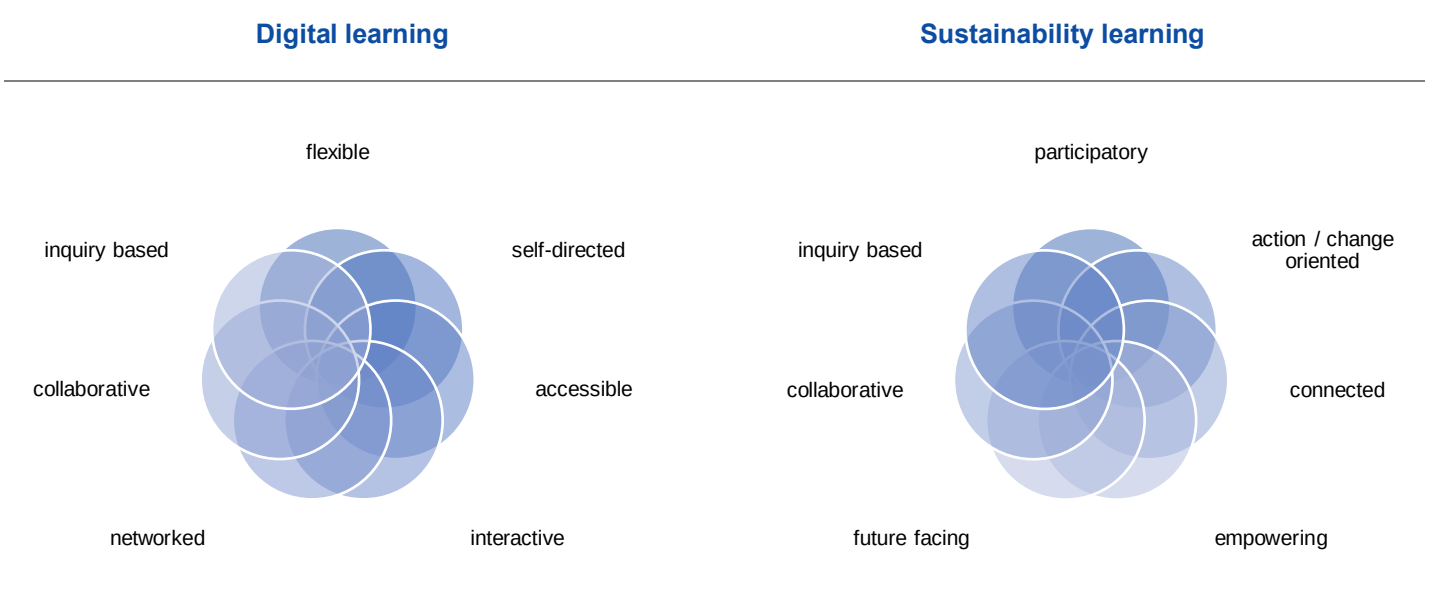

Figure 1: Key features of Digital and Green Education

3. What is the value of digitisation and technology to education?

It is important to note that the adoption of digital technologies in education has often been driven by general advancements in computing power, data storage capacity, algorithms and visualisation, rather than by identified educational needs[x]. This means that teachers, learners, librarians, administrators and other users working in schools may need to be persuaded of the value and trained on their potential use in schools[xi]. This has implications for how these tools, platforms and devices are introduced or enhanced in a school environment. It is therefore important to articulate the value of the new technologies to education at every opportunity rather than assume that users will recognise the needs these can address.

Digitisation and the digital technologies are seen to bring value to education in a number of ways and at a number of levels. These include: improvements in educational management and administration through the adoption of new digital tools and applications; new opportunities for networking with experts, other communities and schools through virtual connections; the monitoring and management of school infrastructure (including buildings) through electronic devices and new communication technologies; the improved monitoring of individual student performance or key trends across the school (including absentism) thanks to data capture and processing tools. Many examples can be cited of how digital technologies can increase effectiveness and bring improvements to many aspects of school life. Together these are seen to foster the development of a high-performing education ecosystem[xii].

Perhaps of greater interest to those engaged in sustainability and learning for sustainability, is the ability of the new digital technologies to extend learner participation and involvement. Digital innovations have the potential to reshape the teaching and learning dynamic displacing the teacher as the source of all knowledge. It can reframe what can be done in classrooms and how the school buildings and grounds become key learning resources. *Table 1* identifies the functions of digital technologies and how these can extend learner participation and engagement, illustrating what these can look like in practice.

