Digital technical tools, skills and competences supporting teaching and learning

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INTRODUCTION

This paper reports on how digital technologies are used to support and enhance pedagogy and formativeassessment in schools with the aim of improving student outcomes, and includes a number of examplesof inspiring policy and practice from across Europe. It then turns to how school leaders and teachershave developed the professional confidence, competence and critical understanding required to usedigital technologies effectively, and includes further examples to illustrate this. This research was conducted at a particular moment, during the Covid-19 pandemic, and subsequent analyses may change the picture presented here.

Providing comprehensive coverage of a rapidly changing field is an impossible task. I will not attempthere to review the latest developments in digital technology use in education or research on effectiveapproaches for enhancing learning. Nor will I explore either the digital curriculum or teaching and assessing digital skills and competences. Indeed, other papers in this project consider the development of key competences and skills students will need in the future, specifically in the areas of digital citizenship, employment and entrepreneurship. Finally, I will leave aside learning analytics; the contribution that digital technologies can make to analysing teaching, learning and student performance, thereby supporting the development of practice. Each of these areas are worthy of extensive separate consideration.

Instead, the focus of this paper is the current use of digital technologies to support teaching and learning, particularly in language and mathematics, in primary and secondary schools in Europe. This will be explored in response to the following five areas of questions:

What is the extent of digital technology use in primary and secondary schools in Europe?

What, in general, are the benefits of digital technology use for supporting teaching and learning in schools?

What examples are there of where digital technologies are used well to enhance student learningin schools? How do these examples link to what we know about effective use of digitaltechnologies to support teaching and learning?

What are the main barriers to supporting teaching and learning using digital technologies in schools?

What examples are there of schools developing their use of digital technologies to enhance student learning? How do these examples link to what we know about the features of schools that are most effective in using of digital technologies to support teaching and learning?

Method

A range of policy and practice examples were sought from a variety of sources. These included international policy documents, frameworks, guidance and evaluations from the Council of Europe, European Union, Organisation for Economic Co-operation and Development (OECD), United Nations Educational, Scientific and Cultural Organisation (UNESCO) and other non-governmental organisations.For each country in the consortium, national policy documents, frameworks, guidance and research evaluations were examined including those from:

- government at national, regional and local levels and associated devolved organisations;

- trade unions, professional associations, subject associations and other representative bodies;
- political parties and think tanks;
- academic and learned societies, universities and research institutes;
- and commercial and philanthropic organisations and trade associations.

Materials were submitted from partners across the consortium, and from these, examples of inspirational policy and practice were selected. For each I describe the policy or practice in detail andidentify key features before drawing out lessons that apply more broadly.

FINDINGS

Digital technology use in primary and secondary schools in Europe

Whilst most countries in Europe have high rates of computer access in schools (EC, 2013; 2019), and initiatives to provide 1:1 devices have increased (Bocconi et al., 2013), Information and CommunicationsTechnologies (ICT) use in classrooms varies considerably. In 2018, the Teaching and Learning International Survey (TALIS) found that 36% of teachers in France (compared with the OECD average of53%) frequently or always allowed students to use ICT in class, whilst 45% (compared with the OECD average of 67%) felt confident using ICT to support student learning (OECD, 2019a). These proportionswere below the OECD average to a similar extent in Austria, Belgium, the Czech Republic and Slovenia,whilst they exceeded the average considerably in Denmark, where 90% of teachers allowed their use every day and 88% felt confident in doing so. Most other European countries were close to the OECD average in one or both areas.

Many agree that the use of digital technologies in education in Europe remains under-exploited, and theevidence of their effects on student achievement is inconclusive (Falck et al., 2015). There is, however, broad agreement that digital technologies benefit socioeconomically disadvantaged students (EC, 2013; 2019). Using PISA 2015 data, Rodrigues et al. (2017) analysed the effect of digital technology use on learning outcomes for low socioeconomic status (low-SES) students. They identified that studentsfrom poorer backgrounds start using digital devices later in life, have slightly less access to ICT at homeand use ICT less in out of school activities than their more privileged peers. They suggest that those lessadvantaged students who rarely use ICT at home and school would benefit from greater ICT use. In thisregard, all European countries taking part in the 2018 TALIS survey exceeded the OECD average (89% for all students and 78% for the lowest quartile for socioeconomic status) for the proportion of students without of school digital access to support their learning (OECD, 2019a).

Benefits of digital technology use in pedagogy, widening access and formative assessment

Although it is widely held that the classroom use of digital technologies, particularly interactive white boards, digital learning platforms and web access, improves student outcomes, evidence for this is patchy (Hammond, 2014). The European Commission consider digital technologies to provide a unique

opportunity to increase efficiency and equity in education, and suggest that digital technologies can benefit socioeconomically disadvantaged students directly by broadening access, widening participation and providing flexible and individualised approaches to learning, and indirectly by affording classroom approaches that better engage such students (EC, 2013; 2019).

There are a number of ways in which digital tools are used pedagogically in schools to support instruction, exploration and inquiry, increase student participation and widen access. Tools can be both generic such as word processing and spreadsheet programmes, and subject specific like graphing calculators or dynamic geometry packages. Similarly, whilst the internet allows for general information gathering, presentational software, adaptive instruction programmes and interactive textbooks can support classroom instruction more specifically. In some circumstances, digital approaches are used to provide formative student assessment and feedback.

