Department for Education

Future opportunities for education technology in England

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1. Introduction

In December 2021, the Department for Education (DfE) appointed Ecorys UK to undertake a research project: **Future opportunities for education technology in England**. The project aimed to provide insights to the future of the EdTech market in England, considering likely developments in digital technology and education policy.

This report presents the triangulated findings from work carried out over four months, from December 2021 to March 2022, which comprised of a rapid review of the literature, telephone interviews with policy and industry key stakeholders, workshops with teachers and EdTech sector representatives, and a survey administered with a nationally representative sample of teachers through the Teacher Tapp app[1].

In this chapter, we introduce the background context to the project. We then present the aims and objectives and explain the methods that were deployed, including sampling considerations, data strengths, limitations and caveats. Finally, we outline the structure for the remainder of the report.

Key concept and definition of EdTech

In order to ensure consistency and clarity, we provide a working definition for how we have presented Education Technology (EdTech) throughout this report. We follow the DfE definition of EdTech, presented in the national digital education strategy, which is defined by the DfE as:

> The practice of using technology to support teaching and the effective day-to-day management of education institutions. It includes hardware (such as tablets, laptops or other digital devices), and digital resources, software and services that help aid teaching, meet specific needs, and help the daily running of education institutions (such as management information systems, information sharing platforms and communication tools).[2]

Background context

The COVID-19 crisis has been the cause of unprecedented economic and social disruption. While from a public health perspective, children and young people represent a comparatively 'safe' population, the pandemic has had far-reaching consequences for their learning and development now and in the future. Figures suggest that the education of one billion children has been disrupted, across 186 countries.[3] Yet, while the pandemic

[1] https://teachertapp.co.uk/
[2] DfE, (2019), Realising the potential of technology in education: A strategy for education providers and the technology industry.
[3] UNICEF. (2019). Coronavirus Global Response. Paris: UNICEF.

has undoubtedly caused setbacks for health, education and the wider economy, it has created unforeseen opportunities with regard to digital technology. There has been rapid development of new or existing provision across education systems to ensure that compulsory school education can continue at home. This has seen education settings move away from traditional face-to-face classroom provision and toward online learning and communication. In many respects, this represents a potential accelerator of progress in digital education and may support longer-term progress in integrating digital tools – moving from a crisis response to a 'reimagining' of the educational landscape.[4]

The COVID-19 public health crisis has also highlighted the importance of student and teacher agency, as all have adapted rapidly to new ways of working and studying in this unprecedented situation, and the shifting roles and interactions between teachers, students and parents.[5]

As education technologies have evolved considerably during the pandemic, it has also become clear that they do not offer a panacea for solving challenges in education and teaching. In a recent report entitled '*Reimagining our futures together: A new social contract for education*', UNESCO highlighted that some education technologies can support inclusivity and hold 'great emancipatory potential', while others come with risks and side-effects.[6] The report highlights that data privacy as a particular important issue to address, where rules and protocols should both protect students and teachers while simultaneously allowing for data capture that can help to improve teaching and learning. To strike a balance, UNESCO favours an approach where an 'ethic of transparency' should guide data policy, and where the default setting should always be to anonymise data in order to avoid harming individuals.[7]

In England, teachers[8] and policymakers[9] recognise the potential for education technology to improve pupil attainment, contribute to reduced teacher workload, save time on school management activities, and complete teaching-related tasks. A recent national survey of schools and colleges found that the majority of schools and colleges had invested in new or updated technology in response to COVID-19, and a continued priority for future investment in education technology will be supporting remote teaching and learning.[10] Other priorities for future investment are supporting pupils with special educational needs and disabilities (SEND), offering online learning, planning curriculum content, and tracking pupil progress. However, the needs and priorities of schools and colleges vary

[4] OECD. (2020). Building Back Better: A Sustainable, Resilient Recovery after COVID-19. Paris: OECD.
[5] Looney, J. (fothcoming) Analysis of Stakeholders Survey on the OECD Global Forum the Future of Education and Skills 2030
6 UNESCO. 2021. Futures of Education entitled Reimagining our futures together: A new social contract for education. P.35. Available at: https://en.unesco.org/news/what-you-need-know-about-unescos-futures-education-report
7 Ibid.
8 CooperGibson Research (2021) Education Technology (EdTech) Survey 2020-2021. UK: Department for Education.
9 Department for Education (2019) Realising the potential of technology in education: A strategy for education providers and the technology industry. UK: Department for Education.
[10] CooperGibson Research (2021) Education Technology (EdTech) Survey 2020-2021. UK: Department for Education.

across primary, secondary and colleges and there is no single education technology initiative that will be optimal in all education settings.[11]

Schools and colleges in England have experienced barriers to the uptake of EdTech, including[12]: the cost and availability of EdTech tools; staff skills and confidence; connectivity barriers; safeguarding and data concerns; and concerns around pupil's ability to engage in EdTech from home, particularly due to the socioeconomic 'digital divide'.[13] Future developments in education technology must overcome these barriers to succeed in achieving improvements in educational outcomes. Additionally, adopting innovative and advanced digital tools and technology alone is not enough to secure improvements in education. The way in which education technology is implemented and embedded by schools and colleges is critical to achieving the perceived benefits.

There is also a clear continued demand for EdTech in the UK, accelerated by the pandemic, with the sector growing by 72% in 2020 and anticipated to be worth £3.4 billion by the end of 2021.[14] Whilst the largest EdTech companies are predominantly based in the USA and China, there are over 600 EdTech companies based in the UK, and the UK attracts almost half of all EdTech investment coming into Europe.[15] According to the European EdTech Funding Report 2021, the UK is the first EdTech investment destination in Europe, taking ~30% of the value of all deals across the continent.[16]

In the UK and Europe, EdTech was already experiencing substantial growth prior to the COVID-19 pandemic. Investment in the sector increased tenfold since 2014 and funding is set to surge from €625 million in 2020 to nearly €1.6 billion in 2021.[17] The enormous demand for EdTech, exposed by the COVID-19 pandemic, has forced incumbents and start-ups to innovate, pivot and expand to supply its consumers who have been under pressure to seek rapid digital solutions. Like elsewhere, the pandemic has thus further served as an accelerator in growing the UK and European EdTech markets.

These trends presented a departure point for the current study, which aimed to bring the evidence up to date with an analysis of the latest research and policy literature, key stakeholder interviews with representatives from the UK, other 'digitally mature' countries from which schools and colleges in England might stand to draw learning from, and primary research with educationalists and EdTech sector representatives in England.

11 Ganimian, A., Vegas, E. and Hess, F. (2020) Realizing the promise: How can education technology improve learning for all?. Brookings Institution.
12 CooperGibson Research (2021) Education Technology (EdTech) Survey 2020-2021. UK: Department for Education.
13 Fellows, T., Cottrill, R., Humphreys, A., Llewellyn, J. and Day, L. (2020) Navigating the digital world; a synthesis of the evidence. Ecorys.
14 Education Technology (2021) 'UK EdTech market expected to reach £3.4bn this year', Education Technology. 16 September 2021.
15 Walters, R. (2021) 'UK #EdTech sector grew by 72% in 2020 – with further growth forecast this year amid Spring Term school closures'. Future of Education, 14 January 2021.
16 https://www.brighteyevc.com/post/european-EdTech-funding-report-2021
17 https://www.brighteyevc.com/post/european-EdTech-funding-report-2021

Aims, objectives and the scope of the study

The main research aim was to better understand the future of the EdTech market in England, considering likely developments in digital technology and education policy.

The specific research objectives were to:

- **Assess the future of EdTech**, including:
    - developments in the domestic education landscape that could change EdTech requirements
    - potential new areas for EdTech and the types of products that will be needed
    - changes to technology in the home environment, taking account of digital inequalities
    - identify barriers to achieving the future potential of EdTech
- **Provide international comparisons for EdTech use**, specifically:
    - identify ongoing developments in EdTech in more digitally mature countries
- **Assess the opportunities and challenges for the adoption of new EdTech**, including:
    - exploration of the capacity that schools and colleges/colleges will have in the next 10 years to implement new EdTech
    - identify how education settings would like to be supported to overcome implementation barriers

Methodology

The research methodology was designed to gather and analyse evidence in relation to the main objectives. Our research involved a mixed methods design, as presented in Table 1.

Table 1. Method overview

Work stream 1 Rapid review	To map and appraise the evidence for EdTech futures in England and internationally, informing: a SWOT analysis; scenarios for testing, and four (4) comparator countries for deeper exploration.	**Work stream 5** **Analysis and reporting** Publishable report, summary and PowerPoint slide deck
Work stream 2 Qualitative semi-structured inter-views	With UK and international policy, academic and EdTech leaders (n=13), to gain policy and practice insights from the selected digitally mature countries in Europe, Asia and North America.	
Work stream 3 Future of EdTech workshops	Bringing together (n=69) school, college and EdTec professionals across three workshops to test the SWOT analysis; attitudes towards tech changes, and to estab-lish support needs.	
Work stream 4 Short online panel survey	To consolidate the key desk research and workshop findings with a representative sample of education pro-fessionals across England (n=5,568), using the *Teacher Tapp* mobile app.	

Each workstream and research activities are described below.

Work stream 1: Rapid review

An initial rapid review was conducted, following the principles of a Rapid Evidence Assessment (REA). The REA sought to answer four research questions:

- How is digital technology used in education (primary, secondary and colleges) in England?
- How are England and other countries using digital technology to improve the quality of teaching, learning and assessment in education?
- What are the key approaches, education system characteristics and policy measures in England supporting digital technology and innovation in education?
- What are the digital approaches and tools that teaching staff would need in the future to support efficient and effective education?

The REA on the future of EdTech provided a snapshot of the global trends and innovations in the use of technology in primary, secondary and college-level education. It mapped and appraised the evidence for potential EdTech futures in England and internationally. By reviewing the literature on global developments in educational

technology, the REA provided an understanding of what can be expected for the future of the EdTech market in England.

The methodology involved a screening of academic literature on the topic, published and unpublished literature (peer and non-peer reviewed), empirical studies, market sector reports by EdTech alliances, policy documents by governments and international organisations, as well as references harvested from key documents and previous reviews. This literature was screened for the level of education that it covers (primary, secondary, college), for its geographic scope (national, European, international), and for its publication date (no literature which is more than 10 years old, with the exception of some specific literature relating to the use of digital technologies in education). The research team developed a coding framework to identify items that provide the best available evidence to meet the requirements of the review. This involved reading abstracts or summaries of literature to assess the relevance of the studies to the topic, the reliability of the sources, the research methods used, and the country of origin. The literature was selected on the basis of this coding and according to its relevance for answering the four REA questions listed above.

It is important to note the limitations of this rapid review, which owe to the concessions that the methodology makes to be 'rapid', with regards to details, depth, and comprehensiveness. Parts of this research may be limited to produce a faster report, such as the screening process (consulting a limited number of databases and articles), and the selection process (selecting a small sample of literature to answer the REA questions).

Based on both the REA and the qualitative semi-structured interviews, we conducted a strengths, weaknesses, opportunities and threats (SWOT) analysis. This analysis (which took place February 2022) teased out potential alternative future scenarios and their anticipated impact on schools and colleges and colleges – from developments in the domestic education landscape that could change EdTech requirements, to potential new types of products (and skillsets) that will be needed, and changes to technology in the home environment, explored as short 'futures narratives' (vignettes). The findings from the SWOT analysis fed into the content of the Future of EdTech workshops (Work stream 3) with school and college staff in March 2022.

Workstream 2: Qualitative semi-structured interviews with UK and international experts

Researchers conducted interviews with 13 subject experts, representing UK and international leaders in EdTech policy, academia, and industry. These qualitative, semi-structured interviews sought expert's views of what the future might hold for EdTech internationally and in England context. The interview data was supplemented and enhanced by the evidence gathered in the rapid review, which allowed the team to

identify digitally mature countries to further research. The findings were also used to develop content and materials for the 'Future of EdTech' workshops.

Table 2 below, provides an overview of the **13 participants** interviewed by the Ecorys research team. The participants were EdTech experts representing 6 countries (2 experts based in China, 1 from Estonia, 2 from Denmark, 2 from the USA, 1 from Sweden, 4 experts based in England) plus one expert with a pan-EU perspective.

Workstream 3: Future of EdTech workshops

This task comprised of three interactive 'Future of EdTech' workshops, two of which were delivered virtually via Microsoft Teams, and one delivered in person, bringing education and EdTech stakeholders together to discuss future digital strategies and EdTech trends in England. A total of **67 respondents** participated in the workshops, with a mix of school, college and EdTech sector representatives. Recruitment combined open channels (social media advertising), third party recruitment and by direct invitation to a number of exemplar schools and colleges identified within the REA.

At each workshop, the research team delivered a short presentation summarising the key drivers and trends for the future of EdTech in an international context. The presentation content was informed by the findings from the REA and semi-structured interviews with experts. This was followed by a facilitated discussion on three key topics within breakout groups, and a plenary feedback session. The three questions were:

1. What types of tools and training are needed to implement long-term digital strategies in your school?
2. What are the expected risks and opportunities for using EdTech?
3. What do you think is the overall value of EdTech?

The workshops lasted between 75 and 90 minutes and two of the sessions were recorded and transcribed, with note-taking at all three.

Workstream 4: Short online panel survey

The final strand of the data collection comprised a short quantitative survey of teachers and school leaders, which was administered using the Teacher Tapp app. Three short survey questions were designed, with the aim of validating the findings from the REA, interviews with experts and workshops, and eliciting feedback from a larger nationally representative sample of respondents.

The survey was administered between 21 and 22 March 2022 with the established Teacher Tapp panel, with an achieved sample of **5,568 respondents**. The survey data

were cleaned and weighted to reflect national teacher and school demographics. The survey questions and demographic categories are presented in Annex 2.

Analysis and reporting

Data management and coding was ongoing throughout the study, to index the research data in an optimal way to address the research questions. Templates were created in Microsoft Excel mirroring the top-level headings from the topic guides. The different sources of data were triangulated at the final analysis stage, to check the coherence and consistency of the survey and interview findings.

The sample quotas were met across all strands of the qualitative research, and the quantitative survey sample achieved a nationally representative snapshot of perspectives from teachers and school leaders across school types and phases, and English regions. The achieved samples and the quality and consistency of the data allows for a high level of confidence in the results for the overall research study.

It should be noted that the venue for the third workshop (in person) was not conducive to recording, so the analysis was based on manual notes and did not allow for verbatim transcription. This issue did not compromise the quality of the data to any significant extent, and a thematic analysis was still possible.

Report structure

The remainder of this report is structured as follows:

- **Chapter 2 "Global EdTech – key drivers and trends"** presents an overview of the size, shape and direction of travel of the EdTech sector globally, with a focus on market trends, identifying the digitally mature countries, and examining the emerging tech.
- **Chapter 3 "Future proofing – applying evidence-based solutions"** presents our findings on how to optimise the use of EdTech by schools and colleges in England, starting with an analysis of the needs and priorities of schools and colleges, and followed by an exploration of potential solutions identified through the study.
- **Chapter 4** concludes the report with a set of **overall conclusions and recommendations** for the DfE and other audiences.

2. Global EdTech – key drivers and trends

Overview of global trends

While EdTech is becoming more prominent on a global scale, the education sector has been described as "*grossly under digitized*", with less than 4% of overall global education expenditure on tech.[18] EdTech is projected to grow by two and a half times from 2019 to 2025, reaching $404 billion in total global expenditure. However, even at this level, EdTech and digital expenditure is projected to make up only 5.5% of the global education market.