When considering the value of digitisation and digital technologies to education it is important to consider not only the platforms, tools or devices independently that bring new entry points to learning but also assess what new relationships and opportunities arise when they are combined. The Internet of Things (IoT) is an example of how wearable sensory devices, new geolocation applications and sensors have not only supported the widespread adoption of smartphones but also helped to establish new purposes and uses for them (e.g. health and fitness applications). The innovation arising from this connectivity has resulted in over 75 billion users and as a direct result of a combination of digital tools and technologies[xiii]. The expectation is that, as new technologies, including Artificial Intelligence, are progressively utilised in teaching and learning environments, bespoke applications will be developed which in turn will innovate the dynamic between digital learning and wider educational goals.

Table 1: The functions of digital technologies and how these can extend learner participation

Area of function[xiv]	Functions of Digital Technologies	Case Studies: Extending learner participation
 **Monitoring and tracking**	Smart sensors, ***data analytics and real-time communication*** enables students to understand and get directly involved in interpreting data related to environmental issues and sustainability. They can, for example, play an active role in: - Monitoring of biodiversity and wildlife in school gardens and green areas by pupils - Monitoring of waste levels and recycling rates of the school - Monitoring energy performance of school buildings and carbon emissions of school buildings. - Monitoring air quality in classrooms or school grounds	***Case Study: AQUA*** AQUA is a citizen science project that aims to determine and map the water quality of households. It involves secondary school students located in Northern Spain in collecting and sharing their own data from samples collected at home. A specifically designed application and webpage helps them determine the water quality of their sample. Students develop scientific literacy, digital competences and communication as they share the findings of their work. They also learn about the issues of water quality facing the communities. ***Source:*** *Queriuga-Dios et al. (2020) taken from ICF (2024)*
 **Simulation and forecasting**	Simulation and forecasting enable the identification of options. Through ***simulation, digital games and gamification*** learners explore the impact of their choices and actions on the environment as well as possible alternatives. These learner-driven programmes help them assess the potential consequences of different sustainability strategies. Through ***forecasting*** learners gain futures perspective. These can support learners in creating alternative futures through envisioning exercises and assist in establishing links between today's actions and more positive and aspiring futures. These learner-centred activities can be helpful in addressing eco-anxiety issues of young people.	***Case Study: Up to You!*** This is a simulation based programme that seek to make Europe's future sustainable. It offers cross-curricular learning opportunities for secondary schools students. The game-based approach engages and immerses students, in situations to help them discover the interconnected nature of SDGs. The programme moves away from the 'mundane studying of scientific facts' to 'learn-by-doing'. It supports student's in grasping the complexity and uncertainty underpining the sustainability transition. The modular learning materials consist of videos (live-action and animation), interactive components (quizzes, scenarios), dossiers and infographics. ***Source:*** *AFDR (2024)*
 **Virtual and Augumnted Realities**	Virtualisation offers new participatory learning possibilities through: • **Video-conferencing** • **Virtual reality experiences** • **Digital storytelling** • **Augmented realities** Virtual and augmented reality technology can be used to provide immersive experiences that help students situate themselves at the centre of environmental issues and understand complex	***Case Study: You and CO2*** This initiative involves 12-13 yrs olds in creating ***interactive digital narratives*** (IDNs). They participate in workshops that enable them to explore climate change issues and then use a 'simple programming platform' to create their own IDNs grounded in their new learning. ***Source:*** *You and Co2 (2024) taken from ICF (2024)*

	interconnections between social and economic decisions that impact on these.	
 **Systems management**	Systems management increasingly relies on artificial intelligence technologies, distributed ledger technology (DLT) and internet of things (IoT). The create participative and digital learning opportunities through: • **Data visualisation** – GIS – remote sensing • **Data capture and sense making** - not just in teaching and learning contexts • **DLT** which underlies blockchain and thus cryptocurrencies, can be used in material tracing, aiding the circular economy by better maintenance and recycling.	***Case-study: Europa's Eco-Logbook*** The Eco-Club partnership use a data visualisation (IDV) dashboard for students to plan, monitor, and evaluate their eco-actions. The Europa's Eco-Logbook is a dashboard developed by the University College London, and uses free-to-use software for creating IDV and linking to data on Google Drive. It is being used mostly in primary schools to support learner engagement with school eco-systems. ***Source:*** *UCL (2024)*
 **Information and communication technologies**	**Information and Communication technologies** enable new levels of learner interaction. The ability to connect with stakeholders beyond the learners' immediate environment is also possible through these technologies supporting the sharing and communication of information and concerns relevant to their locality. These technologies can, for example, enable their participation in a virtual environmental conservation campaigns, allowing them to work together and learn from one another.	***Case Study: TENEMOS*** TENEMOS is a project that supports school students to investigate, write and share articles on sustainable development issues. Information and communication technologies enable secondary school learners in an urban Spanish school to take ownership of this initiative. Students use their own smart phone devices, linking these to ***Google drives and publishing software*** that share drafts of articles. The project offers opportunities for students to develop digital competences, collaborative writing skills and learn about responsible reporting as well as to critical reflect upon local issues to global concerns. ***Source****:* Rodriguez Corrales (2022)

