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Unpacking the impact of digital technologies in Education

Literature review and Assessment Framework

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Contents

Abstract

This report presents a literature review that analyses the impact of digital technologies in compulsory education. While EU policy recognises the importance of digital technologies in enabling quality and inclusive education, robust evidence on the impact of these technologies is limited, especially due to its dependency on the context of use. To address this challenge, this report analyses the focus, methodologies, and results of 92 papers. Our findings, on the one hand, confirm research and policy analysis highlighting mixed research results on the impact of digital technologies in education. On the other hand, looking at the degree of potential permeation of digital technologies in schools, it appears that these technologies can have a profound impact in education. This finding stems from the observation that the impact of digital technologies extends beyond learning outcomes and encompasses various aspects of the school practice, which are identified in this report. These include the nature of the various technology mediated activities (teaching, learning, school operation – administration – communication), the key stakeholders, technology implementation activities and contextual factors influencing the impact of digital technologies. Drawing on the theory of change, our analysis reveals the importance of considering not only the various elements that constitute part of the impact of digital technologies in education but also the relationships between them. This finding is captured in an impact assessment framework that is adapted to the characteristics of self-reflection tools designed to support digital capacity development in education. The report contributes recommendations that can inform policies for monitoring and investment in digital education.

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Executive summary

Developments in digital technologies used in education have triggered many discussions on their impact on teaching and learning. Furthermore, the versatile and disruptive character of some of these technologies has raised the issue of the adaptation of educational systems to take into account the changing technological landscape calling for a digital transformation of education. Digital transformation emphasises the integration of digital technology in teaching, learning and evaluation as well as the development of digital competences. In this context, many scholars have argued that schools need to embrace digital transformation to ensure positive and efficient use of digital technologies in the school environment.

Many education policies have integrated digital transformation into their core priorities emphasising the need for a strategic approach. The development of a strategy for digital transformation requires a good understanding of the current situation of technology use in schools, which then can be used as a basis for the digital development of the school. For this purpose, several self-reflection tools have been developed such as SELFIE, a European Commission tool that enables schools to engage in collective reflection on how they have integrated digital technologies in their practice. Although there is evidence that schools using self-reflection tools receive valid information regarding their digital capacity, there is a need to better understand how these tools can empower schools to develop their digital capacity.

The impact of digital technologies in teaching and learning is central to the discussion about the digital transformation in education and particularly relevant to the evaluation of digital education policies. However, several research and policy analyses highlight that impact assessment studies focusing on the effectiveness of digital technologies in improving learning outcomes report conflicting results. As such, a closer look is required to understand how the impact of digital technologies in education is studied and in relation to which dimensions of the school activity.

This report aims at providing insights to policymakers that can inform digital education policies by (a) unpacking the impact of digital technologies in education beyond learning outcomes, (b) identifying critical factors linked to the impact of digital technologies and their integration in education, and (c) providing a framework for the impact assessment of self-reflection tools.

Policy context

Digital education is a fundamental component of the European Education Area, a policy initiative that fosters collaboration between Member States to build more resilient and inclusive education and training systems. Digital education is also a key driver of the development of digital skills, which is one of the four targets guiding “Europe’s Digital Transformation” under the policy priority “A Europe Fit for the Digital Age”.

In the above policy context, the digital transformation of education is a prominent element of policy initiatives. Specifically, the **Digital Education Action Plan** (2021-2027), which is a renewed EU policy initiative, sets a common vision for digital education and identifies priorities and actions towards supporting the adaptation of the education systems of the Member states to the digital age. Self-reflection tools for digital capacity development like **SELFIE** and **SELFIEforTEACHERS** have been considered to play a pivotal role in the digital transformation process, and they have been included as actions of the previous policy initiative. As the digital transformation progresses, the need for monitoring this progress has been stressed in the Council Recommendation on the **Key Enabling Factors** for successful digital education and training (European Commission 2023b). Furthermore, investments in digital education are growing. Specifically, Member States have allocated **23 billion euros** in their Resilience and Recovery Plans (European Commission 2023c). Assessing the impact of digital technologies in education can inform both monitoring and investment policies.

Key conclusions

The impact of digital technologies should be understood as a **complex concept** where the effectiveness of technologies touches upon many different aspects of school education. It is not restricted to the learning outcomes only, although this is the overall purpose. Specifically, our analysis demonstrated how impact assessment studies have analysed the use of a wide spectrum of digital technologies to support a variety of learning processes, subject matters, teaching approaches as well as school operation procedures (student records, communication with parents etc.). All these different aspects, when mediated by digital technologies, are affected by a set of contextual factors, namely: (a) digital competencies of students and staff, (b) teacher professional development, (c) school leadership and management, (d) connectivity, infrastructure, government

and other support, (e) administration and data management practices, (f) students' socioeconomic background, and (g) the socioeconomic school context.