In addition to EdTech's primary role supporting the formal education sector, B2C (direct business to consumer) EdTech models are also on the rise as students, parents and workers increasingly seek learning support and up-skilling for academic and career outcomes. It should be noted that EdTech does not only concern online learning but the whole suite of digital products, hardware, tools, and services that are created for educational purposes. There is also a difference between educational products that directly target the consumer (B2C), which is the learner, student or parent in the EdTech context; and B2B (business to business) products, referring to EdTech directed towards educational "businesses" – in our study context, educational institutions such as schools and colleges. B2B currently makes up a larger share of the global market, at 54%, compared with the 46% occupied by B2C.

Educational software makes up almost half of global EdTech (49%), followed by educational services (42%), with a very small fraction consisting of EdTech hardware (9%). The table below provides examples of these different EdTech "products".

Table 2 Examples of EdTech "products", with % Global Market share (2019)

EdTech Hardware (9%)	EdTech Software (49%)	EdTech Services (42%)
Classroom Technology and Institutional Devices, including Virtual Reality (VR), Mixed Reality (XR) head-sets and other simulation devices[19].	Marketplaces, Peer to Peer Learning, Coaching and Mentoring Networks, Apps, Cloud-based management systems and tools (LMS, SIS, CRM etc).	All online forms of Pre-K, K12 and HE, Tutoring and Test Prep, OPMs and Bootcamps, Digital Internships, Apprenticeships and Mentoring

Source: Ecorys, derived from https://www.holoniq.com/notes/sizing-the-global-EdTech-market/

[18] HolonIQ (2021), "10 charts to explain the Global Education Technology Market", Available at: https://www.holoniq.com/EdTech/10-charts-that-explain-the-global-education-technology-market/

[19] It does not include consumer purchased and BYOD/family/home/work hardware, library technology, projectors, TVs, monitors, or interactive whiteboards etc.

Key trends driving the EdTech industry include: the COVID-19 global pandemic, which has accelerated the demand for educational technology, tools, and services. While the pandemic has undoubtedly caused setbacks for health, education and the wider economy, it has created unforeseen opportunities with regard to digital technology. There has been rapid development of new or existing provision across many education systems to ensure that compulsory school education can continue at home.[20]

Another trend driving EdTech relates to the imperative to address a host of global education challenges. These include: the accessibility of education, the cost of higher education, the quality of learning in remote settings, the difficulty for teachers of attending to large class sizes with diverse learners, which are some problems that technology start-ups are attempting to solve through their products.[21]

Finally, there is the general trend for digitisation and process automation across numerous sectors, now increasingly including education, which is attracting new actors into the EdTech sector. The wider trend for digitisation is also contributing to the demand for digital skills, which is increasing the pressure for schools and colleges and educational services to equip young people with the digital skills and competences needed for the digital transformation.

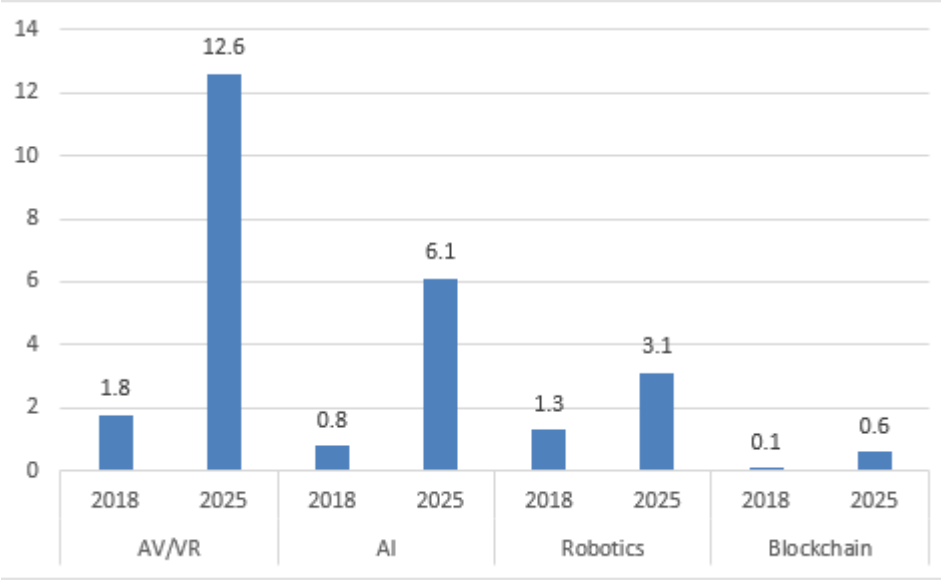
Based on calculations in 2018, the largest global expenditure in advanced technology is in Virtual and Augmented Reality (VAR), followed by Robotics, Artificial Intelligence (AI), and Blockchain (this last one comprising a very small slice of the market). However, by 2025 it is expected that, AI will become the second largest area of expenditure in terms of advanced technology after VR/AR, followed by Robotics, and Blockchain; as shown in Figure 2. This greater relative growth in AI is attributed to its potential to improve access, dramatically reduce cost and accelerate learning outcomes.[22] Deeper applications of AI in robotics are perceived to have unlocked new potential applications (and value), particularly in language learning and social development. Advances in AI have brought about a step-change in the areas of voice, vision and language and transforming how humans interact with smart devices; robots are increasingly used in applications requiring a human's cognitive or emotional skills.

The greatest impact of AI in education is expected in testing and assessment, where data generated from digital learning and teaching will allow for increasingly accurate inferences. Post-secondary, K12[23] and language learning are also considered as sectors which will be highly impacted. A lack of clear AI strategy was cited as the biggest barrier

[20] OECD. (2020). Building Back Better: A Sustainable, Resilient Recovery after COVID-19. Paris: OECD.
[21] Ibid.
[22] Holon IQ (2019), "Adoption of AI in education is accelerating. Massive potential but hurdles remain". Available at: https://www.holoniq.com/notes/ai-potential-adoption-and-barriers-in-global-education/
[23] K-12, a term used in education and educational technology in the United States, Canada, and possibly other countries, is **a short form for the publicly-supported school grades prior to college**. These grades are kindergarten (K) and the 1st through the 12th grade (1-12).

for adoption, with a lack of talent, data and leadership commitment all noted as challenges in moving from aspiration to adoption.[24]

Figure 1 Growth in advanced technology expenditure in Global Education (Billion in USD, 2018-25)



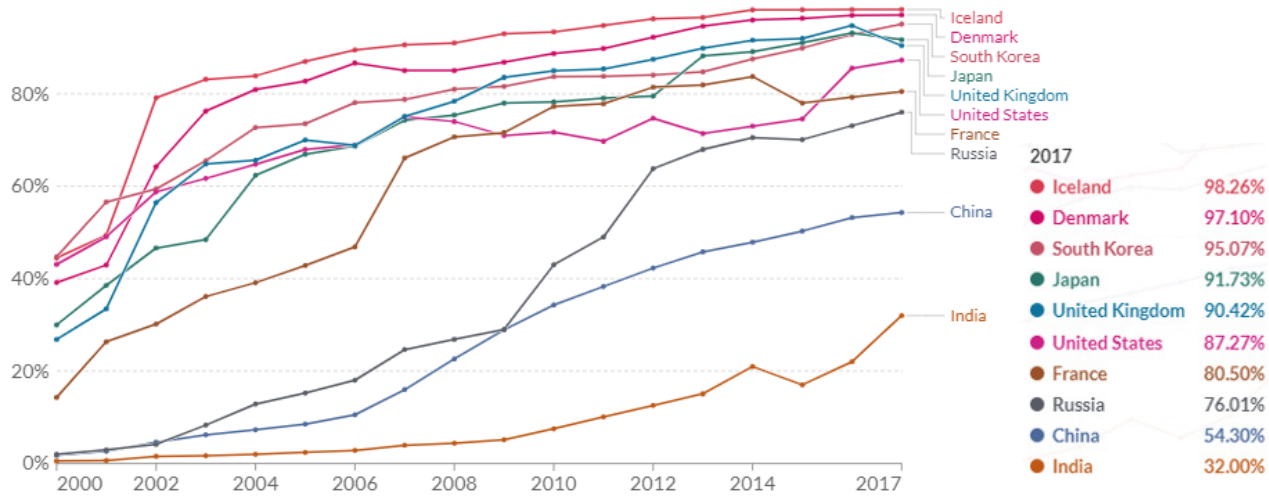
Source: Ecorys based on HolonIQ data

To better understand the changing demand for EdTech, it is necessary to understand global trends in internet access (for households), current levels of digital skills, and the level of tech use in classrooms. This will show us whether there is sufficient demand to meet the supply of EdTech products and innovations that are emerging. If there are low levels of internet, low levels of digital skills, and low use of tech in classrooms in certain regions, it would be difficult for EdTech innovations to penetrate these markets.

As such, Figure 3 provides us with insights into the potential countries or regions where EdTech could be having a large reception or impact. Based on the available data, China has the highest number of internet users, almost double the number of the next highest user, which is in India, followed by the USA. China and the USA also appear to be some of the highest users of tech in the classroom. In Europe, the highest number of internet users are in Germany, followed by the UK, and France. However, when it comes to the digital skills of the population, the most skilled countries in Europe are the Nordic and Baltic countries (Finland, Sweden, Denmark, Estonia, and Norway).

[24] Ibid.

Figure 2 Percentage of individuals using the internet by country, 2000 to 2017



Source: *https://ourworldindata.org/grapher/number-of-internet-users-by-country?tab=chart&time=2017&country=USA~IND~CHN~BRA~JPN~RUS~MEX~DEU~IDN~GBR*

An online survey in 2018, gathering responses from nearly 20,000 teachers and students (ages 12–19) from 100 countries, found that when it comes to the global percentage of students that use tech in the classroom: 48% use a desktop, 42% use a smartphone, 33% use a smartboard, 30% use an IT suite, and 20% use tablets.[25] However, these modalities are subject to considerable variation between countries and regions. The countries with highest use of tech in the classroom are the USA for desktop use (75% of students) smartboard use (59%) and smartphone use (74%); China for the use of tablets (50%); and Indonesia for IT suites (40%). Two-thirds of students (65%) do their homework on a laptop, but almost all students (98%) still use pen and paper. Nearly two-thirds of students (64%) said they use a smartphone to do their homework; with students in Argentina using smartphones the most (84%). Students in the USA were most likely to use a laptop for homework (85%).[26]

[25] Cambridge Assessment International Education (2018) Global Education Census Report. Available at : https://www.cambridgeinternational.org/Images/514611-global-education-census-survey-report.pdf
[26] Ibid.

Learning from digitally mature countries – a snapshot

For the deep dives, the research team selected four countries to explore in further depth, with the aim of identifying transferable learning for the EdTech sector in England.

Three main criteria were applied to inform the country selection: relative maturity in the operation of their domestic EdTech sector, the largest market sizes and potential "consumers" of EdTech, and geographical diversity with attention to the global market. On this basis, we selected **Denmark**, the **United States**, **France**, and **China**. The following table provides an overview of their key characteristics.

Table 3 National EdTech ecosystems – overview

EdTech markets	France	Denmark	USA	China
Percentage of individuals using the internet[27]	81%	97%	87%	54%
Broadband subscriptions per 100 people (2019)[28]	46%	44%	35%	31%
Examples of leading EdTech players and companies	360Learning, Ornikar Formation, Openclassrooms, Livementor, Simundia, Webforce3, PowerZ, Edflex	Labster, Eloomi, Lix Technologies, Lifeasapa Foundation, CanopyLAB, Peergrade, Famly, MyMonii, Shape Robotics	Alphabet Inc., Blackboard Inc., Chegg Inc., Coursera Inc., Edutech, edX Inc., Instructure Inc., Microsoft Corp	17zuoye, DaDaABC, CodeMao, Changingedu, Huohua Siwei, Hujiang, Zuoyebang, VIPKid, and Yuanfudao
Market characteristics	Public-private sector emerging cooperation	Public-private sector cooperation	Private sector with high levels of autonomy	Public sector central control
Key challenges	Facilitating stronger public-private sector cooperation	Retaining expertise to benefit the domestic market, in view of high % of tech exported	Safeguarding public interest, equity and accountability	Continuity in domestic market following policy reforms; widening rural access

[27] https://data.worldbank.org/indicator/IT.NET.USER.ZS Refers to the total population, including persons above 5 years of age.
[28] https://ourworldindata.org/grapher/broadband-penetration-by-country?country=USA~KOR~FRA~GBR~JPN~IND~ISL~DNK

The country profiles were developed using a combination of supplementary desk research, building on the REA, combined with key stakeholder interview findings. A more detailed set of profiles are provided in Annex One, with key insights presented below.

France

France is a medium-sized and growing player in the global EdTech market. In 2021, the French EdTech market was estimated to have a €1.3 billion turnover and hosted 500 start-ups, with a total of 10 000 employees.[29] This represents a significant growth compared to before the pandemic when the sector comprised of 430 companies and 7,800 employees. [30] Business models on the French market mainly focused on B2B (over 75%) with strong focus on companies and training organisations, being the main domestic consumers of EdTech solutions. In parallel, 47% of EdTech providers claim to sell to schools and colleges directly and 40% to local communities. [31]

Despite recent growth, the evidence suggests that the French EdTech sector faces several challenges. First of all, there seems to be a mistrust within the evolving relationship between the world of education (public sector) and the world of EdTech (private sector). EdTech players companies also report systematic bottlenecks including a lack of a national vision, and complex rules for gaining access to both private capital and public financing.[32] Government investments have also been criticised for focusing on building a 'digital fleet' of hardware (e.g., computers or tablets), while largely neglecting the needs for digital resources, including software, and for not investing enough in digital teacher training.[33]

> The French vision of EdTech has been, for most part, utilitarian, with a focus on finding practical and technical solutions within the education system. Instead, a new approach is needed where the daily needs of the students are at the centre (**French EdTech CEO).**[34]

Responding to these challenges, the French government has launched a series of measures. The Ministry of education launched *The Territoires Numériques Educatifs (TNEs)*, which proposes a model of digital acceleration in school education by the joint treatment of equipment, training, digital educational resources and support for e-parenting.[35] The digital education strategy is reflected in particular by the deployment of

[29] https://www.ey.com/fr_fr/strategy/la-filiere-EdTech-francaise-l-annee-du-milliard
[30] Ibid.
[31] https://www.ey.com/fr_fr/strategy/la-filiere-EdTech-francaise-l-annee-du-milliard
[32] https://siecledigital.fr/2021/06/01/lEdTech-france-quelles-dynamiques/#:~:text=Aujourd'hui%2C%20d'apr%C3%A8s,euros%2C%20et%207%20000%20emplois.
[33] Ibid.
[34] Paraphrased and translated excerpt from statement by Rémy Challe, CIO of Skill & You. Available here.
[35] According to Masud S Hoghughi, Nicholas Long, Nicholas James Long (2004), Handbook of Parenting: Theory and Research for Practice, E-parenting refers to the use of electronic technology to assist in the parenting role. The text is available at :

digital equipment, and the pooling of educational content or the training of teachers and families. Ten departments are involved in 2021, with the long-term objective of deploying tools that meet the needs of all throughout the territory. The aim is to develop the digital skills of students, teachers and parents. [36]

To also facilitate the emergence of new digital solutions in education, and experiment with them at different scales and measure their impact, the French Ministry of education has recently launched a priority equipment and research program (PEPR) of 77 million euros, linked to the PPR (Priority research programs).[37]

Denmark

As one of the European EdTech frontrunners, Denmark owes its high level of digital infrastructure and competences to a long-standing tradition of investing in digital equipment, online resources and teacher digital skills since 2011; when an investment of DDK 45 million (approx. 6 million EUR) was made, investments followed in 2015 and 2016. Further investments have been facilitated in recent years, as the national government has continued to indirectly support EdTech organisations and the EdTech business sector via the large portion of public spending going into the educational system.

At a system level, the Danish Government's plan of 2018 outlined a strategy for a Technology Pact[38] to strengthen technological and digital skills, and launched digital education as a stand-alone subject in Denmark, referred to as 'Technology Comprehension'. Since then, the history of investing in information computer technology (ICT) infrastructure and digital skills has paid off during the pandemic, facilitating education continuity and the transition from physical to online learning.