4. Twin Tracks in Education: What are the commonalities and complementarities?

A review of the literature and analysis of documented case studies suggest that sustainability and digital education have charted similar journeys in schools. They share aspirations seeking to embed across education systems and not just learning opportunities (see examples below). The challenges they face also point to similar obstacles as educators 'experiment' in the fringes of school provision, finding it hard to ground green and digital innovation at the core of the curriculum. Both aspire to reach all learners, not just those who opt for specialist courses or extra-curricular experiences in these areas.

Most notable is the way digital education is changing *how* education takes place in schools as the use of digital platforms and tools is changing the teacher-learner dynamic and innovating the broader schooling experience. Learning for sustainability explicitly seeks innovations in *what*, *where* and *how* students learn. Both have contributions to make to school governance and organisational models; recognising that the level and type of innovation required cannot be addressed by individual teachers.

Some recent Erasmus+ examples exist of how these educational agendas can come together but our understanding of how they can be mutually reinforcing or effectively practiced in the school environment is still in its infancy[xv]. Nevertheless it is understood that joined up approaches will strengthen efforts and assist in scaling up their adoption in schools. This section gives focus to the commonalities and complementarities, viewing them as entry points for collaborative efforts:

1. ***A whole-school approach (WSA):*** These twin agendas recognise that education institutions are well placed to model the changes needed for a sustainable and digitally enabled society. A WSA helps learners experience and learn through a range of innovations adopted by the school itself. Essentially, it seeks to place digital and sustainability education at the heart of the school by joining-up efforts that already exist across the educational environment and by extending these it into all aspects of school life.

Figure 2: A Whole-School Approach to Digital Education

Learning for sustainability efforts have been guided by numerous WSA models, over the years, that promote its embedding in the school ethos, governance structures, pedagogical approaches, curriculum resource management, school operations and management of buildings and grounds[xvi]. Digital education has benefited from the European Commission's DigCompOrg[xvii] that provides a framework for systematically integrating digital learning across all educational organisations including schools. It had led the to creation of a self-assessment tool (SELFIE) to deepen the adoption of the digital technologies across all areas. No tools exist that bring together both digital and green concerns together under a WSA.

2. ***Extending <u>where</u> learning takes place:*** Creating a sustainable and digital enabled school necessarily involves the redesign of learning places and spaces. Digital tools and technologies can assist with changes to school infrastructure, buildings and grounds and in ways which can involve the learners in design-making and performance management of buildings and school areas. Using innovative technologies, schools can aspire to be greener, more energy-efficient, flexible, durable, digitally connected and fit for purpose but also to taking learning beyond the classroom to school buildings, grounds, places and spaces.

3. ***Innovating <u>how</u> learning takes place:*** As mentioned previously, digital and sustainability education have the potential to change *how* learning happens. They both promote a 'hands-on' approach rather than simply the development of insight or knowledge about these thematic areas through the development of digital

competences and promoting sustainable lifestyles. They challenge teacher-centred pedagogical approaches and encourage the setting up of educational experiences that give power to the learner to discover, engage and question their experience or areas of interest.[xviii]

4. ***Rethinking <u>who</u> is involved in the learning:*** Embracing the twin transitions will mean rethinking who is involved in education. Learning for sustainability engages stakeholders and other experts in the local or wider community. Digital education in a similar way can give access to a wide range of resources, experiences but also stakeholders, enabling learners to reach out beyond their locality – providing a cheaper and easier alternative. Equally, learners with mobility issues may be excluded from nature visits, fieldtrips and experiences; immersive technologies can give them virtual access to these environments.
5. ***Questioning <u>what</u> is being learnt:*** The introduction of digital technologies also enables educators to explore new scenarios. For example, both sustainability and digital education invite leaners to explore the future in ways that seem more real and immediate. Visualisations and simulation tools, for example, are changing the way these issues are taught enabling students to live through their visions and explore more positive pathways. This is important as research has shown that students can experience eco-anxiety and feel overwhelmed and disempowered when it comes to issues such as climate change.
6. ***Challenging <u>what</u> leaners are able to do:*** Both digital education and learning for sustainability are concerned with empowering the learner to participate in the changes needed to attain a green and digital future. They seek to build capability and learner competences. These areas of learning go beyond describing current scenarios or building conceptual knowledge of what exists and seek to empower the learner with practical competences. The European Commission has offered the DigComp[xix] and GreenComp[xx] frameworks to assist with the incorporation of these agendas in education (*see)*.