Other papers in this project consider the use of digital technologies in supporting collaboration and communication. Further uses that help enhance student learning include:

- access and learning support for isolated students and those with special educational needs anddisabilities;
- games, models and simulations that can support concept or skills development or knowledge application;
- individualised instruction programmes that respond to ongoing formative assessments of student performance;
- information management, manipulation, analysis and re/presentation software;
- online resources, encyclopaedias and databases that can be used for research;
- providing preparatory background materials for flipped classrooms;
- resources that allow interactive explorations, including those providing feedback.

Examples of digital technology use to enhance student learning

Supporting disabled students

Students with disabilities can have a wide range of impairments and needs, and assistive technologies are designed to support them in using digital technologies and accessing online materials. There are many types of assistive technology. They include tools that enhance on-screen displays, for example, through colour adjustments or magnification facilities. Some enhance the audio capabilities of digital technologies, allowing them to read texts aloud – or, for users with visual impairments, to read everything presented on a screen – and convert speech to text. Writing tools help learners with spelling or sentence construction, whilst on-screen keyboards help those learners experiencing physical difficulties to use conventional keyboards. Finally, planning software allows those who may find it difficult to organise their activities to create thought maps or annotate their screens to include comments and reminders. It is quite common for mainstream technologies to have assistive capabilities in built-in display enhancement and audio tools. In addition, word processing software often allows magnification and readability checks, whilst internet browsers also have assistive features.

There is much research (reviewed in Lidström and Hemmingsson, 2014) highlighting the effectiveness ofsuch technologies in supporting inclusive practices in schools from a functional perspective in terms of improved test scores. However, there remains a need to consider other social and psychological effectssuch as the ways in which assistive technologies affect learners' confidence, change their participation and shape their identities.

With this in mind, Cranmer (2020) took an interdisciplinary approach combining digital education with disability theory to investigate disabled children's digital use in schools. An exploratory, participatoryresearch study was designed to gain insights into how visually impaired children, as an illustrative case, experienced digital technologies for learning within the context of inclusive classrooms. She found that whilst youngsters saw benefits to using digital technologies, particularly tablets, for learning, digital accessibility practices were potentially stigmatising and carried an extra task load to overcome barriers that occurred when teachers had not developed inclusive digital pedagogy. Hence, even technologies that are clearly empowering in one sense can have unforeseen social and psychological drawbacks whichmay detract considerably from their obvious benefits.

Flipped classrooms

Sams and Bergmann (2013) have proposed a systematic pedagogical approach called the flipped classroom method. A flipped classroom is a way of organising learning so that students are introduced to subject content at home and practice working through it at school. They are called flipped classroomsbecause the traditional approach, where content is introduced at school and practiced in homework tasks and assignments, is reversed. Digital technologies are often employed to introduce new ideas andareas of understanding through pre-recorded videos and reading material. Students can engage with these at their own level and go over the things they find difficult at their own pace. This means that they come to face-to-face or online discussions with their teachers and peers ready to seek clarifications and address any misunderstandings they have. This can lead to interactive exploration of the topic in more depth than would traditionally be the case.

The Flipped Learning in Praxis (FLIP) project[1] successfully ran from 2014–2016 and brought together schools from Germany, Iceland, Italy, Norway and Slovenia with the support of the European Commission. It aimed to develop guidelines for the implementation of blended learning environmentsthat use digital technologies to enhance student learning, and focused on implementing flipped learning approaches, with special emphasis on schools in rural and remote areas, as well as small and specialneeds schools. Alongside a number of conferences and workshops, a range of initiatives were undertaken in participating schools resulting in an impressive range of support materials, video examples of best practice and professional publications that are available on the website.

A review of research evidence on the effectiveness of flipped classrooms, Raffaghelli (2017) concluded that it is not easy to compare studies or synthesise their findings. This review identified that a number of the separate components of this approach, such as the use of interactive videos, advanced organisers, peer-instruction, mastery learning and teacher and peer feedback have already received positive

[1] http://www.flippedlearning.eu/

evaluations in separate studies. As such, whilst research has not demonstrated definitely the efficacy offlipped classrooms, in spite of its great popularity as instructional method, nevertheless there is much tobe optimistic about in relation to this approach.

Personalised learning

Research on personalised learning supported by digital technologies goes under a variety of names including computer-assisted learning (Bai et al., 2018; Banerjee et al., 2007), computer-aided learning (Muralidharan et al., 2019), computer-aided instruction (Carrillo et al., 2011; Ito et al., 2019), intelligent tutoring systems (Andallaza et al., 2012) and cognitive tutoring systems (Ogan et al., 2012). Of these, computer-assisted learning uses instruction, drills and exercises, simulations, and instructional games (Gambari et al., 2016; Lai et al., 2013; 2015), or involves the use of a computer program that offers corrective learning materials in the form of interesting interfaces and games which aim to improve educational engagement and outcomes (Bai et al., 2018; Mo et al., 2013). Intelligent tutoring systems, however, adjust the material presented in response to learner inputs (Major and Francis, 2020).

One particular area where there are a number of examples of effective computer-assisted learning approaches is in English language teaching in Europe. In this regard, Scott and Beadle (2014) report onstudies in Germany, the Netherlands and Spain, some with remarkable results, and conclude that such approaches can raise the achievement of students in language competences compared to those whohave not participated. Indeed, they suggest that this is well-demonstrated in studies from a variety ofmember states.

In their systematic review of literature since 2006 covering 24 studies in 12 countries, Major and Francis(2020) also presented a broadly encouraging and positive picture of the impact of personalised approaches on student learning outcomes. In particular, the adaptive nature of technology-supported personalised learning to 'teach at the right level' is, they suggest, very significant as it enables students to learn at their own pace and according to their current proficiency. This makes these approaches particularly useful for supporting low achieving students. However, they offer two cautions; the use of these technologies should complement and not replace the work of teachers in supporting such students, and much more research needs to be done to provide greater confidence in the effectiveness and greater awareness of the limitations of such approaches.