An expert consulted for this study reported that one of the barriers for Danish EdTech firms moving forward is the small size of the domestic market, which is dominated by big players. Many EdTech businesses in Denmark, therefore, have to look abroad to build a market position and revenue. As elsewhere, another challenge for the Danish EdTech sector concerns how to manage data governance and ethical considerations, especially in respect to GDPR. Partially addressing this issue, the 'Netflix model' (whereby all teachers and pupils have one unique login access across primary and secondary school to access EdTech tools, this will be further addressed later on in this report) was put in place in country, providing all teachers and pupils with a unique login across primary and

https://books.google.co.uk/books?id=fV0z5i4SnhcC&dq=supporting+e-parenting+through+digital+tools&lr=&hl=it&source=gbs_navlinks_s

[36] Ministère de l'Education Nationale de la Jeunesse et des Sports (2021) « e-Fran : des territoires éducatifs d'innovation numérique ». Available at : https://www.education.gouv.fr/e-fran-des-territoires-educatifs-d-innovation-numerique-326083

[37] https://www.inria.fr/en/education-digital-program-muriel-brunet

[38] Technology Pact

secondary to access a range of EdTech tools.[39] Additionally, teachers and educationalists may at times be reluctant to adopt digital tools in their classrooms.

> In Denmark, the EdTech sector is promoting a shift in how EdTech is perceived. We should not be talking about software, but instead about services and tools. While the technology is ready, there is still a certain level of reluctance to adopt digital technology in education. More training is needed to up-and reskill teachers, allowing them to better understand the offer that is available and how they can be supported. (**Expert, Denmark**).

Promoting further uptake of EdTech, the EdTech Denmark alliance,[40] a non-profit, market-driven cluster association, gathers players across the classic triple helix model, including EdTech businesses, education institutions, government organisations, municipalities and NGOs. The alliance also has a strong collaboration also has a strong cooperation with Nordic EdTech and the European EdTech Alliance, facilitating knowledge exchange and transfer between member countries and widening access to EdTech products and services at an EU level.[41]

USA

Globally, the United States has the largest number of EdTech companies and the most venture capital funding for those companies. The country's large economy, population size, and tech and innovation hubs such as Silicon Valley are factors behind the success.[42]

The American EdTech sector is characterised by private sector procurement of education technologies, and with domination by a handful of companies with two distinct features: a) their main business model and operations have not been developed with the institution of education or young people in mind (i.e., Google, Microsoft, Amazon) and b) most of them are based in the United States. Private corporate interests are infused with state education in the country – based on modern history unrelated to EdTech, corporate influence on state education is often reported to be strong.[43]

The pandemic saw increased efforts to enhance the availability of EdTech across the United States, as massive public investments went into expanding digital infrastructure, including $65 billion earmarked for improving the country's broadband infrastructure.[44]

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[39] Expert interview
[40] EdTech Denmark alliance
[41] Nordic EdTech News (2021). "The NEN Interview: Esben Trier, CEO EdTech Denmark". Available at: https://nordicEdTech.substack.com/p/the-nen-interview-esben-trier-ceo
[42] https://uk.rs-online.com/web/generalDisplay.html?id=did-you-know/the-EdTech-report
[43] Please see: https://apps.publicintegrity.org/oil-education/
[44] https://www.whitehouse.gov/briefing-room/statements-releases/2021/11/06/fact-sheet-the-bipartisan-infrastructure-deal/#:~:text=The%20Bipartisan%20Infrastructure%20Deal%20will%20deliver%20%2465%20billion%20to%20help,investment%20in%20broadband%20infrastructure%20deployment.

The U.S. Department of Education has also made targeted efforts to find new and creative ways to solve the problem of connectivity in learners' homes so that the learning made possible in connected schools and colleges does not end when students leave for the day.[45]

Since before COVID-19, there has been a strong digital divide in accessing EdTech across groups of different socioeconomic background. For example, in 2019, only 54% of all low-income families had a computer at home, compared to 83% and 94% among middle- and high-income families.[46] The digital gap has been widened over the course of the pandemic, as the equity gap has continued to increase. This also corresponds with differences in the confidence and competence with which EdTech is deployed in American schools and colleges, with a reported over-concentration of skills, expertise and infrastructure in schools and colleges within more affluent areas, relative to schools and colleges with a student population including higher proportions of lower Socio-Economic Status (SES) families.[47]

Commenting on the trends in American EdTech, experts highlighted a growing demand for programmes that are tutoring- or quasi tutoring-based. Furthermore, products that help teachers differentiate instruction, have gained in popularity, as personalised attention for pupils has become a priority. These products support teachers assessing students' strengths and weaknesses and help them assign lessons, worksheets and tasks. EdTech is now able to report on student progress on a daily and weekly basis which allows parents and teachers to intervene sooner.

In view of the expanding supply and demand for EdTech, interviewed stakeholders raised their concerns about the lack of evidence in the sector:

> Evaluation of EdTech products is fundamental. (It is) necessary for schools and colleges to know which products work and which don't, and under which circumstances. The amount of money in EdTech is staggering. There is virtually no evidence about what works in the US, there is not much evidence anywhere (else in the world either). The evidence that exists is often over hyped. **(Expert, USA)**

In a response to this issue, one EdTech provider has been developing an evaluation framework and monitoring tool to assess the relative effectiveness of EdTech products that saw growth during the pandemic. This framework is known as the EdTech Genome Project, and forms a large-scale collaboration between education technology researchers, the EdTech industry, educators, entrepreneurs, philanthropic investors, and

[45] https://www.ed.gov/coronavirus/resources-for-learning-at-home
[46] https://EdTech.worlded.org/digital-divide-gaps-opportunities/
[47] Expert interview.

advocates.[48] It was launched in 2019 and is due for completion in 2024. The project will produce a technology 'exchange' platform, with the aim of enabling decision-makers to access data on the efficacy of EdTech products and their implementation. It is intended as a national platform and stands to exert a significant influence vis-a-vis EdTech procurement choices and uses in the USA, as well as helping to define the methodologies and frameworks by which evidence about 'what works' in EdTech will be collected and presented.

China

China governs the largest K–12 education system in the world, with approximately 130 million students enrolled in primary and secondary public schools and colleges. Within the primary education system alone, 167,009 public primary schools and colleges operate 2,683,706 classrooms.[49] To date, approximately 98% of the population has network coverage.[50] The rising popularity of online and mobile learning, including massive open online courses (MOOCs), is partly driven by improved bandwidth in China, making live-streaming technology and online courses more accessible.[51]

In terms of B2C EdTech market penetration, China is a world leader with a well-developed EdTech ecosystem that not only drives innovation through top-tier talent but also supports awareness and adoption via centralised communication and payment platforms that facilitate both word-of-mouth and traditional marketing exposure. There is a direct link between teachers and EdTech providers: teachers are introduced to EdTech platforms (and convinced of their value) by the companies themselves.[52]

The uneven distribution of EdTech products and services across China, became even more uneven with the pandemic. The COVID-19 EdTech roll-out made it clear that internet infrastructure is critical, online training for teachers inadequate and education inequality still an underlying challenge. An interviewed expert highlighted that several issues were accentuated in the national response to the pandemic, for example, that bandwidth is limited in many parts of China, especially in rural areas. A related issue concerned limited parenting guidance and support needed. For example, parents migrating from rural areas to cities often have a much lower base knowledge level with regard to EdTech, due to urban / rural disparities in digital skills. As a consequence, the attainment gap has widened during this period.[53]

> [In China]…technology has been promoted as a way to reduce education inequalities, but instead there is a risk that EdTech

[48] The EdTech Genome Project Report (2021). Available at: https://EdTechevidence.org/EdTech-genome-project
[49] Omidyar Network (2019). Scaling Access and Impact: China Report. Available at : https://assets.imaginablefutures.com/media/documents/Scaling_Access_and_Impact_China_Report_vFinal.pdf
[50] Ibid.
[51] EdTech Hub (2020) CASE STUDY China: testing a decade of online education preparation
[52] Omidyar Network, op. cit.
[53] Expert interview.

> might increase inequality and widen the gap rather than reducing it. EdTech companies really should consider how to deploy their products and services, and consider people of different socioeconomic and territorial backgrounds. **(Expert, China)**

China's iterative policy-making process dictates the conditions for EdTech companies in the country. Local government, researchers and private enterprise all engage in feedback loops in the form of, for example, official public consultation, symposia, internal publications and public discussions. New measures in China will include, for example, the introduction of AI to create more individualised learning environments instead of attempting to mirror the classroom experience online.

Recently, China's Ministry of Education has introduced the so-called double reduction policy, ordering schools and colleges to reduce the time students spend each night on homework and implementing tough new measures to rein-in private tutoring institutions.[54] Linked to this policy, regulators have stopped recommending students to pursue education online, due to concerns about the impact of excessive levels of tutoring and extra-curricular study. According to experts interviewed for the research, this new policy has seen a cooling in public opinion towards EdTech, and some retraction in the domestic market for B2C products and services that were associated with private study.[55]

Experts finally stressed that the issue of data protection is extremely important in China. While many of the national EdTech companies are not aware of the GDPR, China has recently passed regulations to prevent the violation of data. Still, concerns among users regarding data theft and data protection remain very real.[56]

The emerging technologies: AI, VAR, blockchain, and social robots

Having examined the main trends in supply and demand for EdTech globally and within the deep dive countries, it is also important to consider the changing nature of the tech itself, and what this is likely to mean for the future marketplace in England. In this section, we highlight some of the key technologies that underpin, drive and inspire EdTech, demonstrating a range of ways in which different digital applications may support (or limit) creativity, agency, and outcomes in teaching and learning processes.

[54] Protocol (2021). "China's EdTech crackdown isn't what you think. Here's why." Available at: https://www.protocol.com/china/china-EdTech-crackdown-education-inequality
[55] Expert Interview
[56] Expert Interview.

Artificial Intelligence

Artificial Intelligence (AI) tends to have an all-encompassing meaning, as it has become a catch-all term to describe a range of different technologies including machine learning, neural networks, big data, narrow AI, and general AI. In the education domain, NESTA proposes to use the following broad and outcome-based AI-definition, capable of covering different technologies: '*Computers which perform cognitive tasks, usually associated with human minds, particularly learning and problem-solving*.' [57]

While not yet fully established, a plethora of emerging uses can be found for AI in the area of education and training. Holmes, Bialik and Fadel (2019) identify AI systems capable of operating at the student, teacher and system level across the following areas: [58]

- **Student teaching:** Intelligent tutoring systems, dialogue based tutoring systems, language learning applications (including pronunciation detection).
- **Student supporting:** Explanatory learning environments, Formative writing evaluation, learning network orchestrators, language learning applications, AI collaborative learning, AI continuous assessment, AI Learning companions, Course recommendation, self-reflection support (learning analytics, meta-cognitive dashboards), learning by teaching chatbots.
- **Teacher supporting:** Intelligent tutoring systems (ITS) learning diagnostics, summative writing evaluation, essay scoring, student forum monitoring, AI teaching assistants, automatic test generation, automatic test scoring, open education resources (OER) content recommendation, plagiarism detection, student attention and emotion detection.
- **System supporting:** Learning management systems (LMS), early warning systems, educational data mining for resource allocation, diagnosing learning difficulties (e.g., dyslexia)

Already, these AI systems are being used and tested in education and training. Intelligent tutoring systems (ITS), for example, defined as a '*software that aims to provide immediate and customised instruction or feedback to learners*', typically operate without human teacher involvement.[59] Such programmes can verify if a student answer is correct, and if the answer is incorrect, explain why. The software, which employs machine learning, can detect patterns in written work, speech, and other actions, which then can be individually adapted to students' learning styles and needs.[60]

[57] Educ-AI-tion Rebooted? Exploring the future of artificial intelligence in schools and colleges and colleges. nesta. 2019. P.10. Available here.
[58] HOLMES, Wayne, BIALIK, Maya, et FADEL, Charles. Artificial intelligence in education. Boston: Center for Curriculum Redesign, 2019. Available here.
[59] Akkila, A. N., Almasri, A., Ahmed, A., Al-Masri, N., Abu Sultan, Y. S., Mahmoud, A. Y., ... & Abu-Naser, S. S. (2019). Survey of Intelligent Tutoring Systems up to the end of 2017. IJARW. P.36. Available here.
[60] Adams Becker, S., Cummins, M., Davis, A., Freeman, A., Hall Giesinger, C. and Ananthanarayanan, V. (2017), "NMC horizon report: 2017 higher education edition", The New Media Consortium, Austin, TX, available at: http://cdn.nmc.org/media/2017-nmc-horizon-report-he-EN.pdf

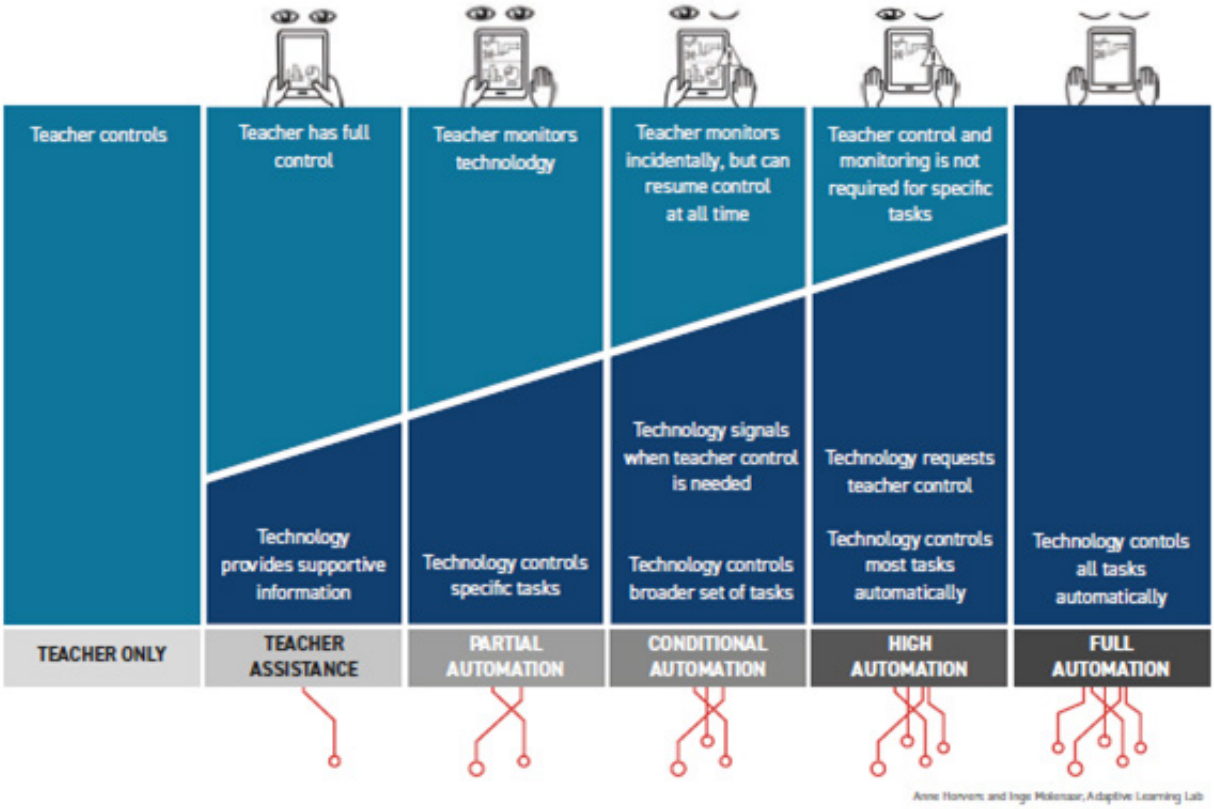
ITS software can be applied using a wide range of technologies, from basic web-based learning tools to mobile apps, and more sophisticated learning devices such as VR and robots (see sections below). One example of ITS is the mobile learning application Toppr, based out of India, which offers a personalised learning across a wide range of grades and subjects.[61] Toppr leverages machine learning to optimise the experience for each student, offering personalised questions and adjusting the speed of learning. At the system level, administrators may use learning management systems (LMS) to refer to student data gathered through different digital learning platforms and to analyse of learning trends and patterns to identify students who are "at-risk". In the USA, for example, there has been a rapid growth of so-called 'early warning systems', predicting in advance which students are at risk of school leaving. These predictions are often based on information explaining why a student is likely to have a negative outcome, such as poor grades or an elevated number, and can be followed up by timely interventions.[62]

Baker (2021) notes that while different types of AI systems have developed at different paces, and that interoperability between different systems is a growing issue. A school may, for example, use different AI applications, in parallel to the ones used by students themselves. As a result, a fragmented learning ecosystem emerges in which there are major costs associated with the lack of integration – not only in terms of economic costs but also in terms duplicated efforts towards optimising learning.[63]

Regarding the potential future direction of AI, Horvers and Molenaar discuss the "6 levels of automation for personalised learning model" as the different stages and extents of incorporating personalised AI technologies in education (see Figure 4 below).