   DigComp is the European framework for digital competences for citizens that can be applied to education. It involves 'the confident, critical and responsible use of and engagement with, digital technologies for learning, at work and for participation in society' (2022). GreenComp is a similar framework developed to support educational experiences so that the learner can develop the capability to engage and participate in changes for sustainability. *Figure 4* maps the competences across the two frameworks. Although the competences are not overlapping, they have a shared quest for a more capable and engaged learner and require participatory approaches to learning.
7. ***Building teacher competences:*** Teachers are often the gatekeepers of innovation and the implementation of digital and sustainable changes in schools relies on their willingness and ability to advance these agendas. A recent study documented numerous case studies of teacher education initiatives, some interweaved digital and sustainability learning and in ways that brought catalytic change to practices[xxi]. These showed compatibilities but also how innovation can be escalated when efforts are twinned. Uniting these educational concerns within teaching standards could also extend the reach and impact of these areas of learning[xxii].

   A recent study noted that some teachers need to see the value of sustainability to their core interests or subject specialisms[xxiii]; equally, some wish to see the benefits of digital technologies to learning to motivate their own engagement[xxiv]. A lack of teacher confidence is also a shared concern of digital and sustainability education; with many seeking ways to develop their own capabilities in these areas[xxv]. Of note, is the *Self-reflection on Effective Learning by Fostering the use of Innovative Educational technologies (**SELFIE**)*. This tool is based on the DigCompOrg framework and developed to support primary and secondary schools in self-assessing their engagement with digital technology. Given the synergies that exist

between the twin transitions, consideration could be given to a SELFIE version that that integrates both sustainability and digital learning concerns.

@Visual prepared by PPMI based on DigComp (Vuorikari, Kluzer, and Punie, 2022)

@GreenComp (Bianchi, Pisiotis, and Cabrera Giraldez, 2022)