Exploring mathematical relationships

ICT allows the interactive exploration and representation of mathematical relationships, an aspect ofmathematics with which many struggle, in ways that are otherwise difficult to achieve. This can allowstudents to notice how, for instance, the shape of a graph changes as the mathematical equation itrepresents is changed slightly, say, from y=2x+3 to y=3x+3. The benefits of interactivity are also evidentin spreadsheet use. So, a spreadsheet that calculates the mean of a data set might allow students toexamine how the mean changes as new data is added. Or they might explore different visual representations of data sets, such as bar charts, pie charts and line graphs, in order to identify the strengths and limitations of each.

The use of dynamic geometry software to explore patterns in space is a particularly powerful example ofhow ICT can benefit student learning. Such programmes allow students to identify invariant geometric

relationships as other features change. An example that young learners might explore is how the sum ofthe angles of a triangle remains 180 degrees as the side lengths of the triangle are dragged and stretchedin a virtual environment. Learners gain greater understanding when they are allowed to discover such properties through their own explorations rather than being told them.

However, digital technologies have not had the expected impact in the classroom (Jones, 2011; JMC, 2011). Even in mathematics departments regarded as the most successful, dynamic geometry software,for example, is often primarily used as a demonstration tool (Ruthven et al., 2008) which has limitedpotential for learners to form and test their own conjectures. Indeed, Denton (2017) suggests that digitaltechnologies are not used to their full potential in any area of mathematics. This is because the approaches adopted are 'predominantly teacher-led and mainly focused on presentational software'(JMC, 2011: 6). As Denton reports, this is despite the opportunities that digital technologies allow for students to engage, think and make choices for themselves, in investigative and exploratory approachesthat support the development of mathematical thinking and understanding. Clearly, more needs to bedone to give teachers the confidence and equip them with the adequate tools and pedagogical methods to address students' needs.

Barriers to supporting teaching and learning using digital technologies in schools

The experiences of three countries illustrate differences in ICT use in schools in Europe and illustrate some of the barriers to future development. The digital divide and unequal opportunities for digital access are significant concerns in both Germany and Italy. Debates in Germany point to limitations in infrastructure and digital teacher competences (KMK, 2016; OECD 2016). In response, beginning in 2019, the Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung, BMBF) supported individual states or 'Länder' and municipalities by investing in digital education infrastructure, and will continue do so until 2024. Resources were allocated nationwide as part of the Digital Pakt Schuleinitiative, which aimed to prepare students for the future demands of a digitalised and technologised working world. Similarly, schools in Italy are generally poorly equipped with new technologies. Although government initiatives, such as the National Plan for Digital Schools (OECD, 2013) and the developmentof a Curriculum for Digital Civic Education (MIUR, 2019), have attempted to strengthen digital competences amongst teachers and students in the last two decades, many still lack digital know-how (Save the Children, 2020). There also remain geographical differences in online learning provision, whichoccurs most frequently with older students.

England, however, has long been an enthusiastic adopter of digital technologies in schools. By 2016, pupils were exposed to IT for over half of teaching time, whilst the adoption of mobile technology had increased, with around three quarters of primary and secondary schools using tablets in the classroom (BESA, 2016). A year later, primary schools had 70 computers on average, secondary schools had 431 and interactive whiteboards were almost universal (BESA, 2017). Although the provision of resources is clearlya huge commercial interest, many studies report the effectiveness of technologies in supporting learningis variable (summarised in McFarlane, 2019). And whilst most students have online access outside school,

the way the internet is used also varies according to socioeconomic status (Livingstone et al., 2005; more recently corroborated internationally in Harris et al., 2017).

Recognising that teachers and students in the central and east part of Europe often have lower levels ofdigital literacy than elsewhere, Buda (2020) has reported on barriers to effective ICT use in schools in Hungary and Mynaríková and Novotný (2020) have done the same for those in the Czech Republic. Earlier, Bingimlas (2009) had identified the main barriers to effective ICT use by teachers as a distrust of the technologies, an inadequacy of teachers' digital competencies and a lack of access to digital resources. In Hungary, Buda (2020) found that, whilst there was a general wish to use digital technologies to support teaching, many teachers were concerned that students did not have an equal access to digital devices outside of school, and were themselves unable to appreciate the opportunities provided by technologies,tending instead to view tools such as electronic white boards as replacements rather than improvements on traditional approaches. In the Czech Republic, Mynaríková and Novotný (2020) confirm that there hasbeen considerable investment in technological infrastructure and devices for schools, but emphasise that this investment needs to be accompanied by educational programs for teachers so that teachers know how to operate digital technologies and not be afraid to use them.

Examples of policies for developing the use of digital technologies to enhance student learning

Supporting school development

The e-Schools programme[2] aims to increase the use of digital technologies in primary and secondary education in Croatia by providing digital tools for schools and teachers, enhancing teachers' professional development and thereby improving the quality of education. This programme, that began in 2015 and will run until 2022, comprises several projects; a pilot project, which was implemented between 2015 and2018, leading to an ongoing substantive project since 2019, continuing until 2022 and based on the results of the pilot project.