[61] https://www.toppr.com/
[62] Bowers, A. (2021), "Early warning systems and indicators of dropping out of upper secondary school: the emerging role of digital technologies", in OECD Digital Education Outlook 2021: Pushing the frontiers with AI, blockchain, and robots, OECD Publishing.
[63] Bakers. R (2021), "Artificial intelligence in education: Bringing it all together ", in OECD Digital Education Outlook 2021: Pushing the frontiers with AI, blockchain, and robots, OECD Publishing.

Figure 3 The "6 levels of automation for personalised learning model"



Source: Illustration - Anne Horvers and Inge Molenaar, Adaptive Learning Lab
https://www.ru.nl/bsi/research/group-pages/adaptive-learning-lab-all/

Such models should be interpreted in light of research suggesting that current AI-systems are far from replacing teachers, and that such an outcome may not be desirable.[64] As Rose Luckin et al. (2016) note “It is teachers who will be the orchestrators of when and how to use AI tools”.65

Blockchain technology

A further emerging key technology is blockchain[66], which has been described as a technology more mature than AI due to its current capacity to transform validation and credentialing in education and training.[67] A study from the EU Joint Research Centre, notes that blockchain technology has potential to disrupt the market in student information systems and to diversify the number and range of EdTech providers.[68]

[64] Ibid.
[65] Luckin R, Holmes W, Griffiths M, Forcier LB. Intelligence Unleashed: An argument for AI in Education. Pearson Education; 2016.
[66] For a relevant definition of blockchain, see p. 21 of OECD (2021), OECD Digital Education Outlook 2021: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots, OECD Publishing, Paris, https://doi.org/10.1787/589b283f-en.
[67] Ibid.
[68] Inamorato Dos Santos, A., editor(s), Grech, A. and Camilleri, A., Blockchain in Education, EUR 28778 EN, Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-73497-7, doi:10.2760/60649, JRC108255.

Essentially, blockchain allows for transparent and secure sharing of credits, qualification and badges. By doing so, it stands to achieve a range of potential benefits, including[69]:

- Reducing the need for a paper-based system for certification of prior learning by educational institutions.
- More cost-efficient and secure data management structures, with limited exposure to liability resulting from data management issues.
- With a simplified transfer of educational records, blockchain technology can facilitate the exchange and credentialing of small units of learning such as MOOCs or corporate professional development provided by companies.[70]
- With an augmented ability to validate credentials, blockchain technology has the potential to stop fake degrees and certifications.[71]
- As a last example, blockchain can also help facilitate payments within institutions. In many countries, blockchain-based cryptocurrencies are likely to find significant use in grant or voucher-based funder.[72]

Considering the numerous benefits, and the maturity of the technology, the question arises – what barriers are there today for implementing blockchain in education? In a recent publication, OECD (2021) highlights that the human and legal infrastructure for the technology remain underdeveloped, including interoperability and open standards.[73] Nonetheless, some countries have incorporated blockchain to their education systems. Malta is predicted to be the first country to offer education certificates and credentials on blockchain for all students. This step is made possible through BlockCerts technology that facilitates an open standard for creating, issuing, viewing, and verifying blockchain-based certificates. Students can organise and store educational and professional certificates through an online portal, enabling digital access to their portfolio. Some of the benefits reported so far include users' increased autonomy over credentials and the ability to add certificates over time, as well as lowered administrative costs.[74]

Virtual and augmented reality (VAR)

Virtual and augmented reality (VAR)[75]-systems can facilitate immersive and interactive learning in new environments that are not usually accessible to students. Recent studies show that VAR-systems are becoming more widespread, with increasing scalability to education systems. [76] O'Leary and colleagues (2018) note that while costs initially

[69] Ibid.
[70] Smolenski (2021) "Blockchain for Education: A New Credentialing Ecosystem" in OECD Digital Education Outlook 2021: Pushing the frontiers with AI, blockchain, and robots, OECD Publishing.
[71] Ibid.
[72] Inamorato Dos Santos, op.cit.
[73] OECD (2021), OECD Digital Education Outlook 2021: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots, OECD Publishing, Paris, https://doi.org/10.1787/589b283f-en.
[74] Ibid.
[75] Virtual reality refers to technology creating an experience completely isolated from the outside environment inside an outside world. Augmented reality refers to systems that combine virtual content (e.g. generated through an animation or video recording) with real-world imagery). Motejlek, J., & Alpay, E. (2019), available here.
[76] Bezegová, E., Ledgard, M., Molemaker, R., Oberc, B., & Vigkos, A. (2016). Virtual Reality and its Potential for Europe. Brussels: Ecorys.

prohibited widespread use of virtual reality, there has been a revolution in availability of high-quality, usable and affordable applications.[77]

Thanks to their ability to place a learner in any scene with a high degree of immersion, VAR-systems are particularly useful for students that need to practice new skills and tasks before applying them in a real context. When implemented successfully, VAR-systems allow students to rehearse risky or expensive processes in safe and controlled conditions that otherwise would not be possible. In these settings, VAR-based simulations can be used to assess skills that are not easily measurable through written or oral tests.

VAR-technology is also capable of creating completely fictional worlds. Learners working in digital storytelling, for example, can be supported in visualising and contextualising learning objects. The start-up Labster[78], in Denmark, has seized this possibility and offer their students a gamified 3D learning virtual environment combined with engaging storytelling and a scoring system. The learning venue can be a laboratory, a forest, or the desert plains of an imaginary exoplanet.

With regard to Augmented Reality (AR), Octagon 4D59 from Indonesia, uses multidimensional flashcards, powered by augmented reality technology, that enrich the learning process by allowing students to witness animals and dinosaurs come to life and interact with them. The Belgian example Vrhoogte is also interesting to consider. This teacher-led project, funded by the Flemish government, develops a VR training module for secondary Vocational Education and Training (VET) students to learn how to work safely in high places, such as high-voltage pylons or wind turbines.[79]

Virtual reality is also a common feature of “serious games”. The World Bank’s EVOKE[80], for example, invites players to design social innovation interventions in order to address complex challenges. The game is intended to support the development of ‘21st century skills’ such as critical reflection, collaboration and creativity, as well as social-emotional skills, such as curiosity, empathy and generosity. A further example is ‘FoldIt’[81]; a crowdsourcing computer game allowing players to contribute to academic research in the capacity of ‘citizen scientists’. Developed by researchers at the University of Washington, players participate in sandbox puzzles to support research and development in the understanding of protein structures and their role in diseases such as Alzheimer’s, cancer and HIV/AIDS, and potential medical treatments. The results of Foldit games have been documented by scientific journals.[82]

[77] O’Leary, M., Scully, D., Karakolidis, A. and Pitsia, V. (2018). The state-of-the-art in digital technology-based assessment. European Journal of Education, Vol. 53, No. 2, 160 - 175 DOI: 10.1111/ejed.122
[78] https://www.labster.com/about/
[79] Please see: https://www.imec-int.com/drupal/sites/default/files/inline-files/VR_HOOGTE_V4.pdf and https://www.buildingyourlearning.be/learningobject/5672/NL
[80] https://www.worldbank.org/en/topic/edutech/brief/evoke-an-online-alternate-reality-game-supporting-social-innovation-among-young-people-around-the-world
[81] www.fold.it
[82] https://fold.it/portal/info/about

Social robots

Robotics, like AI, are another form of emerging technology with the potential to support students and teachers in specific tasks and make education more personalised. In particular, the use of "social robots" in education has been described as one of the most promising prospects for adaptive learning.[83] These robots tend to have a friendly design with face-like features, indicating an ability to speak, hear and see – giving them lifelike behaviour. Some robots have built-in AI systems that allow them to detect and identify individuals by using face and voice recognition.[84]

There is growing evidence that social robots are capable of supporting students and teachers in a myriad of different contexts, from teaching and learning to classroom connectivity and overcoming isolation for students accessing learning remotely. Research has shown that this type of robot appeals to a large audience and can make learning more engaging and effective.[85] An encounter with a robot can, for example, spark the curiosity of students and inspire them to learn more about science, technology, engineering, and mathematics (STEM) subjects.

Beyond the benefits of short-term attraction, social robots are usually programmed to take one of the following three roles in educational settings:

1. Teaching assistant
2. Peer learner
3. Digital avatars

As a teacher assistant, a robot is capable of providing one-on-one support, and in doing so enhancing the capabilities of a teacher in a classroom setting. In parallel to classroom teaching, the robot can, for example, direct attention to individual pupils falling behind, or challenge those who are ahead (including gifted students).[86] The robot has unlimited patience and can rehearse subjects as long as needed. Notably, the robot is typically considered non-judgemental by learners, reducing anxiety often linked to raising questions to a human teacher.[87]

When addressing groups of students, robots are also capable of substituting teachers by, for instance, giving a lecture or by helping out during class. The robot can, for example, assist with administrative tasks, such as taking care of student registration or performing simple tasks, such as announcing the topic of the day. The purpose is not only to

[83] Belpaeme & Fumihide (2021), "Social robots as educators", in OECD Digital Education Outlook 2021: Pushing the frontiers with AI, blockchain, and robots, OECD Publishing.
[84] Bartneck, C. et al. (2020), *Human-Robot Interaction,* Cambridge University Press, http://dx.doi.org/10.1017/9781108676649.
[85] Kennedy, J., P. Baxter and T. Belpaeme (2015), "The Robot Who Tried Too Hard", *Proceedings of the Tenth Annual ACM/IEEE International Conference on Human-Robot Interaction*, http://dx.doi.org/10.1145/2696454.2696457.
[86] Belpaeme & Fumihide, op. cit.
[87] Bhakta, R., M. Savin-Baden and G. Tombs (2014), "Sharing Secrets with Robots?", in Viteli, J. and M. Leikomaa (eds.), *Proceedings of EdMedia 2014--World Conference on Educational Media and Technology (pp. 2295-2301).*

alleviate the workload of teachers, but also to free up their time and allow them to direct more individual attention to learners who need it.

While robots used as teacher assistants have been developed, they are in reality mostly used to 'spice up' a lecture by acting as a teacher 'side-kick'.[88] In Iran, for example, a robot was introduced as teacher side-kick in an all-female English language class of 12- to 13-year-olds, offering them feedback on exercises and providing the correct pronunciation of English words and phrases. Results showed that students in the class with the robot, over a 5-week period, enjoyed the class more and learned more vocabulary than a control group of students in a class taught only by a teacher.[89]

A second role that a social robot can take, which has been described as novel and promising, is that of a peer learner.[90] Building on the idea of learning-by-teaching effect, the learner or the child is asked to instruct and teach the robot while learning together. By engaging in this type of human-machine interaction, research has found that children tend to spend more time on learning activities and learn more. Examples include handwriting and second-language learning.[91] Another finding has been that learning among lower ability students has been greater, possibly linked to the confidence the child gains from attainment, and from being responsible for teaching the robot.[92]

Lastly, social robots can take the role of digital avatars, such as telepresence robots, to create meaningful social interactions between learners with long-term illnesses and their school environments. In Denmark, AV1 robots have been reported as highly effective as a physical representation of sick learners in the classroom, even for young children (i.e. primary school learners). This is made particularly evident through the frequent personalisation of such telerobots by teachers and peers, *e.g.* through classmates gently touching the telerobot's cheek to comfort the learner or conducting other comforting physical gestures directed at the robot, or learners themselves using terms like 'me' and 'I' when referring to the AV1.[93]

While the availably of robots remains in education remains very limited, the technology does have a great potential and offers clear benefits over other technologies, such as screen-based tools. A long-term perspective is needed on if, when and how robots will support education. EdTech companies will also have to face the technical, social, economic and logistical challenges associated with rolling out social robots in classrooms.

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[88] Belpaeme & Fumihide, op. cit.
[89] Ibid.
[90] Hood, D., S. Lemaignan and P. Dillenbourg (2015), "When Children Teach a Robot to Write", *Proceedings of the Tenth Annual ACM/IEEE International Conference on Human-Robot Interaction*, http://dx.doi.org/10.1145/2696454.2696479.
[91] Tanaka, F. and S. Matsuzoe (2012), "Children Teach a Care-Receiving Robot to Promote Their Learning: Field Experiments in a Classroom for Vocabulary Learning", *Journal of Human-Robot Interaction*, pp. 78-95, http://dx.doi.org/10.5898/jhri.1.1.tanaka.
[92] Belpaeme & Fumihide, op. cit.
93 Weibel, M, Nielsen, MKF, Topperzer, MK, et al. Back to school with telepresence robot technology: A qualitative pilot study about how telepresence robots help school-aged children and adolescents with cancer to remain socially and academically connected with their school classes during treatment. Nursing Open. 2020; 7

3. Future proofing – applying evidence-based solutions

Future priorities and support needs

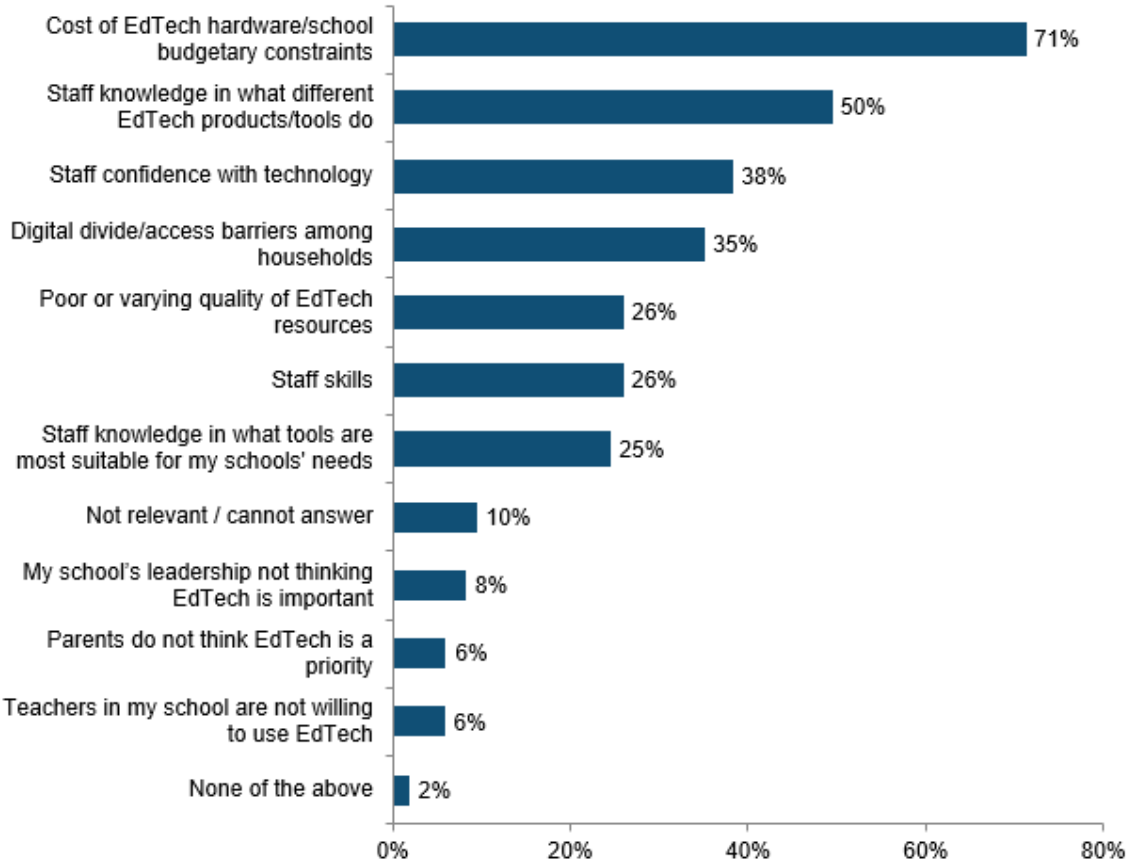
In this chapter, we first consider the main findings from the study regarding what the future of EdTech might look like for schools and colleges in England specifically, and how well-placed teachers, school leaders and EdTech professionals feel to respond. The section draws on the Teacher Tapp survey, interviews and supporting evidence from the literature and workshop findings.