Figure 3: Mapping Competences: DigComp and GreenComp

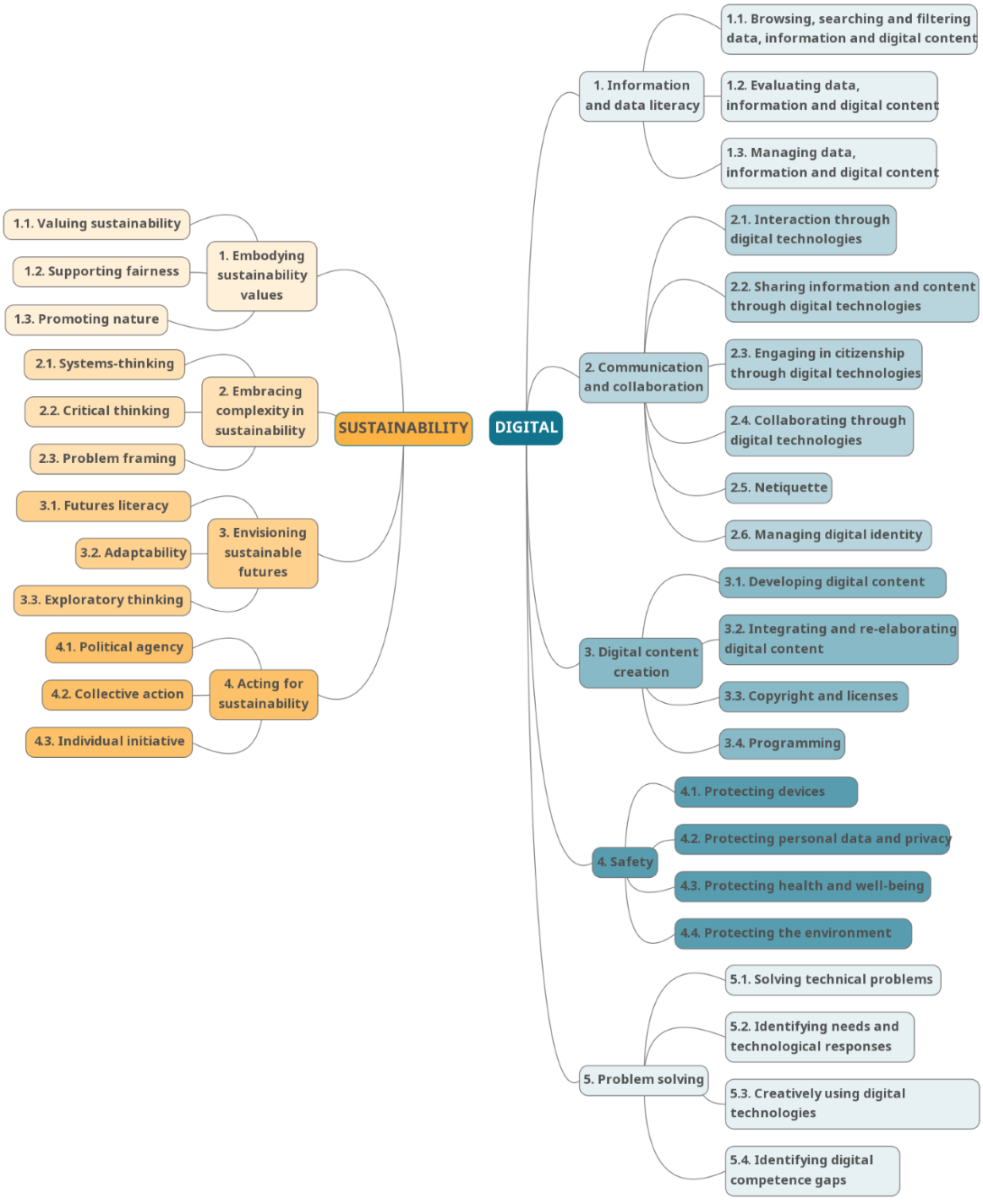

Figure 4: Mapping Sustainability and Digital Competences

@compiled by PPMI based on Bianchi, Pisiotis, and Cabrera Giraldez (2022); Vuorikari, Kluzer, and Punie (2022)

5. Twin Tracks in Education: What tensions exist?

The twin tracks of digital and sustainability education have been carving their own distinct yet parallel pathways in education over the last three decades. Recent developments have

accelerated their adoption in schools but also given rise to some tensions between them. The COVID-19 pandemic forced education authorities, school leadership teams and teachers to embrace new technologies as a means to address the inability of leaners to physically attend classes. This more 'top-down' approach contrasts with learning for sustainability work that has been driven more recently by young people who are concerned with the climate crisis and the health of the planet[xxvi]. Understanding these distinct trajectories will be important for those seeking to unite the twin transitions; however, these differences do not necessarily make these agendas incompatible. Other tensions exist that may prove trickier to address:

- ***Carbon Tensions:*** The green transition is the EU's pledge to decarbonise the economy. Digital technologies are energy intensive; at present much of our energy is fossil fuel dependent which means that our efforts to digitise will inevitably increase carbon emissions. Many digital technologies are also resource-intensive and create waste which can be toxic and difficult to dispose of, exacerbating the issue [xxvii]. Climate change is also influencing digital technologies as its supportive infrastructure (including data centres) will need to adapt to temperature increases and build up resilience to the effects of climate change and the extreme weather events that will be experienced in coming years[xxviii].

  Looking forward, it is thought that the proliferation of energy-intensive digital technologies such as AI and blockchain will escalate the carbon burden of education[xxix]. However, measures are already being adopted to source alternative electronic components, rethink the value chain, improve energy consumption rates, climate change resilience and embrace circular economic principles.

- ***Disengagement and wellbeing:*** The European Commission recognises the potential impact of digital technologies on learner wellbeing as young people spend an increasing amount of their leisure time indoors on digital devices [xxx]. Sustainability learning, on the other hand, creates outdoor learning opportunities engaging learners in working on a school garden; local community project; visiting botanical gardens; local nature park or a marine environment. There is some concern that screen-based technologies are undermining the very purpose of being outdoors as digital experiences can be more 'comfortable' without the need to face challenges (eg cold, heat, rain etc) in the real environment[xxxi]. There is also scrutiny around the reliance of young people on digital tools and questions about how this may affect their socio-emotional learning. Spending long amounts of time with technology means that they not only miss out on the benefits of exposure to natural environments but they also have limited experience of learning how to interact with others and develop key social engagement skills[xxxii].