A key aspect of the initial pilot project was the provision of a computer or tablet for each teacher. Science,technology, engineering and mathematics teachers each received a hybrid computer, while teachers of other subjects were given a tablet. ICT equipment was also provided for non-teaching staff to allow themto use the online material developed within the project. Learning scenarios for ensuring creative ICT useand digital educational content for STEM subjects were developed for use by teachers, who could also access educational and technical support. The equipment was used by around 920 teachers, making them active participants in raising their own levels of digital competence as part of their professional development and, alongside this, raising levels of ICT use in the schools. As such, the project expected tohelp around 5000 students attending schools from across the country.

The e-schools programme employs the concept of digitally mature schools. In short, such schools plan and implement ICT use at the organisational level in accordance with local and national policies, and havea high level of integrating ICT into their life and work. They are systematic in planning for and using ICT

[2] https://ec.europa.eu/regional_policy/en/projects/croatia/e-schools-project-to-increase-ict-use-in-croatia-s-education-system; https://pilot.e-skole.hr/en/e-schools/project-description/

in educational processes. Such schools operate in a supportive environment, with adequate resources, including adequate ICT equipment for classrooms, teachers and students. Although the programme largely depended on school self-evaluations, there were also some external evaluations, and based on acombination of these self-evaluations and external evaluations, Kolić-Vehovec et al. (2018) concluded that most schools significantly improved their digital maturity during the e-School project implementation.

Rapid development of a comprehensive online teaching and learning platform

In England, at the start of the Covid-19 crisis in March 2020 there was much talk of extensive online teaching for the majority of students and some called for an educator-designed and led educational technology platform. Wales, Scotland and Northern Ireland already had their own free-to-use platforms, providing resources to support the use of digital technology in schools. Amongst those in England to respond were nine multi-academy trusts who formed the Oak Academy[3]. A largely charitable endeavoursupported by education secretary Gavin Williamson, this project was backed by government grant funding and a contribution from Google. Forty teachers from highly-rated schools compiled a sequencedplan of hour-long online lessons and curricular resources, including videos, worksheets and quizzes, for use both by teachers and directly by students. This followed the commissioning of an EEF 'rapid evidenceassessment' of research on distance learning in early April, which reported three weeks later. The report(EEF, 2020) summarised the findings from sixty systematic reviews and meta-analyses. It concluded thatthe results from online approaches were either higher or the same as those from traditional instruction, although the EEF did concede that more research was needed.

The resulting online environment contains nearly 10,000 freely available lesson video presentations andresources that cover a wide range of subjects for school students of all ages. Each lesson is an hour-long,and delivered by a teacher, with a pre-recorded video as well as quizzes, worksheets and creative activities. In addition, teachers can, amongst other things, adapt lessons and resources and either follow a schedule or use single presentations.

Whilst the rapid development of this resource is impressive, there are other barriers to student engagement with such platforms. Later surveys revealed that the majority of students in England studiedusing online resources for less than two hours per working day for the rest of the school year. What is more, this approach emphasises teacher-led instruction at the expense of student exploration and investigation. Clearly, developing the provision is only half of the picture.

The use of digital platforms is well-developed in Estonia, largely as a result of the national Lifelong Learning Strategy 2020. This was implemented between 2014 and 2020, and included the provision of both teaching resources and materials and professional development and support to schools. Two platforms, eKool[4] and Stuudium[5], bring students and their families together with schools and school authorities. Students can access homework and assessment feedback, catch up when they are absent and receive messages from their teachers. Information for parents, including reports on their children's

[3] https://www.thenational.academy/

[4] https://ekool.eu/index_en.html

[5] https://stuudium.com/

progress, is also available. Another platform commonly used in primary and secondary schools, Opiq[6], comprises digital study-books, text-books and learning resources. Estonia announced in spring 2020 thatit would be sharing its digital education tools to support education in other countries during the pandemic[7].

Distribution of digital technologies to students with a socioeconomically disadvantaged background

Also, as part of national responses to Covid-19, concerns were raised relating to the necessity to home-school children and the availability of digital devices for students to access learning resources.

The extent of the digital divide and limitations in the digitalisation of schools were a concern in Italy.Guidance was published by the Ministry of Education, University and Research (MIUR, 2020), which indicated that teaching during school closures could address social isolation as a source of discomfort and stress by providing online support. The implementation of the framework for digital teaching andlearning was largely delegated to individual schools and teachers, and this was seen by politicians, schoolleaders, and parents as an opportunity to innovate in schools and lessen the digital divide. Many institutions at all levels responded to the lockdown immediately by offering online teaching through arange of platforms and devices, and local authorities and publishers provided webinars on online teaching, digitalisation courses for teachers, and online teaching materials. In May, the Ministry of Education in the Province of Bolzano told teachers to inform learners without a suitable device or withonly shared access to a family computer that they will receive government support. A Ministry of Education (2020) initiative followed. 'Smart Class' provided emergency funding, which schools could apply for to purchase technological devices. Schools were encouraged to consider alternatives such as communication by phone or encouraging classmates to share notes in the interim. The importance of teaching in some form, for motivating and encouraging all learners, especially those less engaged or otherwise disadvantaged, was emphasised, with suggestions that it may be necessary to involve children's family or others to achieve this. Finally, it was suggested, assignments should be set at differentlevels of difficulty to ensure that each child experiences success. Early surveys and other research evidence showed that whilst students, especially in secondary and tertiary education, were satisfied with distance learning, there were problems with accessing suitable technologies (for a report on data in oneItalian region, South Tyrol, see ASTAT, 2020) and specific support for disadvantaged learners.