Barriers and challenges

As part of the survey, respondents were asked “Which are the main barriers to using EdTech in the next 10 years?” and presented with a pre-defined list of options as outlined in the following figure. They were asked to select up to 3 options. These response options were based on previous research into potential barriers around implementing EdTech.[94]

[94] CooperGibson Research (2021); Fellows, T., Cottrill, R., Humphreys, A., Llewellyn, J. and Day, L. (2020) Navigating the digital world; a synthesis of the evidence. Ecorys.

Figure 4 Which are the main barriers to using EdTech in the next 10 years?



Source: Ecorys teacher survey. n=5,485.

Funding

The most frequently cited barrier was the cost of EdTech hardware and/or school budgetary constraints, with approaching three quarters (71%) of teachers selecting this option. Teachers from state schools and colleges were more likely to select this option (73%) compared to private schools and colleges (53%). This corresponds to feedback from the workshops, with participants noting that funding was uneven and inconsistent.

Concerns were raised about uneven levels of access to expertise to bid for EdTech funding, with better resourced schools and colleges positioned advantageously. This was felt to have contributed towards an “uneven playing field”. Funding shortfalls were also cited as a factor in reduced EdTech capacity and expertise within colleges in recent years, slowing the uptake of new technologies. One workshop respondent noted that even EdTech events and training were expensive, which further restricted access to best practices and networks.

According to a survey launched by BESA with 1200 schools and colleges in England (unpublished), schools and colleges expect to reduce their spend on ICT hardware and

software resources by 5-6% - particularly in secondary school; and both primary and secondary schools and colleges intend to reduce spend on devices and online servers, as they are moving to cloud solutions.

Lack of clarity around EdTech solutions and quality

The second most prominent barrier according to the teacher survey relates to teachers' knowledge about what different EdTech products and tools can do. Half of teachers (50%) said that this was one of the three most important barriers, while one quarter (25%) identified "staff knowledge about what tools are most suitable for my school's needs" as a challenge. Confidence around staff knowledge of tools decreased with age: 20% of teachers in their 20s selected this as an issue, increasing in each age group to 31% for the over 50s. For both issues, there was no clear difference by Free School Meal (FSM) quartile or Ofsted rating, suggesting that knowledge around tools was no worse in schools with a higher number of disadvantaged pupils or those judged to have lower effectiveness and education quality.

A related issue highlighted in both the survey and workshops was the variable quality of EdTech resources, with a quarter of teachers (26%) selecting this as a top-three barrier to future EdTech use. Workshop participants echoed this view, saying that overall, there is confusion and lack of clarity around the current range of EdTech offerings, coupled with a lack of support for identifying the most suitable solutions.

As one workshop participant noted:

> It just doesn't seem fair that individual schools and colleges are having to shoulder the burden of responsibility and having to make the final call and final judgement. I've not been able to find much in the way of support for schools and colleges making that sort of level of decision. There is a real range of intentions with a lot of EdTech companies – they're private industries and they want to make money. The fact that it is an unregulated industry makes it a jungle that schools and colleges are having to try to negotiate as best they can without an enormous amount of clear support. **(Workshop delegate)**

The workshops further surfaced the compounding effect of the for-profit basis of the EdTech sector, meaning that providers may have different priorities to teachers and government. One EdTech expert said that schools and colleges are "bombarded" by EdTech companies who want to sell them their products. Workshop participants noted that teachers are already under-resourced and do not have time to assess and quality assure different products. This was seen as a particular issue for schools and colleges which are not part of a multi-academy trust (MAT), and do not therefore benefit from the economies of scale that this model offers.

Staff confidence, skills and support

The third most significant barrier selected by teachers in the survey was staff confidence, identified by well over one third of respondents (38%). Notably, teachers from private schools were more likely to select this as an issue (48%) compared to those from state-funded schools (37%). It is not possible to infer the cause of this from the survey data, although one possible explanation is that to private schools may have more advanced EdTech solutions, which makes staff feel less confident. Staff skills were also seen as an issue by around one quarter (26%) of teachers. The fact that confidence was seen as more of an issue than skills may indicate that staff have the technical capabilities to use EdTech more widely but require more assurance and training on how to maximise its benefits. Feedback from the workshop suggested that some teachers view EdTech as an afterthought and have a "tick box mentality" where they view their role as limited to adding minor IT components to existing teaching. As one participant said, teachers "…*are not really on board with the idea of planning EdTech to be core*".

Encouragingly, only a small minority of surveyed teachers (6%) cited a lack of willingness to use EdTech as a barrier to take-up, while fewer than one in ten (8%) though that their school leadership did not see EdTech as a priority. The importance of school leadership came through strongly within the workshops, where there was a central message around the critical role played by head teachers and college principles in decision making about the procurement and use of EdTech and the strategic positioning of technologies. Capacity building at this level was seen as important, especially as senior leaders were viewed as being less likely to come from technology backgrounds and therefore not necessarily able to appraise the opportunities offered by EdTech.

One participant described the "20/80" split within their school, in terms of teacher attitudes towards and propensity to use EdTech. This represented an uphill struggle:

> Twenty percent of our teachers are up for anything EdTech and really keen and very proactive in learning. Eighty percent struggle with digital skills, or simply don't have the time or motivation. **(Workshop delegate)**

In order to shift this mindset, workshop participants thought it is important to ramp-up the focus on EdTech within continuous professional development (CPD). Participants reported that there were large gaps in teachers' knowledge around digital solutions, and that any training should start with basics in order to be inclusive. One dimension related to the age range within the workforce, with older teachers less likely to be "digitally native" in their everyday uses of technology, less likely to have received prior training in EdTech during their Initial Teacher Training (ITT), and therefore proportionately at a greater need of up-skilling. It was suggested that government could play a role in coordinating and delivering initial and ongoing training, and should explore certification pathways for teachers.

As with selecting EdTech products, resources and capacity issues also emerged as a barrier with regard to teacher education. One workshop participant reported that their college had received £50,000 through the Digital Change Makers programme which was in part allocated to training a small number of staff and students in how to use Google Suite and MS Teams so that they could educate other staff and students. However, it was a five-week training course which both teachers and students struggled to commit to given other pressures. Similarly, participants noted that while there was a need for more EdTech guidance during initial teacher training, there was limited space to add additional content.

Digital divide/access barriers among households

The fourth most frequently cited barrier to future EdTech use in the survey was the digital divide and/or access barriers among households, with just over one third (35%) of teachers selecting this. This was supported by the workshops, where digital poverty emerged as a challenge. One participant reported that some of their students did not have access to computers or tablets during COVID-19 school closures, and therefore had to access online teaching resources through their mobile phone. Workshop participants suggested that EdTech solutions assume that all pupils have access to necessary technology, when this may not be the case. Participants expressed concern that increased use of EdTech could exacerbate educational inequalities if access to computers and internet continues to be unevenly distributed.

Digital inequalities are not only a challenge at home; the literature suggests that schools and colleges may lack infrastructure, technical support, technical staff, and other resources to support teachers to deliver effective classes with EdTech products. During the COVID-19 pandemic, these issues presented obstacles to effective remote learning.[95]

Other barriers

Feedback from workshop participants identified a number of other potential challenges to implementing EdTech more widely in the future. Concerns around data privacy and GDPR were viewed as potential obstacles, and it was suggested that an independent certification system for EdTech products would help to inform schools and colleges. There was also uncertainty around what pupils and parental consents are required for different EdTech solutions.

EdTech solutions were sometimes seen as unnecessarily complex, which discouraged teachers and pupils from using them. Features such as two-factor authentication and multiple platforms caused frustration and led to less positive experiences. This was

[95] Singh J, Steele K, Singh L. Combining the Best of Online and Face-to-Face Learning: Hybrid and Blended Learning Approach for COVID-19, Post Vaccine, & Post-Pandemic World. Journal of Educational Technology Systems. 2021;50(2):140-171. doi:10.1177/00472395211047865

especially true for teachers who are often over-burdened and do not have time to familiarise themselves with multiple platforms. By contrast, one participant praised the Tribal platform due to its simplicity: “absolutely everything is literally on one page”.

While the survey found that only a small number of teachers identified lack of appetite for EdTech from parents, workshop feedback suggested that following lengthy periods of remote education during the COVID-19 pandemic, some pupils were not supportive of online learning. As one college noted:

> Our students don’t want to learn online. Our students want to be in college. **(Workshop delegate)**

However, it is important to note that EdTech is not confined to online teaching.

A final barrier raised during a workshop was related to external exams (GCSEs, A-Levels, and equivalents). These are still completed using a traditional classroom-based written assessment, but this creates challenges for students as they do most of their work on computers and are not used to writing for long periods. It was felt that as long as key summative assessments are hand-written, schools and colleges cannot transition completely to online solutions.

Two UK EdTech experts consulted as part of this research noted that schools and colleges are often not set up to facilitate use of technology. Buildings can be old and not designed for implementing EdTech solutions, and some schools and colleges suffer with connectivity and WiFi coverage issues.

Detrimental impacts of EdTech on learning outcomes

There is evidence, both from our research and from existing literature, that digital solutions may have negative impacts on pupils’ educational and social development where they are not fully integrated to teaching and learning practices and / or lack a sound pedagogical basis[96]. Over-reliance on digital tools at the expense of high-quality instruction has been linked with negative outcomes for pupils’ cognitive and social emotional development.[97] Other research has found that digital texts resulted in lower levels of reading comprehension compared to printed texts, suggesting that too much reliance on digital tools and materials may impede development of key competencies.[98]

The workshops and interviews also highlighted these potential drawbacks. One key stakeholder who was interviewed referred to the popularity of personalised learning tools which rely on machine learning, and which adapt to learners’ strengths and weaknesses

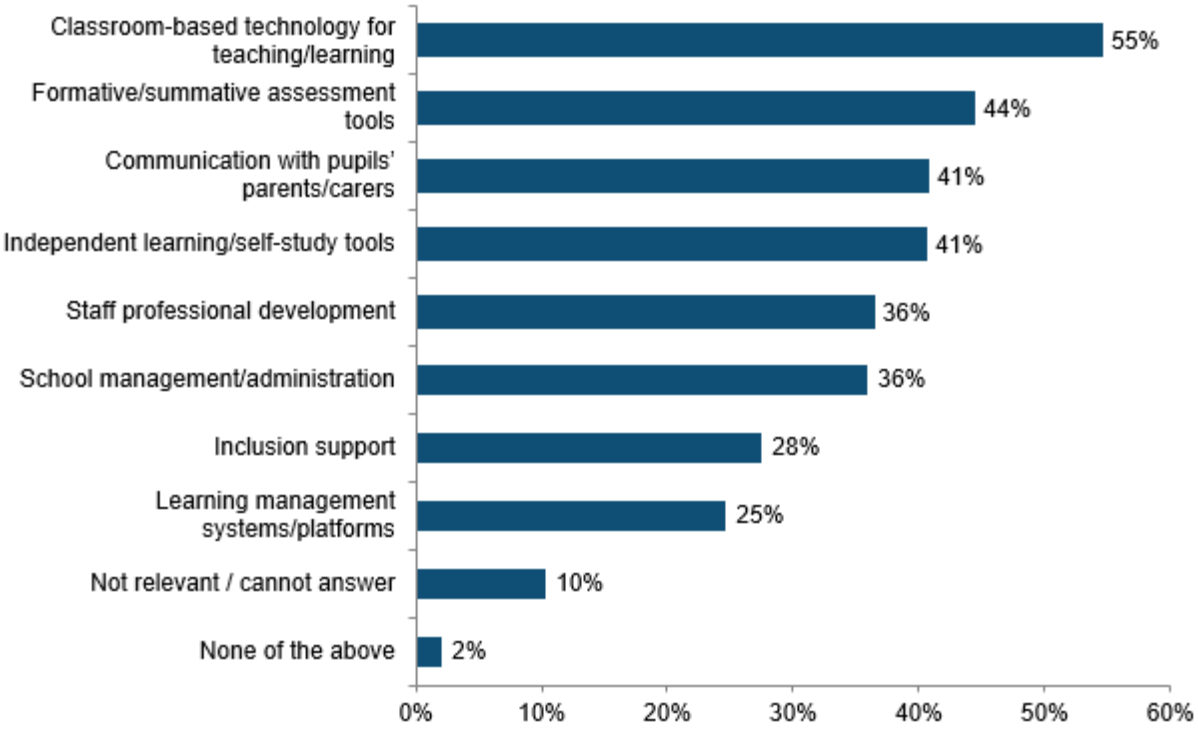
[96] Denoël, E., Et. al. (2017) Drivers of student performance: Insights from Europe. New York: McKinsey & Company
[97] MHC (2020) *az Európai Unió számára készített köznevelési stratégia 2021-2030* (sic with lowercase initial, without author, publisher and date) (Public education strategy prepared for the European Union 2021-2030) Budapest, Emberi Erőforrások Minisztérium (Ministry of Human Capacities)
[98] Delgado, P., et al., (2018). Don't throw away your printed books: A meta-analysis on the effects of reading media on reading comprehension. Educational Research Review 25: 23-38.

to provide tailored content. They felt that, in practice, the tools did not always provide the most suitable content and can in fact impair learning. Some concerns were also expressed that these tools can remove the human interactions, both with teachers and other students, which are important to a rounded and holistic learning experience.

Future opportunities and strengths

During the survey, teachers were asked “Which of the following uses of EdTech have the greatest potential benefits for your school in the next 10 years?” and presented with a pre-defined list of options as outlined in the following table. Respondents were asked to select up to 3 options, with these based on findings from the literature review and feedback from workshops.

Figure 5 Which of the following uses of EdTech have the greatest potential benefits for your school in the next 10 years?



Source: Ecorys teacher survey. n=5,568.

When asked about potential future benefits of EdTech, the option most frequently selected by teachers was classroom-based technology for teaching/learning (55%). Teachers at primary schools and colleges were more likely to select this (63%) compared to teachers at secondary schools and colleges (46%). Primary teachers may see this as more of a benefit than secondary teachers due to the greater ease which EdTech can be applied in a cross-curricular context compared with the needs of subject specialisms at 11+ stage, although other explanations may exist. Support for classroom-based technologies corresponds to views from the workshops, where participants stressed that future use of EdTech should be understood as being complementary to in-person learning.