  Whilst acknowledging this important tension and the need to manage or balance screen time versus outdoor experiences, there are also examples of learning programmes that address this issue. For example, the UK's Department for Education in collaboration with numerous scientific institutions has combined digital and sustainability learning through its *National Education Nature Parks* Programme[xxxiii]. The partnership is working with geospatial partner Esri UK who are providing the digital mapping platform for pupils to use in their school grounds and local areas and identify the value of these natural areas. They encourage young people to get out of the classroom to engage, map and seek ways to increase biodiversity. This initiative shows that the use of digital technologies in sustainability learning can either obstruct or enhance outdoor learning, depending on how learning experiences are designed.

- ***Trustworthiness and partiality of information:*** Studies have shown that some headteachers may be resistant to using digital tools that give wider access to information, such as the internet[xxxiv]. They express concern about the impact of misinformation and fake news on young minds as these may cause polarization of views and social tensions particularly with regards to climate change. They also

comment on how students are not prepared adequately to use these tools or process the information they access which may, in some cases, lead to well-being issues such as eco-anxiety. A recent survey also identified concerns of educators regarding the use of Artificial Intelligence as an obstacle to their introduction in education; some citing plagiarism as an example of how it will prove difficult to 'police' the use of the new technologies[xxxv]. These tensions are not unsurmountable; teacher professional development as well as greater regulation by the technology industry would be needed to address these concerns.

- ***Security and Safeguarding:*** Much of the data produced in the European Union is stored and processed elsewhere, which poses both a security risk and a potential loss of the value. Schools will need to be adopting robust cybersecurity measures and establish secure data sharing frameworks to protect privacy, identity and preserving the safety of online learning. This requires headteachers and senior management teams as well as teachers to be trained and aware of these concerns.
- ***Teacher preparedness:*** From a teacher's perspective, aligning sustainability learning with digital education requires the development of new skills and abilities. Teachers are expected to browse, collate, evaluate information and assess the value and potential of digital platforms and programmes to their areas of responsibilities. In some instances, they will create new digital content, amend learning plans and collaborate with others within or outside the school to progress these agendas[xxxvi]. Professional learning opportunities that combine digital and sustainability education will be critical to adoption of the twin agendas in schools.
- ***Lack of empirical evidence:*** There are an increasing number of academic articles that document how digital tools can be integrated into sustainability learning but a lack of empirical evidence of how these efforts impact student learning[xxxvii]. Evidence gathering across a range of cases, pedagogical effectiveness studies as well as longitudinal research are required to compile the evidence needed to motivate as well as guide teachers and school leaders to embrace the twin transitions. Teachers are more likely to embrace the innovations if they know that pupils achieve better learning outcomes thanks to advances and new way of working[xxxviii].
- ***Inequitable access to technology:*** The 'digital divide' is also of concern to some engaged in sustainability education. It arises as a result of some, not all, schools, teachers and learners having limited or no means to benefit from digital technologies. Differentiated learning outcomes arise as a result of unequal access to technology infrastructure, support or technical expertise. The European Commission has documented how this is the reason for wide differences between Member States as well as within regions and districts[xxxix]. Influencing this dynamic, is the lack of high-speed internet, the limited ability to purchase or renew software licences, high computer- student ratios and the small number of technical support staff available to some schools. Restricted budgets and purchasing powers of education authorities and schools could also prohibit the progress of the twin transitions. Investment is key to overcome this important obstacle but given the current economic challenges it may take some time to overcome this particular challenge to twining the transitions.

6. Doorways to Twinning Agendas in Education

This input paper had mapped the relationship between the sustainability and digital transitions defining common pathways and complementarities as well as identifying where tensions and challenges arise. It has pointed to authoritative documents and frameworks and accompanied these with examples that show how these agendas can be mutually supportive in schools. These initiatives have shown how digital education can be: a resource for learning for sustainability; an innovation that inspires new ways of learning; as

well as, a driver for advancing whole-school approaches to sustainability. This final section proposes 6 doorways that can advance the twin transitions in school education and combine considerations relevant to educational policy, action and investment.