In mid-April 2020 the UK government announced that care leavers, children with social worker support and those pupils sitting national examinations the following year, would receive free laptops and tablets to enable them to study online if they did not already have them. Internet routers would also be suppliedto families without mobile or broadband to ensure children could access online resources, with data charges waived on certain websites providing educational resources. Trade union leaders generally welcomed this initiative, some calling for it to be widened to all age groups. Education secretary Gavin Williamson, indicated that the £85 million scheme would pay for about 200,000 devices, the first of whichwould reach pupils by the end of May and accelerate thereafter. As responsible bodies, local authority schools and academy trusts were allocated these resources based on the number of eligible pupils and

[6] https://progetiiger.ee/?q

[7] A list of the tools available can be found here: https://education-nation.99math.com/

a Department for Education estimate of the proportion without access to appropriate devices. By theend of the year, the government reported that schools and councils had received over 560,000 devices during 2020 to support remote education.

School leadership and professional development approaches to improve teachers' digital competences

In a review of research exploring teacher preparation for the digital age, Starkey (2020) introduces theidea of professional digital competence; the ability of the teacher to work in the context of a digitisedschool and education system. This includes mastering a range of teacher competencies such as beingable to teach in a digitally infused context, manage digital learning environments and carry out thebroader professional work of being a teacher. The development of professional digital competence, shesuggests, must begin in initial teacher education.

Ongoing professional development opportunities, suggested by the OECD, follow models of schools as learning organisations or professional learning communities, which are school-based groups involving teachers in collaborative professional development to improve teaching. They provide the following categorisation of approaches that teachers can engage with in face-to-face or online environments (OECD, 2019b: 15):

Setting	**Formal**	**Informal**
Private	Online courses and seminars Self-study with monitored outcomes	Exchange on online platforms Self-study without monitored outcomes
SchoolBased	Workshops and on-the-job training Structured induction programmes Observation as part of formative appraisal Structured coaching and mentoring	Professional learning communities Peer exchange and collaboration Peer and self-observation Ad-hoc coaching and mentoring
Off-Site	External courses and seminars Qualification programmes Teacher conferences	Inter-school exchangesTeacher networks

A number of researchers such as Dexter (2008) and Vanderlinde and van Braak (2010) insist school leaders have a central role in promoting professional learning communities and professional digital competence. To do so, McGarr and Kearney (2009) assert that school leaders must focus on student learning when making decisions about ICT and must act as a learner and role model alongside the teachers. Meanwhile, Hatlevik and Arnseth (2012) found that positive teachers' perceptions of computeruse correlate to the supportiveness of their school leaders in relation to ICT. However, there is hesitanceamong some school leaders who may not have experience or formal training with digital technologies (Flanagan & Jacobsen, 2003).

In Sweden, digitalization is one of eight prioritized areas for national school development (National Agency for Education, 2017). Supporting strategic leadership in leading the digitalization of schools beganin 2002, and strengthened in the digitalization strategy for schools (Swedish Government, 2017). The necessity for professional development in digitalization for all levels of Swedish schools (National Agencyfor Education, 2016) was also stressed. Here, school leaders have an important role in strategic leadership for digitalization and pedagogical development. The Committee for Leading Digitalization is a program for school leaders to work together to support the use of digital technologies (National Agency for Education, 2018).

Studies by Mårell-Olsson and Bergström (2018), Håkansson Lindqvist (2019) and Håkansson Lindqvist and Pettersson (2019) have all explored school leaders' practices for innovative use of digital technologiesin Swedish schools. These reveal a complex picture, somewhat clouded by the role that marketisation has played in determining the priorities of schools. Nevertheless, it is clear that school leader confidenceand competence with ICT are key to the development of ICT use in schools in teaching and for supportingstudent learning. Adapting Dexter's (2008) categories, Håkansson Lindqvist and Pettersson (2019) identified the following themes for school leadership:

- setting the direction, including teaching for the future, school development and more efficient school organisation;
- developing people, including professional development for leading for digitalisation, professional development for teachers and digital competency for students;
- developing the organisation, including improving accessibility and introducing new technology for administration and communication;
- developing teaching and learning, including creating conditions for new forms of teaching and learning and collegial learning.

However, allowing school leaders the time to prioritise leadership for the use of digital technologies remains a significant barrier.

CONCLUSION

(1) Digital tool use in classrooms remains under-exploited and varies considerably across Europe. Indeed,evidence of the effects of digital technologies on student achievement is no better than mixed. Nevertheless, there is broad agreement that digital technologies benefit disadvantaged students, especially poorer students who rarely use digital devices at home and at school.

(2) Digital technologies benefit socioeconomically disadvantaged students directly by broadening access, widening participation and providing flexible and individualised approaches to learning, and indirectly by affordingclassroom approaches that are better at engaging such students.

(3) Assistive technologies are effective in supporting students with a wide range of impairments and needs. However, little consideration has been given to the social and psychological effects of assistive technology use on learners' confidence, participation and identities, or attention paid to practices that are potentially stigmatising.

(4) Flipped classrooms, as one of the many examples mentioned in the report, allow students to engage with new ideas at their own level and go over the thingsthey find difficult at their own pace, with potential benefits for subsequent classroom activity. Although there are few convincing evaluations of this approach, its individual components are known to be effective.

(5) Computer-assisted learning is particularly effective in early language teaching. Evaluations in other areas are also broadly encouraging, especially for low achieving students who can learn at their own paceand according to their current proficiency.

(6) Digital technologies can enhance the teaching of difficult areas of mathematics. However, they have not had the expected impact in the classroom because teachers adapt the technologies to benefit teacher instruction rather than using them to enhance student engagement and exploration.