Another popular potential future use was formative/summative assessment tools, which were selected by 44% of teachers. There was some difference by subject: science teachers were most likely to select this option (58%) while arts teachers were least likely (39%). There was also variation by length of time as a teacher, with recently qualified teachers more likely to support the use of EdTech in assessments (50%) compared to those with over 20 years' experience (38%). Feedback from workshops showed that where schools and colleges are using EdTech for assessments, this can be both time-efficient and more responsive as a means to understand and act upon student feedback.

Various other potential opportunities for future EdTech use were mentioned in the workshops. It was suggested that giving teachers the ability to teach remotely could add flexibility that would reduce the need for agency cover, therefore representing cost savings for schools and colleges and minimising disruption for pupils. Participants were also interested in how future EdTech solutions could be used to save teachers time, for instance through using AI to assist with marking and reports.

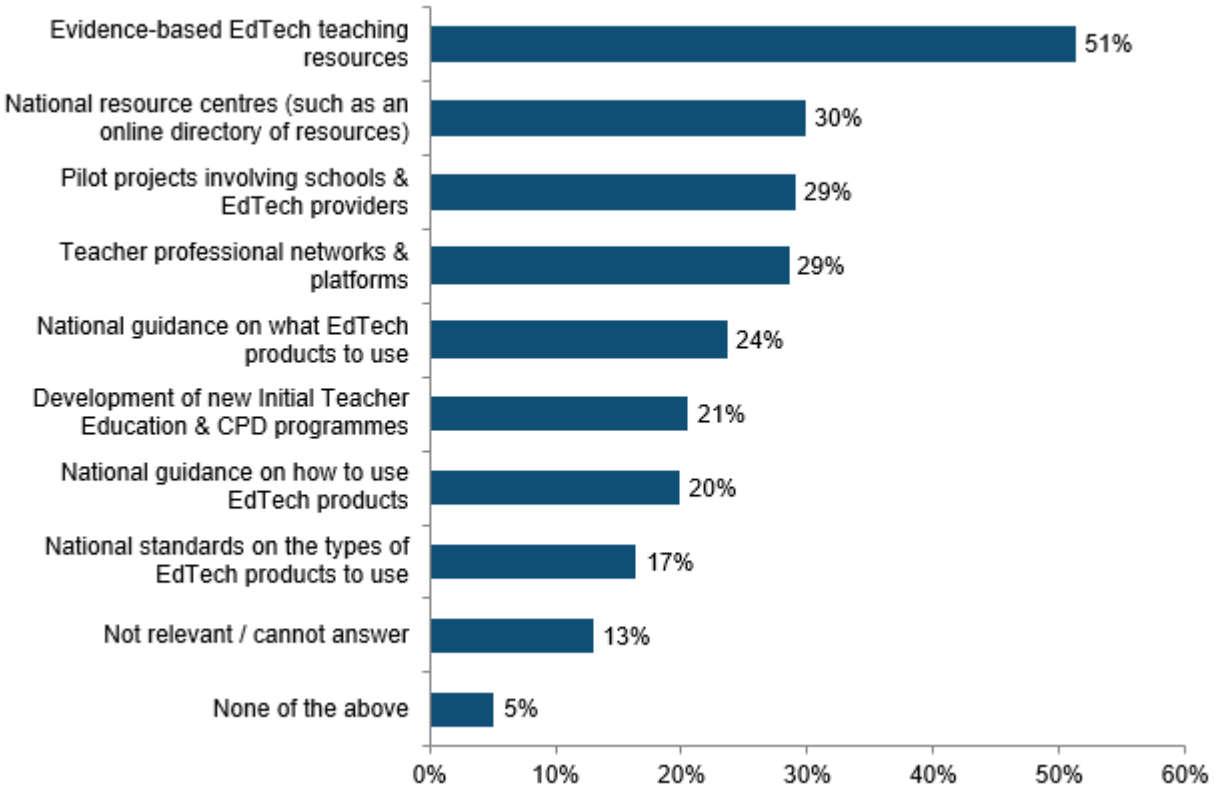
Some participants noted the benefits of a blended teaching model, whereby teaching is delivered both in-person and online simultaneously. It was reported that some students actually work better from home (especially if they have chronic health conditions which limit school attendance), and a permanent blended model could therefore be used to make teaching more inclusive and accessible.

More generally, participants felt that the COVID-19 pandemic had created momentum around EdTech, and that now is a good time to capitalise on this. Teachers and students are more familiar with using EdTech in school settings, and schools and colleges are thinking carefully about how they want to incorporate digital solutions in the future.

Future policy and practice priorities

As part of the survey, teachers were asked “What policy support would be the most effective in helping schools and colleges get the best out of EdTech in future?” and presented with a pre-defined list of options as outlined in the following table. Respondents were asked to select up to 3 options, with these based on findings from the literature review and feedback from workshops.

Figure 6 What policy support would be the most effective in helping schools and colleges get the best out of EdTech in future?



Source: Ecorys teacher survey. n=5,568

Evidence-based EdTech teaching resources were the most popular form of future support, having been selected by just over half (51%) of teachers in the survey. A desire for better evidence was expressed by workshop participants and EdTech experts. While acknowledging that there is some available evidence about ‘what works’, the workshops showed a demand for more nuanced information about the educational benefits of diffident tools and platforms, along with guidance to support practical implementation. Support for pilot projects involving schools and colleges and EdTech providers (selected by 29% of teachers) could be one possible way for building the evidence base. One of the consulted EdTech experts noted a greater need for educator and pupil involvement in

the development of EdTech solutions, so pilot projects could be a way to facilitate greater involvement from end users.

The next most popular form of policy support was the introduction of national resource centres (such as an online directory of resources), which was selected by approaching two thirds (30%) of teachers. This corresponds to the barrier described above of lack of clarity around different available EdTech solutions and their quality. Workshop participants echoed the need for a centralised hub, with one commenting that *"it's crying out for an umbrella organisation to take over and manage this".*

There was also support for professional networks and platforms aimed at teachers (29%). This corresponds to feedback from workshops, where peer support was seen as an effective way to boost teacher skills and confidence in using EdTech, both within and between schools and colleges. One workshop participant who teaches in Wales noted that following the COVID-19 pandemic, teachers increasingly used the Hwb platform[99] and *"peer to peer support was really important*" in supporting its wider uptake. They created a MS Teams channel where teachers could post queries and receive solutions which enabled them to make the most of existing knowledge within the school. The workshops also showed considerable demand to democratise knowledge, so that more technologically developed schools and colleges are empowered to share their experiences and insights with other schools and colleges.

There was lower support for Development of new Initial Teacher Education and CPD programmes (21%), although support was higher for teachers with less than 5 years' experience (24%) compared to those with over 20 years' experience (16%). One EdTech expert noted that the teacher training syllabus has not changed in 10 years, despite significant advances in EdTech during this time.

There was some support for national guidance on what EdTech products to use (24%) and how to use EdTech products (20%), as well as for national standards on the types of EdTech products to use (17%). These solutions were suggested during workshops, particularly as a way to help schools and colleges navigate the market. Participants stressed the need for a national strategy and/or consolidated guidance so that schools and colleges were better supported in understanding and selecting appropriate EdTech solutions. Two non-governmental solutions were mentioned during workshops: EdTech Impact has facilitated comparisons between EdTech suppliers and products based on end user feedback, while the EdSurge product index allows schools and colleges to assess products based on desirable factors (e.g., interoperability), verified independently by experts.

[99] https://hwb.gov.wales/

So far in this chapter, we have reviewed the current and future needs of schools and colleges in England, based on the themes from the workshops, key stakeholder interviews, and Teacher Tapp survey. In the following sections, we draw on the international evidence (based on our REA findings and semi-structured interviews with EdTech experts) to consider how these identified future needs might be met. We start by considering the policy-level response (system characteristics and policy measures supporting innovation), before turning to the practice-level (tools and support needed by teachers and educationalists in the future). In each case, we consider a range of practical examples from other countries, to identify the relevant learning for schools and colleges in England.

System characteristics and policy measures supporting innovation

Ensuring EdTech remains democratic

A recent United Nations paper argues that traditional models of EdTech procurement are not sustainable, as they can distort the competition benefits and work against a culture of continuous improvement.[100] The authors identify that an improved system of checks and balances is needed to balance the public and social value of EdTech with commercial interests. This diversification of the supplier base is important in a future digital education landscape that is growing increasingly complex and nuanced, and where providers must combine pedagogical, business, tech, and legal expertise.

There is some evidence that distortions in the market grew more pronounced during the COVID-19 pandemic due to the differential capacity of providers to respond. For example, a report from EY-Parthenon and EdTech France indicates that during the pandemic the largest and longest established EdTech companies had the largest profits, both in terms of popularity and financial gains[101]. Lalilo, a platform for personalized reading in kindergarten and primary school, grew from 100,000 to 600,000 users.[102]

Education innovation is driven by the private sector, and it has been growing and becoming ubiquitous. However, it does not reach most classrooms, and benefits only a very small proportion of learners globally. Education systems have been slow to pick up and benefit from learning innovations, whilst private sector and corporate learning innovation is booming. This situation seems to reflect a lack of awareness in the demand side (education authorities and institutions) on the available and emerging solutions, as well as a lack of skills and confidence in sourcing and utilising EdTech as well as a weakness in the supply side (EdTech) with regard to raising awareness of the potential

[100] https://unesdoc.unesco.org/ark:/48223/pf0000379707.locale=en
[101] Siecle Digital (2021). « L'EdTech en France : quelles dynamiques ? ». Available at : https://siecledigital.fr/2021/06/01/lEdTech-france-quelles-dynamiques/
[102] Ibid.

benefits and in capturing the imagination (and trust) of schools and colleges and teachers.[103]

To support innovation, educational authorities can try to protect small-scale players in the field. National sources of innovation funding can provide potential sources to invest in innovation and encourage more experimental uses of digital tools in pedagogical contexts; particularly to foster playful approaches for younger learners stimulating important soft skills and transversal competences like creativity, innovation, cultural awareness and expression.

Educational authorities can also identify, scale-up and disseminate successful approaches showcasing how gamification and other digital approaches can support learner engagement and motivation, particularly among low-achievers and learners at risk of dropping out, but also as relates to re-engaging learners that have already left formal education. Indeed, sharing knowledge and practices within and across education institutions as well as across countries can be an enabler for innovative digital technologies.[104] Public authorities can encourage the establishment of nationally and/or regionally coordinated and funded "digital resource-centres" from which local schools and colleges can borrow digital equipment free of cost. This may help to support access and subsequent take up of more costly tools, e.g., AR, VR and AI, for all schools and colleges.[105]

From a digital inclusion perspective, facilitating closer links between schools and colleges, the EdTech sector and representative organisations is an important future priority. This is needed to bring the developments of the sector closer to the classroom generally, and the needs of vulnerable learner groups specifically. This raises questions about governance, ethics and data rights where classrooms and private sector intersect, to ensure that education data governance is fit for purpose. Support for EdTech testbeds and pilot programmes is a potential model to facilitate joint working in a controlled way, incentivised by funding.[106]

It is also important for governments to implement long-term national solutions to mitigate the impacts of the digital divide. Governments and regional authorities can do this by implementing policies which support learner development and access to remote learning. As aforementioned, access to remote learning proved especially difficult for many pupils from less affluent backgrounds during the lockdowns caused by the COVID-19 pandemic. Delegates attending the workshops mentioned that many children across

[103] Inclusive EdTech ecosystem (2020). Available at : https://docs.google.com/document/d/1ZLq1Tj514DpwqFxTqfLawp-j57mmGzJOB_8T7ZDQsVc/edit#
[104] Vuorikari, R., Punie, Y. and Cabrera Giraldez, M. (2020). Emerging technologies and the teaching profession, EUR 30129 EN, Publications Office of the European Union, Luxembourg.
[105] European Commission, Directorate-General for Education, Youth, Sport and Culture (2021).
[106] NESTA, (2019), Models for improving evidence, Available at: https://media.nesta.org.uk/documents/EDTech_testbeds_v5.pdf

England were accessing teaching through their mobile phones during the pandemic. This was reinforced anecdotally by a workshop participant who said that:

> Because they didn't have tablets or laptops at home, they [students] were using their phones for months on end, hours every day, doing A-Levels at home. I just thought that must have been actually quite an awful experience at home. They sat and articulated that to me, and I was quite shocked by that. That was one of the main reasons they were all so pleased to come back [to in-person teaching].
> **(Workshop delegate)**

The focus box below presents two inspiring practice examples of countries which implemented long-term national and local solutions to ensure all children have access to digital tools for education, thereby democratising EdTech.

Table 4 Focus box - A long-term national and local vision

The **Plan CEIBAL** (Conectividad Educativa de Informática Básica para el Aprendizaje en Línea)[107] was implemented in **Uruguay** in 2007.[108] The Uruguayan government introduced this national digital inclusion initiative to ensure that every child owned a laptop, and that internet connectivity was free of charge at home and at school.

> The main purpose of the plan was, and remains, to attain equality in access to information through the distribution of laptops and the provision of Internet connectivity services to all the schools and colleges and districts in the country. Such services are accessed through the distributed laptops, which have been designed especially for the needs of children. They have basic operating features that enable them to work in such different environments as classrooms, homes, or even public places. This, in turn, offers a number of possibilities for teaching purposes.[109]

When implemented, this was the world's first experience with such a project on a nationwide scale, although it had been piloted in other South American countries and based on the One Laptop per Child (OLPC) project introduced by the Massachusetts Institute of Technology (MIT).[110] The national plan also foresaw complementing the hardware with a digital plan for teachers, pupils and families.

The literature concludes that

> Plan CEIBAL has helped to narrow the digital divide in terms of access to computers and Internet connectivity from education centers.[111]

[107] Translated as: Basic Computer Educational Connectivity for Online Learning
[108] https://www.ceibal.edu.uy/es
[109] Pittaluga, Lucía, and Ana Rivoir. "One laptop per child and bridging the digital divide: The case of plan CEIBAL in Uruguay." Information Technologies & International Development 8.4 (2012): pp-145.
[110] Morgan G. Ames, (2020). The Charisma Machine: The Life, Death, and Legacy of One Laptop per Child. https://mitpress.mit.edu/books/charisma-machine
[111] Pittaluga, Lucía, and Ana Rivoir. "One laptop per child and bridging the digital divide: The case of plan CEIBAL in Uruguay." Information Technologies & International Development 8.4 (2012): pp-145.

Table 5 Focus box – Transparent national guidelines for schools and colleges

In **Wales,** in 2012 the Government developed guidelines to help schools and colleges create foundation for a sustainable digital infrastructure, known as the **Hwb programme**. The programme allows for grant funding to invest in EdTech coordinated via local authorities and provides a range of digital services for teachers and learners. Hwb is considered a best practice example in both research[112] and practice:

The Hwb EdTech programme is widely regarded as the Welsh Government's most successful digital transformation programme. It is regularly referenced by other government administrations who are keen to establish similar programmes of work and hailed as 'world-class' by tech giants including Microsoft, Google and Adobe.[113]

One workshop delegate who is a teacher in Wales found that the Hwb allowed for a seamless transition into remote learning during the pandemic. She emphasised the importance of peer support through the platform: "*peer to peer was really important and we had a staff Team which had a digital channel*", which meant that if people were unsure on how to use digital tools, they could ask their peers questions and teachers with more experience of the platform could answer. Overall, she concluded that:

> Hwb is fantastic, I couldn't live without it … we are very, very lucky to have it. (Workshop delegate)

[112] Alison Glover & Steven Hutchinson (2022) Delivering education reform in Wales: a flexible route into teaching, Education Inquiry, DOI: 10.1080/20004508.2022.2051822

[113] https://civilserviceawards.com/award-nominee/digital-learning-division-hwb-edtech-programme-welsh-government#:~:text=The%20Hwb%20EdTech%20programme%20is,including%20Microsoft%2C%20Google%20and%20Adobe.