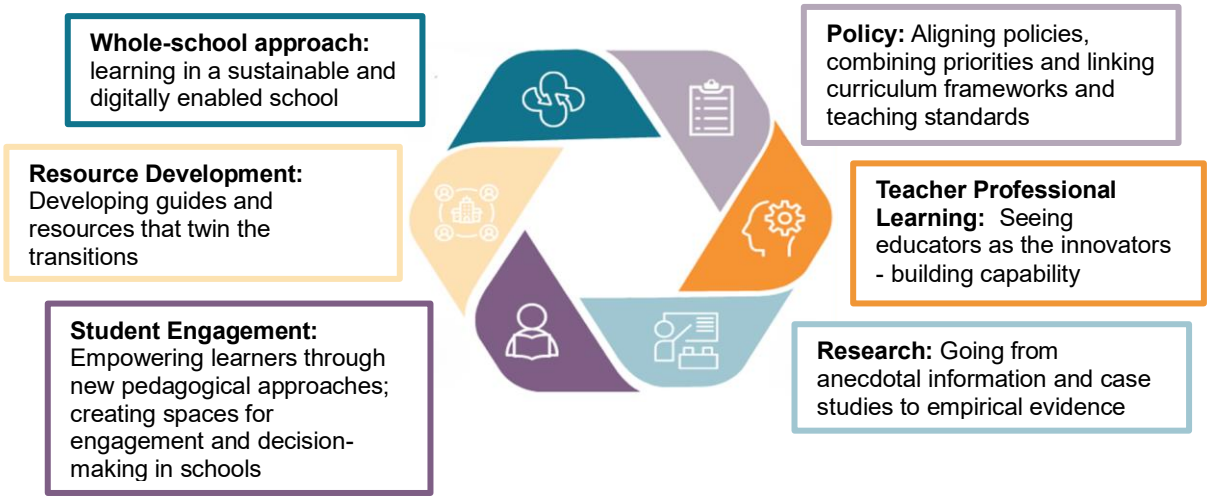

Figure 5: Doorways that can advance the twin transitions in school education

6.1 The Policy Doorway: The value of advancing both digital and green education to improve educational as well as socio-environmental outcomes is increasingly understood but few European countries have integrated their policy or investment efforts across the two agendas.[xl] Germany[xli], Finland[xlii] and Spain[xliii] have made progress in twinning the transitions through integrative training, financial support, educational research and/or curriculum development[xliv]. Given time, it is likely that more Member States will develop policies and measures to support the twin transitions in education as they familiarise themselves with the value and benefits of joining efforts and the recently developed frameworks and tools that support their adoption[xlv].

6.2 The Research Doorway: Only anecdotal information exists of the mutually beneficial ways in which the twin transitions can potentially influence student engagement in learning. Equally we know of case studies that document improvements in knowledge and see increased motivation of learners to act for the environment[xlvi]. Investment in research studies could prove to be a game-changer in consolidating the complementarities and addressing some of the tensions identified in this paper.

6.3 The Doorway on Teacher Professional Learning: Every sub-section of this paper has referenced the critical role that teachers play in effecting the green and digital transitions. Without initial and continuing teacher education and/or, quality frameworks to support the development process, it is unlikely that the twin transitions will be attained. They are the innovators and drivers of sustainability and digital education in schools and learning communities.

6.4 Resource Development Doorway: Developing teaching guides and resources that make explicit connections to the educational value, processes and learning outcomes between sustainability and digital education could prove catalytic in advancing these agendas in schools. Teachers need support to connect their lesson plans and activities to the interdisciplinary and whole-school approaches thus helping to upscale the impact of these efforts and ensure all children experience learning in these areas.

6.5 The Doorway of Student Engagement: Young people have their own experiences as well as concerns about sustainability and digital technologies particularly as they relate to fake news, greenwashing, cyberbullying and data security. Opportunities must be created

for them to bring these into the classroom and influence learning. They have their own communication channels as well as sustainability issues they are concerned about. Inclusion of student voices in school governance and management is also important for student engagement. This engagement is underpinned by opportunities to develop of both sustainability and digital competences.

6.6 The WSA Doorway: It is both a challenge and a priority for schools to themselves become sustainable and digital enabled. Students must experience the sustainability and digital change in their schools beyond the taught and teacher-led curriculum. Digital technologies can catalyse efforts to embed learning for sustainability across all aspects of school life as documented in this paper. Promoting whole-school approaches to the twin transitions provides a win-win situation for schools, learners and society.