(7) The digital divide, unequal opportunities for digital access and limitations in infrastructure and access to CPD on digital skills andcompetence are significant concerns in a number of European countries.

(8) In those countries where digital technology use in schools is established, the effectiveness of technologies in supporting learning is variable, and even when most students have digital access outside school, the way technologies are used varies with students' ethnicity, gender or socioeconomic status.

(9) Sustainable investment in infrastructure, digital teaching and learning platforms, digital devices and professional development within supportive environments can significantly improve the degree to which digital technologies are integrated into the life and work of schools.

(10) The Covid-19 pandemic has highlighted the additional need to provide digital devices to students without access to them outside school. Meanwhile, the crisis has shown how coordinated groups of experts under strong leadership can be rapidly mobilised to produce digital teaching and learning platforms.

(11) The model of schools as learning communities or organisations – where teachers enjoy a wide variety of formal and informal collaborative professional development opportunities – is particularly suitable for developing the digital maturity of schools.

(12) School leaders have a central role in acquainting themselves with and supporting access to professional high-quality digital competence training for teachers to achieve digital school maturity. Their confidence and competence with technologies is key to the development of digital tool use to support student learning in schools, and they should focus on student learning and to improve teaching and working conditions of the teachers when making decisions. However, allowing school leaders the time to prioritise leadership for the use of digital technologies remains problematic in some contexts.

RECOMMENDATIONS

(1) As areas of national school development, governments should invest in ensuring equal access for all students, teachers, school leaders and schools to digital infrastructure, digital teaching and learning platforms, digital devices and associated professional development. Such infrastructure should support and not be the aim of teaching.

(2) Within schools as learning communities, school leaders should prioritise the development of theirown and their colleague's digital confidence and competence as a well-tested route to digital maturity, and allow sufficient time to focus on the development of digital tool use to enhance student learning.

(3) In particular, schools should prioritise digital tool use that supports disadvantaged students (a) directlyby broadening access, widening participation and providing flexible and individualised approaches to learning, and (b) indirectly by encouraging classroom approaches using digital tools that engage such students.

(4) More research is needed to evaluate all areas of digital tool use to support student learning in schools,not only to provide greater confidence in the effectiveness of such approaches, but also to raise awareness of their limitations. Focuses should include:

- the pedagogic principles behind the effective use of digital technologies to support student learning, and professional development approaches that encourage teachers to follow theseprinciples;
- effective ways of using digital tools to complement other classroom approaches;
- the social and psychological implications of digital technology use in schools, including identifying practices that are potentially stigmatising and considering how these might be improved.

(5) The Covid-19 pandemic provides an opportunity for research to explore the relation between learning outcomes and access to digital devices and engagement with online teaching and learning platforms. Studies should usefully contrast the experiences of teachers and students in different countries andidentify the effect of digital pedagogies, including flipped classrooms and participatory approaches, on student outcomes when compared with traditional approaches.

REFERENCES

Andallaza, T., Rodrigo, M., Lagud, M., Jimenez, R. & Sugay, J. (2012) Modeling the Affective States of Students Using an Intelligent Tutoring System for Algebra, Proceedings of The Third International Workshop on Empathic Computing (IWEC), 4.

ASTAT (2020) Covid-19 – Lockdown, retrieved from: https://astat.provinz.bz.it/de/aktuelles-publikationen-info.asp?news_action=4&news_article_id=641709 [accessed 01-09-2020].

Bai, Y., Tang, B., Wang, B., Auden, E. & Mandell, B. (2018) Impact of Online Computer Assisted Learning on Education: Evidence from a Randomized Controlled Trial in China. REAP Working Paper, 51.

Banerjee A. V., Cole S., Duflo E. & Linden L. (2007) Remedying Education: Evidence from Two Randomized Experiments in India, The Quarterly Journal of Economics, 122 (3), 1235–1264.

BESA (2016) ICT in UK State Schools, retrieved from: https://www.besa.org.uk/insights/ict-uk-schools-2016/ [accessed 01-09-2020].

BESA (2017) ICT in UK State Schools, retrieved from: https://www.besa.org.uk/insights/ict-uk-schools-2017/ [accessed 01-09-2020].

Bingimlas, K.A. (2009) Barriers to successful integration of ICT in teaching and learning environments: Areview of the literature, Eurasia Journal of Mathematics, Science and Technology Education, 5(3), 235–245.

Bocconi, S., Kampylis, P. & Punie, Y. (2013) Framing ICT-enabled Innovation for Learning: the case of one-to-one learning initiatives in Europe, European Journal of Education, 48(1), 113–120.

Buda, A. (2020) Stumbling Blocks and Barriers to the Use of ICT in Schools: A Case Study of a Hungarian Town, Informatics in Education, 19(2), 159–179.

Carrillo, P., Onofa, M. & Ponce, J. (2011) Information Technology and Student Achievement: Evidence from a Randomized Experiment in Ecuador, SSRN Electronic Journal, retrieved from: https://doi.org/10.2139/ssrn.1818756 [accessed 01-02-2021].

Cranmer, S. (2020) Disabled children's evolving digital use practices to support formal learning. Amissed opportunity for inclusion, British Journal of Educational Technology, 51(2), 315–330.

Denton, J. (2017) Transforming Mathematics: Using Dynamic Geometry Software to Strengthen Understanding of Enlargement and Similarity, Warwick Journal of Education, 1, 69–84.

Dexter, S. (2008) Leadership for IT in schools, in J. Voogt, & G. Knezek (Eds) International handbook of information technology in primary and secondary education, New York, Springer, 543–554.