Table 6 Focus box – Transforming the national curriculum and standards through EdTech

In **Ireland,** the Digital Learning Framework (DLF)[114] was published in 2017 and developed to assist schools and colleges in effectively embedding digital technologies in learning, teaching and assessment. The DLF and its associated planning website is available to all schools and colleges and provides resources to enable education settings to use technology. The development of the DLF was underpinned by the Department of Education's Digital Strategy 2015-2020 vision to[115]:

> "Realise the potential of digital technologies to enhance teaching, learning and assessment so that Ireland's young people become engaged thinkers, active learners, knowledge constructors and global citizens to participate fully in society and the economy." **(Department of Education's Digital Strategy 2015-2020)**

The DLF adapted the UNESCO ICT Competency Framework for Teachers (2011)[116] for the Irish education context and was designed to complement the Framework for School Improvement in Irish Schools and colleges[117]. The key aims of the DLF were to:

- outline what **effective** and **highly effective** practice in the use of digital technologies looks like in schools and colleges
- support schools and colleges and teachers to self-evaluate, and to improve the use of digital technologies as part of teaching, learning and assessment
- inform teacher professional learning, including CPD

The implementation of the DLF is being evaluated across a nationally representative sample of primary, post primary and special schools and colleges[118]. The emerging findings are encouraging including, improvements in decision making around digital infrastructure, progress in school improvements/action plans, enhancement of student engagement through use of digital technologies, and evidence of teachers sharing digital resources. The key implementation challenges were infrastructure, leadership and time for implementation, and limited changes in assessment practices.

[114] The Digital learning Framework planning website (Ireland): https://www.dlplanning.ie/
[115] In April 2022, the Government of Ireland published an updated the strategy: Digital Strategy for Schools and colleges to 2027
[116] The UNESCO ICT Competency Framework for Teachers (2011): https://iite.unesco.org/pics/publications/en/files/3214694.pdf
[117] Looking at our schools and colleges: A quality framework (2016) Department of Education, Ireland: https://www.gov.ie/en/publication/743565-looking-at-our-school-2016/
[118] Evaluation of the Digital Learning Framework, Educational Research Centre: https://www.erc.ie/programme-of-work/dlf/

Key approaches to support teachers

Studies point towards a far more positive school climate and teacher attitudes towards digital technologies, where leaders have a clear vision for all things digital and adopt a whole school approach.[119]

A recent pan-European report on Digital Inclusion recommends that it is important that teachers have the necessary training and practical strategies to use digital tools to implement differentiated and inclusive teaching.[120] It is also crucial that teachers receive sufficient practical training to support learners using digital tools in order to access education, i.e., learners using assistive technologies, to maximise the benefits of these tools for learners in the classroom and avoid these learners feeling unsupported or as burdens to their teachers or peers. One expert interviewed for the study stated that:

> Exchange of experience certainly represents one of the most important enablers offering start-up companies…the possibility to exchange on their practices and to reflect together on how to provide the best services in terms of innovative education solutions to the school community. While professional development of teachers needs further investments, the mindset and eagerness of many educators to explore innovative teaching practices and introduce EdTech in their classroom can be an invaluable incentive to other less enthusiastic teachers and schools and colleges, especially in the framework of peer learning and mentoring activities. **(Expert, EU)**

The findings also suggest that it is highly effective to support teachers' action research and networks where teachers can share practical insights and participate in peer-learning on digital inclusion. Such collegial support can be effective in increasing teachers' confidence in their use of digital tools. This would also be a key tool in organising dissemination of innovation among teachers so that effective methods do not remain limited to the classroom in which they were invented and first tested.

The focus box below presents a European inspiring practice which supports digital skills and literacy of teachers and educationalists in the field of digital technology.

[119] European Commission, Directorate-General for Education, Youth, Sport and Culture (2021).
[120] Ibid.

Table 7 Focus box - Supporting digital skills and literacy of teachers and staff

Activities developed under the **Future Classroom Lab**[121] created by European Schoolnet in 2012 offer a framework and a vision of how learning spaces, educational technology, and innovative pedagogies, can support teaching and learning. The programme gives a platform to schools and colleges and teachers, providing the chance to explore and experiment with the most appropriate innovative education solutions.

The **Impact EdTech project**.[122] is a pan-European programme designed to offer advice and support to EdTech start-ups and small and medium-sized enterprises (SMEs). Its goal is to support, through a hybrid incubator-accelerator, promising start-ups and SMEs to progress their prototypes towards more viable products. The programme has supported 43 promising EdTech start-ups to access a wide range of services: equity-free financial support, mentoring, intensive bootcamp, Minimum Viable Product (MVP) development, piloting pathways, and investment opportunities.

Supporting a safe EdTech and AI sector

In 2018, a report by the Joint Research Centre of the European Commission concluded that AI offers considerable potential for teaching and learning. However, without having a better understanding of the needs of schools and colleges and learners in the future, educational AI has remained principally focussed on providing solutions to existing problems. The authors argue that this risks a counterproductive scenario in which AI automates outdated teaching practices and makes them increasingly difficult to change. It may, therefore, become necessary to develop appropriate visions and policies by simultaneously creating future-oriented models for education and teaching.[123]

The safeguarding of ethical standards in digital technology also presents a future challenge, in lieu of internationally recognised ethical standards.[124] The European Commission's Expert Group on artificial intelligence and data in education and training is developing rubrics for teachers on the competences for the ethical use of AI and data in education, which could provide guidance on how the English EdTech sector can tackle the ethical and legal aspects of AI. The following provides two promising examples.

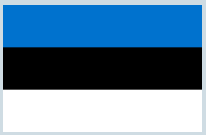
[121] https://fcl.eun.org/
[122] https://www.impactEdTech.eu/
[123] Tuomi, I. (2018) The Impact of Artificial Intelligence on Learning, Teaching, and Education, Cabrera Giraldez, M., Vuorikari, R. and Punie, Y. editor(s), EUR 29442 EN, Publications Office of the European Union, Luxembourg.
[124] Inclusive EdTech ecosystem (2020).

Table 7 Focus box – Data security

In **Denmark,** the government has put in place universal log-ins in order to create efficiencies across EdTech tools and store data in one secure place. The Danish Ministry of Education has termed this **UNI-Login**:

UNI•Login is a digital ID used by students, parents, and employees/teachers to get access to the national educational services, such as online teaching materials, national tests, etc.[125]

One expert, based in Denmark, termed this system a "**Netflix model"**.[126]



In **Estonia**, The Estonian Education Information System EHIS is a state database that brings together and secures all of the information related to education in Estonia within a data 'lake'. The database stores details about education institutions, students, teachers and lecturers, graduation documents, study materials and curricula.[127]

[125] https://twentyfour.dk/en/integrations/uni-login/
[126] Ministry of Children and Education, National Agency for IT and learning, (2019), Development of digitalization in the schools and colleges - insights from Denmark. Available at: https://www.danskeforlag.dk/media/1782/finn-togo.pdf
[127] https://www.educationestonia.org/data/

Tools and support needed by teachers and educationalists in the future

A conclusion from the 2019 European Forum on the Future of Learning was that digital technology is here to stay, both in education and training, and in wider society.[128] One expert interviewed for this research stated that:

> We do not see technology going away, we don't see this as a blip. We will continue to see expansion and reliance across the education sector. **(Expert, USA)**

Although their roles in the digital age of learning are still evolving, teachers and other learning professionals remain central, no matter how education is conceptualised (UNESCO, 2013).[129] The future of teaching and the skills needed are outlined below for consideration.

Enabling teachers to spend more time with learners

Just as AI will be used to automate productive processes, so changes may be necessary to educational institutions. For example, one scenario presented in the literature is that formal education will play a diminishing role in creating job-related competences. This could mean that the moral and ethical aspects of education will become increasingly important.[130] In general, the balance may shift from the instrumental role of education towards its more developmental role. For example, the current AI systems make almost continuous assessment of student progress possible. Instead of high-stakes testing that functions as a social filter, AI supported assessment can help learners to develop their skills and competences and keep students on effective learning paths. With such ongoing assessment, high-stakes testing may become redundant, and broader evidence may be used for assessing skills and competences. This may be important in particular for assessing transversal key competences that are now relatively difficult to assess.

As with all digital tools, the practical implementation of AI technology, will be driven by teachers choices about how to make best use of these tools. Critically, the effective use of such tools could reduce teacher time spent on administrative assessment tasks and increase time invested in skilled teaching activity. Nesta's (2019) report exploring the future of AI in schools and colleges and colleges[131], predicts that the future role of teachers is set to evolve and supported by the innovation that AI offers. The authors suggest that AI tools, such as the adaptive learning platform developed by CENTURY[132],

[128] European Commission, Directorate-General for Education, Youth, Sport and Culture (2019).
[129] Scott, C. L. (2015). The Futures of Learning 3: what kind of pedagogies for the 21st century?, UNESCO.
[130] Tuomi, I. (2018)
[131] Baker, T., Smith, L. and Anissa, N., 2019. Educ-AI-tion Rebooted? Exploring the future of artificial intelligence in schools and colleges and colleges. NESTA.
[132] CENTURY Edtech: https://www.century.tech/

with built-in assessment have the potential to reduce the amount of time teachers spend on marking. Additionally, the platform's automated data analytics provide insights for teachers on student and class progress. This information can enable teachers to prioritise individual interventions and support for learners who need it most, organise students into different learning groups, or reallocate classroom seating plans for example. Importantly, teachers are set to benefit from real-time analytics to evaluate the effectiveness of their implemented change measures on learner progress.

Workshop delegates expressed a keen interest in using tools to reduce time spent on ongoing assessments. However, none of the participants were currently using such technologies or aware of tools to support this important teaching function.

Helping teachers identify and communicate content effectively

In twenty-first century learning environments, teachers may need to transform their roles from 'content conveyors to content curators'.[133] The ability to identify and locate information and resources for learning is a critical skill and teachers can support learners in identifying the necessary resources.[134] Tools and platforms to engage learners and guide them to appropriate learning opportunities will grow in importance. However, creating teacher-designed content and applications to transform emerging technologies into tools for learning is an essential next step.[135]

Some authors have argued that the role of teachers in the twenty-first century must move away from imparting knowledge, towards guiding, discussing and measuring the progress of learners. In classrooms of the future, teachers may also assume the role of 'invited professors' to support student learning.[136] If the main goal of twenty-first century education is to build the learning capacity of individuals and support their development into lifelong, active, independent learners, then teachers may need to become 'learning coaches' – a very different role from that of a traditional classroom teacher.

Learning coaches may provide guidance to help students develop skills but their main role is to offer the kinds of support that will help students attain their learning goals. Teachers as learning coaches will encourage students to interact with knowledge – to understand, critique, manipulate, design, create and transform. Teachers will need to reinforce learners' intellectual curiosity, problem identification and problem-solving skills, and their capacity to construct new knowledge with others.[137] A key part of their role will

[133] Institute for the Future, 2013
[134] Scott, C. L. (2015)
[135] Ibid.
[136] Ibid.
[137] Bull, A. and Gilbert, J. (2012). Swimming Out of Our Depth: Leading Learning in 21st Century Schools and colleges. Wellington, New Zealand Council for Educational Research.

be to model confidence, openness, persistence and commitment for learners in the face of uncertainty.[138]

Teachers as creators of EdTech

In the future, educators can become co-creators of new applications and 'create demand' for future EdTech solutions, instead of just being users of such technologies. Essentially, the future EdTech solutions "should be co-designed and co-created using processes that involve educators, learners and other stakeholders in the development process".[139] To achieve this, a broad range of digital competence, general pedagogical knowledge and subject-specific pedagogical knowledge is needed.

Moreover, as there may be fundamental theoretical and practical limits in designing AI systems that can explain their behaviour and decisions, it is important to keep learners, parents and carers, and educators, in the decision-making loop. As several recent reports have emphasised, ethical considerations become highly relevant when AI is applied in the society or in educational settings.[140]

To prepare educators, learners and future citizens for the increasing presence of AI, existing frameworks for digital competence and that of educators' digital competence will need recalibrating.[141] In addition to covering knowledge, skills and attitudes, it will also be necessary to guide ethical reflections about AI and with AI (e.g., ethics of pedagogical practices, data, algorithms and pedagogical models). This implies a need for a radical rethink of teacher education programmes. Relevant examples include the teacher training programme on using AI developed by INTEF in Spain,[142] online courses on AI by French and Portuguese Ministries of Education. "Elements of AI" also extends the approach of winning hearts and minds from educators to the general public, by dispelling myths, and scaffolding levels of knowledge on this topic. Basic understanding of issues allows better co-creation and co-construction processes.[143]

[138] Ibid.
[139] Ibid.
[140] Tuomi, I. (2018).
[141] In Europe, the two principal Digital Competences Frameworks include the European Digital Competence Framework (DigComp), which provides comparable data on learners' digital skills, and the Digital Competence Framework for Educators (DigCompEdu), which is the equivalent for teachers and educators. These frameworks can be found at: https://joint-research-centre.ec.europa.eu/digcompedu_en
[142] The Professional Development and Technology Institute (INTEF) is the National Agency for Educational Technology and Teacher Development funded by the Spanish Ministry of Education, Culture and Sport.
[143] Vuorikari, R., Punie, Y. and Cabrera Giraldez, M. (2020).

Table 8 Focus box – KlasCement

The KlasCement digital platform run by teachers for teachers in Belgium (Flanders).[144]

KlasCement is an educational resources network managed by the Flemish Department of Education and Training. Since its inception in 1998, it has put in place a number of initiatives to support teachers in their online teaching activities and professional learning. On KlasCement, teachers can share and use educational resources, and can access training, which are in turn shared by other teachers or organisations. The network also allows for teachers to exchange with other teachers using the teacher forum.[145]

The new needs of teacher training and upskilling

The shift explained above creates the potential for teachers to have deeper, more fulfilling engagement with students and a more creative role in the design and delivery of curricula. However, teachers will need time to design their own units or access educational content provided by third-party enterprises and incorporate those offerings into learning activities.[146] Teachers will also need substantive professional development to support their transformation, especially regarding the potential and range of social media and Web 3.0 applications.

Research also shows that teachers are likely to require meaningful support and time to exploit available resources and tools to create tailor-made learning experiences that are motivating and engaging, yet efficient, relevant and challenging.[147] Traditional educational institutions must experiment with alternative structural formats and strategies for learning and teaching that respond more flexibly to individual learners' needs and changing labour market requirements. Assessment that focuses on student mastery of core academic content and the development of deeper learning skills (i.e. critical-thinking, problem-solving, collaboration, communication and metacognition) will be a high priority.

[144] https://www.klascement.net/ict/thema/ict-eindtermen-voor-lager-en-secundair-onderwijs/
[145] Minea-Pic, A. (2022), "Belgium (Flemish Community): KlasCement", in Vincent-Lancrin, S., C. Cobo Romaní and F. Reimers (eds.), How Learning Continued during the COVID-19 Pandemic: Global Lessons from Initiatives to Support Learners and Teachers, OECD Publishing, Paris, https://doi.org/10.1787/9a09dc2a-en.
[146] USDOE (2013). Expanding Evidence Approaches for Learning in a Digital World. Washington DC, US Department of Education, Office of Educational Technology. Available at: www.ed.gov/edblogs/technology/files/2013/02/ExpandingEvidenceApproaches.pdf
[147] Scott, C. L. (2015)

Emerging technologies impose a burden of continuously updating one's knowledge and skills. In many of the scenarios, educators carry on a dialogue with their colleagues or engage in continuous professional learning activities to further share and learn. This concept puts forward the idea of educators as learning professionals.