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[i] Muench et al. (2022)
[ii] European Commission (2023)
[iii] Muench et al. (2022)
[iv] Muench et al. (2022)
[v] European Commission (2023)
[vi] European Commission (2023)
[vii] European Green Digital Coalition (2020)
[viii] Council of the European Union (2022)
[ix] European Commission (2020)
[x] The exception was the Covid19 pandemic that accelerated the adoption of technologies as a result of the inability of pupils to attend school.
[xi] Some teachers questions the assumption that 'technology is a good thing'. More research evidence and examples of good practice may be needed to mainstream this agenda.
[xii] European Commission (2023)
[xiii] Muench et al. (2022)
[xiv] As defined in Muench et al. (2022)
[xv] PPMI (2023)
[xvi] For example: Tilbury and Galvin (2021); Mathie and Wals (2022); Tilbury and Henderson (2004)
[xvii] Vuorikari, Kluzer, and Punie (2022)
[xviii] Brečka, Valentová, and Tureková (2022); Trott and Weinberg (2020)
[xix] Vuorikari, Kluzer, and Punie (2022)
[xx] Bianchi, Pisiotis, and Cabrera Giraldez (2022)
[xxi] Mulà and Tilbury (2023)
[xxii] 'Career Progression and Assessment Tools: Hungary' and 'Embedding LfS into Teachers Professional Standards: Scotland' in Mulà and Tilbury (2023)
[xxiii] Mulà and Tilbury (2023)
[xxiv] Some teachers are concerned that children already have too much screen time limiting social engagement and outdoor experiences.
[xxv] Mulà and Tilbury (2023)
[xxvi] In recent years students have actively campaigned for the inclusion of climate education in schools: See for example: *Teach the Future*; *Fridays for Climate*.
[xxvii] Building and running digital systems is energy intensive; the resources required to manufacture digital and electronic technologies are also problematic and include the exploitation of rare elements that need to be mined; the non-recyclable and partially toxic waste that results at end of life-cycle is also an issue. The ICT industry's contribution to global greenhouse gas emissions was more than 3 % of total emissions in 2020 and growing as more users access the technology.
[xxviii] Muench et al. (2022)
[xxix] Greenwood and Hougham (2015)
[xxx] European Commission (2023)
[xxxi] Thomas and Munge (2014) cited in ICF (2024)
[xxxii] Dyment, J., T. O'Connell, and I. Boyle, 'The Intersection of Web 2.0 Technologies and Reflective Journals: An Investigation of Possibilities, Potential and Pitfalls', International Journal of Leadership in Education, Vol. 3, October 31, 2011, pp. 137–150.; Greenwood, D., and R. Hougham, 'Mitigation and Adaptation: Critical Perspectives toward Digital Technologies in Place-Conscious Environmental Education', *Policy Futures in Education*, Vol. 13, January 29, 2015.
both cited in ICF (2024).
[xxxiii] National Education Nature Parks Initiative (Department for Education (DfE) and partners, 2023)
[xxxiv] In the UK, for example. New mobile phones in schools guidance issued on 19 February 2024 backs headteachers in prohibiting the use of mobile phones throughout the school day, including at break times. Many schools around the country are already prohibiting mobile phone use with great results - https://www.gov.uk/government/news/government-launches-crackdown-on-mobile-phones-in-schools#:~:text=New%20mobile%20phones%20in%20schools,phone%20use%20with%20great%20results.
[xxxv] Study conducted in the US – Imagine Learning (2023)
[xxxvi] Napal, Peñalva, and Lacambra (2018)
[xxxvii] ICF (2024)
[xxxviii] Wikan and Molster, (2011); ICF (2024)
[xxxix] European Commission, EACE, and Eurydice (2019)
[xl] ICF (2024)
[xli] Germany the '*German National Action Plan on Education for Sustainable Development*' (2017) explicitly seeks digitalisation as a means to attain sustainable development. Following on from this the German Steering Committee on ESD published "Bildung für nachhaltige Entwicklung – Ein Kompass im digitalen Wandel unserer Gesellschaft".
[xli] and "Unterricht der Zukunft - BNE und Digitalisierung in der schulischen Bildungspraxis"[xli], that seek to build bridges between the twin transitions. These call on schools to play their part in attaining a digitally enabled and sustainable future – Source: ICF (2024).
[xlii] Finland developed curriculum frameworks that embedded ICT into the school curriculum in 2016. These frameworks also give importance to nature studies, outdoor education and more recently to SDGs. In 2023, the education ministry published the *Policies for the Digitalisation of Education and Training until 2027* seeking to make Finland the world's leading developer and user of sustainable digitalisation in teaching, education and training. It has developed transversal competences that map sustainability and digital competences in schools.
[xliii] Numerous programmes have been launched at the national level bringing these concerns together: For example: State Research Agency, Spain, 'Strategic Projects Oriented to Ecological Transition and the Digital Transition, Madrid, Spain', 2022.
[xliv] Muench et al. (2022)

[xlv] For example, Cyprus is revising its "National Strategic Plan for Environmental Education to include the digital education dimension into it – source: ICF (2024).
[xlvi] Trott and Weinberg, (2020); Borda and Jerowsky (2022)