EC (2013) Survey of Schools: ICT in Education, retrieved from: https://ec.europa.eu/digital-single-market/en/news/survey-schools-ict-education [accessed 01-02-2021].

EC (2019) Second Survey of Schools: ICT in Education, retrieved from: https://ec.europa.eu/digital-single-market/en/news/2nd-survey-schools-ict-education [accessed 01-02-2021].

EEF (2020) Remote learning: rapid evidence assessment, retrieved from: https://educationendowmentfoundation.org.uk/evidence-summaries/evidence-reviews/remote-pd- rapid-evidence-assessment/ [accessed 01-09-2020].

Falck, O., Mang, C. & Woessman, L. (2015) Virtually no effect? Different uses of classroom computers and their effects on student achievement, CES-IFO Working Paper No. 5266.

Flanagan, L., & Jacobsen, M. (2003) Technology leadership for the twenty-first century principal, Journalof Educational Administration, 41(2), 124–142.

Gambari, A., Shittu, A., Falode, O. & Adegunna, A. (2016). Effects of computer-self interactive package (CSIP) on students' performance, achievement level and attitude toward mathematics at secondaryschool in Nigeria. Al-hikma Journal of Education, 3(1), 14.

Håkansson Lindqvist, M. (2019) School leaders' practices for innovative use of digital technologies in schools, British Journal of Educational Technology, 50(3), 1226–1240.

Håkansson Lindqvist, M. & Pettersson, F. (2019) Digitalization and school leadership: on the complexityof leading for digitalization in school, The International Journal of Information and Learning Technology, retrieved from: https://doi.org/10.1108/IJILT-11-2018-0126 [accessed 01-02-2021].

Hammond, M. (2014) Introducing ICT in schools in England: Rationale and consequences, British Journalof Educational Technology, 45(2), 191–201.

Harris, C., Straker, L. & Pollock, C. (2017) A socioeconomic related 'digital divide' exists in how, not if, young people use computers. PLoS ONE 12(3), e0175011, retrieved from: https://doi.org/10.1371/journal.pone.0175011 [accessed 01-02-2021].

Hatlevik, O. & Arnseth, C. (2012) ICT, teaching and leadership. How do teachers experience theimportance of ICT-supportive school leaders? Nordic Journal of Digital Literacy, 7(1), 55–69.

Inamorato dos Santos, A., Punie, Y. & Castaño-Muñoz, J. (2016) Opening up Education: A Support Framework for Higher Education Institutions, Joint Research Centre, European Commission, EUR 27938 EN.

Ito H., K. & Nakamuro M. (2019) Does Computer-aided Instruction Improve Children's Cognitive and Non-cognitive Skills: Evidence from Cambodia, Discussion papers 19040, Research Institute of Economy, Trade and Industry (RIETI), retrieved from: https://ideas.repec.org/p/eti/dpaper/19040.html [accessed 01-02-2021].

JMC (2011) Digital technologies and mathematics education, Clark-Wilson, A., Oldknow, A. & Sutherland,

R. (Eds) Joint Mathematical Council of the United Kingdom (JMC), retrieved from: http://cme.open.ac.uk/cme/JMC/Digital%20Technologies%20files/JMC_Digital_Technologies_Report_2 011.pdf [accessed 01-02-2021].

Jones, K. (2011) The value of learning geometry with ICT: lessons from innovative educational research,in: Oldknow, A. & Knights, C. (Eds), Mathematics Education with Digital Technology, London, Continuum, 39–45.

KMK (2016) Bildung in der digitalen Welt. Strategie der Kultusministerkonferenz, Berlin, KMK, retrieved from: https://www.kmk.org/fileadmin/Dateien/veroeffentlichungen_beschluesse/2018/Strategie_Bildung_in_der_digitalen_Welt_idF._vom_07.12.2017.pdf [accessed 01-09-2020].

Kolić-Vehovec, S., Sušanj, Z., PhD, Ćulum, B., Smojver-Ažić, S., Kalebić Maglica, B., Martinac Dorčić, T., Pahljina-Reinić, R., Rončević Zubković, B., Mohorić, T., Miletić, I., Mehić, N., Močibob, M., & Vuković, A.(2018) Scientific Research on the Effects of the Project "e-Schools: Establishing a System for the

Development of Digitally Mature Schools (Pilot Project), retrieved from: https://pilot.e-skole.hr/wp- content/uploads/2019/11/Initial_research_report.pdf [accessed 01-02-2021].

Lai, F., Luo, R., Zhang, L., Huang, X. & Rozelle, S. (2015) Does computer-assisted learning improvelearning outcomes? Evidence from a randomized experiment in migrant schools in Beijing.
Economics of Education Review, 47, 34–48.

Lai, F., Zhang, L., Hu, X., Qu, Q., Shi, Y., Qiao, Y., Boswell, M. & Rozelle, S. (2013) Computer assisted learning as extracurricular tutor? Evidence from a randomized experiment in rural boarding schools in Shaanxi. Journal of Development Effectiveness, 5(2), 208–231.

Lidström, H. & Hemmingsson, H. (2014) Benefits of the use of ICT in school activities by students withmotor, speech, visual, and hearing impairment: A literature review, Scandinavian Journal of Occupational Therapy, (21)4, 251–266.

Livingstone, S., Bober, M. & Helsper, E. (2005) Inequalities and the Digital Divide in Children and Young People's Internet Use: Findings from the UK Children Go Online project, London, Department of Media and Communications, London School of Economics and Political Science, retrieved from: https://www.york.ac.uk/res/e-society/projects/1/UKCGOdigitaldivide.pdf [accessed 01-02-2021].