Beyond teacher support, it is important to note that **parental support can be highly effective in enhancing student learning**.[148] As aforementioned, the digital divide increases the attainment gap in education, according to the Education Endowment Fund, these causes of educational disadvantage may be mitigated by supporting parental engagement.[149] Parental engagement strategies can allow parents to further support and assist their children's learning.

The whole school community

Our research finds that a 'whole school' approach is necessary for the effective embedding of EdTech tools in schools and colleges. According to a European study:

> A strategic approach is needed to integrate digital tools and approaches into classrooms and into home learning environments, requiring **strong and effective school leadership** and **whole school approaches** towards digitalisation incorporating strategy development, funding alignment, cooperation and distributed responsibilities.[150]

[148] European Commission, Directorate-General for Education, Youth, Sport and Culture, Melstveit Roseme, M., Day, L., Fellows, T., et al., Enhancing learning through digital tools and practices : how digital technology in compulsory education can help promote inclusion : final report : October 2021, Publications Office, 2021, https://data.europa.eu/doi/10.2766/365846
[149] Education Endowment Fund, Parental Engagement, available at: https://educationendowmentfoundation.org.uk/education-evidence/teaching-learning-toolkit/parental-engagement
[150] European Commission, Directorate-General for Education, Youth, Sport and Culture, Melstveit Roseme, M., Day, L., Fellows, T., et al., Enhancing learning through digital tools and practices : how digital technology in compulsory education can help promote inclusion : final report : October 2021, Publications Office, 2021, https://data.europa.eu/doi/10.2766/365846

Table 8 Focus box – SELFIE

SELFIE (Self-reflection on Effective Learning by Fostering the use of Innovative Educational technologies) is a free tool designed to help schools and colleges embed digital technologies into teaching, learning and assessment. The SELFIE tool is based on the European Commission framework on promoting digital-age learning in educational organisations[151] and is based on research.

SELFIE aims to gather anonymous views of the educational community (students, teachers and school leaders), as well as parents and carers, on the use of educational tools in their school in relation to different aspects of digital education. Based on this input, the tool generates a diagnostic report of a school's strengths and weaknesses in their use of technology (what the European Commission terms as a SELFIE) and allows for schools and colleges to review and take action to improve the digital tools implemented.[152]

SELFIE is available for primary, secondary and vocational schools and colleges in Europe, as well as outside of Europe, and in over 30 languages. For what concerns data protection, the tool is hosted on a server owned and managed by the European Commission and data gathered is subject to the Commission's data processing rules.[153] The anonymised and aggregated data can be used for policy and research purposes only and cannot be used for commercial purposes.[154]

[151] https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/promoting-effective-digital-age-learning-european-framework-digitally-competent-educational
[152] European Training Foundation, (2021), SCALING UP AND INTEGRATING THE SELFIE TOOL FOR SCHOOLS AND COLLEGES' DIGITAL CAPACITY IN EDUCATION AND TRAINING SYSTEMS. Available at: https://www.etf.europa.eu/sites/default/files/2021-03/integrating_selfie_in_education_and_training_0.pdf
[153] https://ec.europa.eu/info/privacy-policy_en
[154] https://education.ec.europa.eu/selfie/data-and-privacy

4. Conclusions

This report has presented the findings from work carried out as part of the **Future opportunities for education technology in England** study. In the previous chapters, we gave a brief overview of the global drivers and trends, and explored what future-proofing looks like in a cross-section of four countries that might be considered 'digitally mature' in their particular context. We then drew on primary research evidence to explore the future priorities of teachers and EdTech provider in England before considering how these might be addressed.

In this final chapter, we provide some overall reflections on the learning from the study before drawing out some themes to inform the Department's own thinking on future-proofing EdTech, and identifying key messages for policy and practice.

Assessing the future of EdTech in England – barriers and enablers

The research has shown that in England, as globally, EdTech is now an established part of the education landscape. The domestic EdTech market was already buoyant prior to the COVID-19 crisis, with the UK accounting for half of tech coming into Europe. The use of tech has become increasingly hard-wired following the COVID-19 pandemic and its spotlight on schools and colleges' preparedness for using digital tools.

In England, as well as in other countries, education technology has been implemented to improve pupil attainment, contribute to reduced workload, save time on school management, and complete teaching-related tasks into the future. In response to the COVID-19 pandemic, schools and colleges in England have increased their investments in new or updated technology to support remote teaching and learning, however, important barriers to the uptake of EdTech remain.

The workshops and survey showed a good degree of consensus among teachers about what the main barriers might be. A perceived lack of affordability of EdTech products and services was coupled with concerns regarding the extent to which schools and colleges are equipped to make smart procurement decisions. In turn, insufficient information to navigate products and services, and mixed levels of confidence in being able to apply EdTech to its best effect seem to have held schools and colleges back. This is despite higher levels of recognition of the *potential* value of EdTech, and high overall levels of confidence in the extent to which technology is viewed as a priority by school leaders. Without knowing what tools and resources to source, and how to deploy them effectively, demand has been somewhat suppressed.

The disparities between schools and colleges and between households also stood out as being a push factor for the more wholesale adoption of EdTech in the future. The workshops in particular showed an awareness of the relative advantage of more digitally equipped schools and colleges, and the extent to which this gap has widened following the reliance on EdTech during the COVID-19 crisis. There was frustration at the lack of a level playing field and many schools and colleges not having the purchasing power to embrace emerging technologies wholesale, for example, when considering investments in VR/XR kit, and purchasing Learning Management Systems. This was despite seeing potential efficiencies in the medium term – through the smart use of AI for assessment or from a shift to a cloud-based system.

Teachers wanted to see a more equitable distribution of resources, opportunities for less digitally advanced schools and colleges to benefit from those who have trailblazed the use of EdTech, and collegiate and collaborative approaches towards CPD, procurement and equipment hire. There was an appetite for digital resource centres, pooled budgets, and greater centralisation and curation of digital content.

Schools and colleges were also reticent to invest in EdTech without first addressing digital divide issues at a household level, for fear of doing more harm than good by anchoring teaching and learning to technologies that may be out of reach for some families, or that may alienate sections of the teaching workforce who are not pro-tech. There was a sense of ‘no-one left behind’ which had tempered levels of optimism about how much of a radical shift was possible to close the digital skills gap.

The research also provided clarity on what schools and colleges need to implement new EdTech in the next few years and into the longer-term. Access to evidence-based resources and materials, shared infrastructure, and peer support were among the main priorities, as we go on to explore further within the recommendations below.

The global landscape – incoming technologies

The study highlighted changes on the horizon with regard to specific tools and platforms. AI is in the ascendance and set to assume prime market position by 2025 on a global scale. Its potential for transforming assessment and for personalisation is impressive but at the same time the literature warns of a lack of AI strategy and leadership at national and school levels limiting its growth. Robotics have been used to enhance learner support and to engage students who are unable to access classroom-based teaching, while the immersive potential of VR/XR is fast becoming apparent for the assessment of practical skills and competences, and gamification has shown real potential for students with learning difficulties or disabilities.

Crucially, research suggests that providing access to EdTech has little intrinsic value without an underpinning strategy for realising educational outcomes. Instead, it is *how*

practitioners use this technology and *how* they integrate it within their pedagogies and curriculum delivery, which will contribute towards learning outcomes and student wellbeing. There is no easy or straightforward relationship between ICT and student performance, firstly because the tools need to be successfully situated within individual school contexts by digitally empowered teachers and school leaders, but also because the translation of findings from controlled studies into actual practices can sometimes be challenging. Practice and future research should therefore focus on pedagogical, organisational and leadership aspects and their contribution to improving and disseminating good pedagogy and assessment.

International comparisons provide important snapshots for how other countries have adapted and scaled the use of EdTech within their education systems. The examples in the study show relative strengths and drawbacks that are unique to the policy framework (centralised or decentralised, and relative complexity of the school governance arrangements), the regulatory environment and relationships between national and municipal government and the EdTech sector, and educational expenditure. The development of the EdTech sector between countries and regions is influenced by cultural and structural factors as well as purchasing power.

In France, a focus on scaling and spreading has resulted in an impressive “digital fleet” of EdTech tools, but the emphasis has increasingly turned towards the skills, behaviours and confidence needed to utilise these tools to their full potential. In Denmark, too, scalability has brought benefits – in this case through the ‘Netflix model’ of accounts for all teachers and students to universalise access to EdTech tools and products. While being a well-established player globally, however, there have been challenges relating to more established EdTech providers exerting a growing influence and the checks and balances needed to put schools and colleges and students’ best interests first. The ‘triple helix’ model of cross-sectoral collaboration has been part of the solution. In the USA, there has been a ramping-up in the use of EdTech to tackle the digital divide post-COVID, through investment in tutoring-based products and tools to support formative assessment, while in China the equivalent inclusion measures have centred on investment in MOOCs and improving WiFi for rural areas.

All of the country examples considered for the deep dive have seen a recent ‘participative turn’, whereby government has sought to find ways to bring teachers and EdTech providers together in a more direct and inclusive way, whether through innovation projects (France), a cross-sectoral EdTech alliance (Denmark), a collaborative project to define standards of evidence for EdTech (USA), or through local symposia and communities of practice for schools and colleges and providers (China). This is very much a characteristic of future-proofing in these country contexts.

Mapping a path forward

A number of central themes emerge from the research, which form the basis of potential areas of focus to DfE for future policy action in the EdTech space.

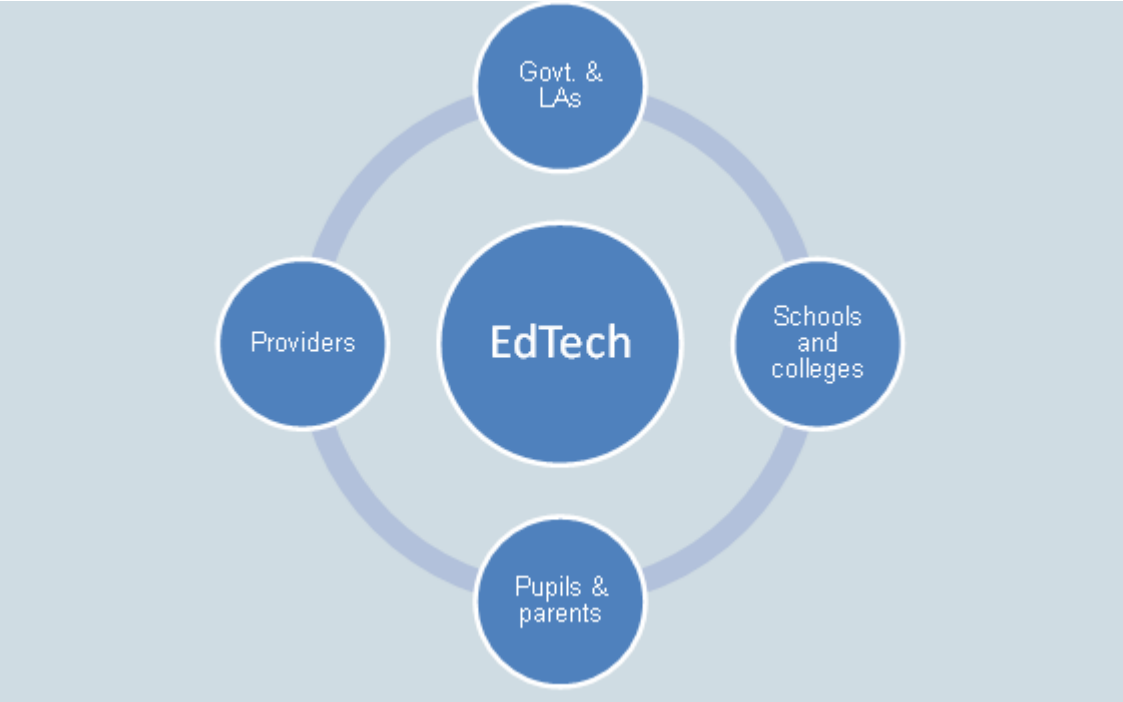
A democratic system – throughout this report it has been apparent that EdTech is not inherently democratic and that there are inevitable tensions between commercial and public interests. Looking to the future, concerns abound about larger EdTech companies commanding a growing share of the market, the 'platformization' of digital content, and the restrictive influence of paywalls and algorithms over what teachers and learners can access and how digital content is recommended to them. These concerns are offset by the positive future potential of disruptive technologies such as Blockchain, which stand to diversify the supplier base, and put more control in the hands of learners to manage their educational credit history.

The solution doesn't rest solely in the technology, however, and the potential benefits of EdTech can only be realised by adopting a mature approach towards the governance of the sector. All of the international comparator countries have sought to identify a clear role for government in setting direction and strategy, while maintaining an appropriate level of regulatory oversight of EdTech industry. The COVID-19 pandemic showed the benefits of collaboration between education ministries, private companies, publishers, broadcasters, schools and colleges and teaching unions, and it is important not to lose sight of the benefits that this offers.

Focus on inclusion – from the digital divide to learning loss, the uneven impacts of the disruption caused by the COVID-19 crisis have been laid bare. There is evidence that the crisis had a disproportionate negative impact on socio-economically disadvantaged students, and those with SEND, who were often cut-off from the support available within a classroom setting. The international picture is very much one of rebooting EdTech with equity and inclusion in mind. This includes re-designing services and platforms for accessibility, as well as maximising the benefits of new tech such as Robotics and gamification for teaching and learning.

A whole system approach – the evidence suggests that an alignment is needed between national, local and school levels to provide the most effective means of accessing the right EdTech at the right time. Digitally mature countries have often combined a clear national digital strategy and funding with a joining-up of departmental objectives, a clear signalling of the importance of EdTech within national curricula and inspection frameworks, and a strong independent voice for the sector. Decisions about procurement reside at different levels when comparing centralised systems (e.g. France) with decentralised (e.g. Sweden), while in England the complexity of governance arrangements presents a particular challenge.

Figure 7 A whole system approach



Source: Ecorys

Investing in digital leadership: there is a strong and consistent finding from the research about the importance of digital leadership – at all levels, but especially so within schools and colleges and colleges. The literature shows that teachers in schools and colleges where the head teacher has a strong vision and commitment to EdTech are more likely to have a positive view towards the role of technology in education. More specifically, the workshops showed that the technical knowledge required of school leaders has increased with the growth of EdTech, often without a specialist background.

Building digital skills and confidence – the research has shown that teacher's digital skills gaps within schools and colleges (often between generations) and between schools and colleges are an area for attention to harness EdTech more effectively for teaching and learning. The digital skills that teachers will need in the future are likely to shift from a knowledge-based towards competence-based approaches for assessment, while the literature indicates the potential for teachers' more active involvement in the decision-making loop. Digital technologies stand to position teachers as content creators and curators, especially with the more widespread availability of VR/XR and AI. This points towards a number of different professional development needs.

Importance of winning hearts and minds – a key study finding is that teachers, learners, parents and carers must become '*experts by experience'* to make EdTech relevant and meaningful, having opportunities to develop and test EdTech solutions. Investment in the availability of technology needs to be coupled with awareness-raising,

clarity of information, and opportunities for teachers to test and experiment within a safe and controlled space. Examples considered in the report ranged from large-scale communities of practice (such as the Digital Education Hub in Europe), to moderated platforms for teachers to share content and seek peer advice. These opportunities are likely to become increasingly important as EdTech products and services become more diffuse and more user-led over the next decade.

Accessing the evidence – with an emergence of new tech, so the evidence base is also rapidly catching-up, as a greater number of emerging tools and platforms have been subject to controlled studies. The generalisability of the results is often limited, however, with a lack of agreement about what standards of evaluation should look like. Indeed, it is perhaps striking that the top priority for teachers within our survey related to the availability of evidence-based EdTech teaching tools and resources and guidance on their implementation. Projects such as the EdTech Genome Project in the USA are a comparatively rare example of collaboration between public authorities, academics and the sector to maintain a national evidence repository.

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