Major, L. & Francis, G. A. (2020) Technology-supported personalised learning: Rapid Evidence Review, EdTechHub, 10.5281/zenodo.3948175.

Mårell-Olsson, E. & Bergström, P. (2018) Digital transformation in Swedish schools: Principals' strategic leadership and organisation of tablet-based one-to-one computing initiatives, Seminar.net: Media, technology and lifelong learning, 14(2), 174–187.

McFarlane, A. (2019) *Growing up digital: What do we really need to know about educating the digitalgeneration?* London, Nuffield Foundation.

McGarr, O. & Kearney, G. (2009) The role of the teaching principal in promoting ICT use in small primaryschools in Ireland, Technology, Pedagogy and Education, 18(1), 87–102.

Ministry of Education (2020) Smart Class II° Ciclo. retrieved from: https://www.istruzione.it/pon/avviso_smart-class_secondo-ciclo.html#sec_int [accessed 01-09-2020].

MIUR (2020) MI/AGIA – Miniguida per docenti su didattica a distanza e diritti. retrieved from: https://miur.gov.it/web/guest/-/mi-agia-miniguida-per-docenti-su-didattica-a-distanza-e-diritti [accessed 01-09-2020].

Mo, D., Swinnen, J., Zhang, L., Yi, H., Qu, Q., Boswell, M. & Rozelle, S. (2013) Can One-to-One Computing Narrow the Digital Divide and the Educational Gap in China? The Case of Beijing Migrant Schools, World Development, 46, 14–29.

Muralidharan, K., Singh A. & Ganimian A. (2019) Disrupting Education? Experimental Evidence on Technology-Aided Instruction in India, American Economic Review, 109(4), 1426–60.

Mynaříková, L. & Novotný, L. (2020) Knowledge Society Failure? Barriers in the Use of ICTs and Further Teacher Education in the Czech Republic, Sustainability, 12, 6933, retrieved from: www.mdpi.com/journal/sustainability [accessed 01-02-2021].

National Agency for Education (2016) It-användning och it-kompetens i skolan [IT-use and IT-competence in school], Stockholm, Sweden, Skolverket.

National Agency for Education. (2017) Nationella skolutvecklingsprogram [National school development programs], retrieved from: https://www.skolverket.se/skolutveckling/nationella-skolutvecklingsprog#Digitalisering [accessed 01-02-2021].

National Agency for Education (2018) Leda digitalisering [Leading digitalization], retrieved from: https://www.skolverket.se/kompetens-ochfortbildning/skolledare/styrning-ledning [accessed 01-02-2021].

OECD (2013) Review of the Italian Strategy for Digital Schools, retrieved from: http://www.oecd.org/education/ceri/Innovation%20Strategy%20Working%20Paper%2090.pdf [accessed 01-09-2020].

OECD (2016) Innovating Education and Educating for Innovation: The Power of Digital Technologies and Skills, retrieved from: http://dx.doi.org/10.1787/9789264265097-en [accessed 01-09-2020].

OECD (2019a), TALIS Database, retrieved from: https://www.oecd.org/education/talis/talis-2018-data.htm [accessed 01-09-2020].

OECD (2019b) Teachers' Professional Learning Study: Design and Implementation Plan, retrieved from: http://www.oecd.org/education/teachers-professional-learning-study/continuing-professional- learning/TPL-Study-Design-and-Implementation-Plan.pdf [accessed 01-02-2021].

Ogan, A., Walker, E., Baker, R, Rebolledo Mendez, G., Jimenez Castro, M., Laurentino, T. & de Carvalho, A. (2012) Collaboration in cognitive tutor use in Latin America: Field study and design recommendations, Proceedings of the SIGCHI Conference on Human Factors in Computing Systems,1381–1390.

Raffaghelli, J. (2017) Does Flipped Classroom work? Critical analysis of empirical evidences on its effectiveness for learning, Open Journal per la formazione in rete, 17(3), 116–134.

Rodrigues, M. & Biagi, F. (2017) Digital technologies and learning outcomes of students from low socio-economic background: An Analysis of PISA 2015, Joint Research Centre Science for Policy Report, European Commission, EUR 28688 EN.

Ruthven, K., Hennessy, S. & Deaney, R. (2008) Constructions of dynamic geometry: A study of the interpretative flexibility of educational software in classroom practice, Computers & Education, 51,297–317.

Sams, A., & Bergmann, J. (2013) Flip your students' learning, Educational Leadership, 70(6), 16–20.

Save the Children (2020) Riscriviamo il futuro. L'impatto del coronavirus sulla povertà educativa, retrieved from: https://s3.savethechildren.it/public/files/uploads/pubblicazioni/limpatto-del- coronavirus-sulla-poverta-educativa_0.pdf [accessed 01-09-2020].

Scott, D. & Beadle, S. (2014) Improving the effectiveness of language learning: CLIL and computer assisted language learning, Report for the European Commission, J60173.

Starkey, L. (2020) A review of research exploring teacher preparation for the digital age, Cambridge Journal of Education, 50(1), 37-56.

Swedish Government (2017) National digitalization strategy for schools, retrieved from: www.regeringen.se/4a9d9a/contentassets/00b3d9118b0144f6bb95302f3e08d11c/nationell- digitaliseringsstrategifor-skolvasendet.pdf [accessed 01-02-2021].

Vanderlinde, R. & van Braak, J. (2010) The e-capacity of primary schools. Development of a conceptualmodel and scale construction from a school improvement perspective, Computers & Education, 55(2), 541–553.