As a consequence of this complexity, it becomes apparent that a re-conceptualisation of the impact of digital technologies in education is necessary. Instead of focusing on learning outcomes, the impact of digital technologies should be explored in relation to the degree they **enable the creation of rich learning environments** providing **opportunities for high-quality and inclusive education**. To better understand the impact of digital technologies, it is necessary to consider combinations of different research methods and data sources. A systems' approach could be further explored as a potential basis for studying the impact of digital technologies in education. Based on the importance of context, of the quality of implementation actions and the wide-range of digital technologies available, policymakers should provide seamless methodologies and instruments that allow schools to assess the technologies they use, in relation to their specific contexts.

Main findings

Our analysis confirmed research and policy analyses that highlight the conflicting results reported from impact assessment studies. However, in the last few years, research seems to report **slightly higher effect sizes**, but this shift cannot be attributed solely to digital technologies but also to developments in a complex set of contextual factors (e.g., infrastructure, digital skills, etc.). The record of school activities that can be mediated by digital technologies allowed us to adopt a different viewpoint in looking at the impact of digital technologies. Specifically, looking at the degree of potential integration of digital technologies in schools, it appears that these technologies **can have a profound impact in education**. This observation does not merely stem from the multitude of activities but also from the transformative capacity of digital technologies to reshape these activities and introduce new dynamics. These **emerging dynamics** encompass not only improvements but also **unforeseen consequences**, a dimension that also needs to be considered when the impact of digital technologies is explored.

These findings further illustrate that the impact of digital technologies in education is a complex concept, the complexity of which cannot be captured in linear causal relationships between technology use and learning outcomes. Instead, this impact is multifaceted, influenced by a range of contextual factors (e.g. infrastructure, school profile, digital skills etc.), and shaped by the dynamic interactions among the various sectors involved in technology use. Building on these findings and on the Theory of Change, we propose an impact assessment framework adopted to self-reflection tools for digital capacity development in education.

Related and future JRC work

This report is part of a study on Qualitative Impact Assessment of the SELFIE tool and its role in supporting digital transformation in education. The study was implemented by the University of Valladolid in Spain (GSIC/EMIC Group), the University of Twente in The Netherlands, and CYENS Center of Excellence (Nicosia-Cyprus) & Cyprus University of Technology, Cyprus Interaction Lab (Limassol-Cyprus).The work presented belongs tothe first part of the study, which aimed at exploring the literature review on unpacking the impact of digital technologies in education. This work constituted the basis for the creation of a framework to inform the impact assessment of SELFIE. The study followed a qualitative approach and involved 15 schools from Cyprus, Spain and The Netherlands (five schools from each country).

Quick guide

This science for policy report is divided into seven chapters. The **Introduction** chapter provides a background on digital transformation and digital capacity development, which are key concepts of this report. It also offers an overview of the EU-policy context in relation to digital education. In particular it analyses how the digital transformation of schools and impact assessment of digital technologies is central to the Digital Education Action Plan (2021-2027) and to policies that will be focusing on investments in digital education and on monitoring the digital transformation of education. **Chapter 2** is dedicated to the research questions guiding the literature review. **Chapter 3** presents the method followed to conduct the literature review. **Chapter 4** analyses research studies focusing on the impact of digital technologies in education and identifies trends and salient characteristics. Furthermore, from the same analysis key contextual factors influencing the impact of digital technologies are extracted. **Chapter 5** focuses on the impact assessment of self-reflection tools analysing their role in the digital transformation in education and their links with the Theory of Change. This chapter closes by offering a framework for assessing the impact of self-reflection tools. **Chapter 6** summarises the work done drawing the main conclusions. Finally **Chapter 7** provides policy recommendations in relation to policies that focus on investments and monitoring of digital education.

1 Introduction

1.1 Background

1.1.1 Digital transformation in schools

Digital technologies have brought about significant changes in education. Technological innovations, such as smart devices, the Internet of Things (IoT), Artificial Intelligence (AI), Augmented Reality (AR) and Virtual Reality (VR), blockchain, to name a few, have prompted many discussions on their role in teaching and learning (OECD, 2021; Gaol & Prasolova-Førland, 2021). Hence, in recent years, many education systems worldwide have increased their investments in the integration of Information and Communication Technologies (ICTs) in teaching and learning practices (Fernández, Gimenez, & Calero, 2020; Lawrence & Tar, 2018; Turgut, & Aslan, 2021) and have prioritised in their educational agendas the adaptation of a strategy or a policy for the integration of digital technologies (European Commission, 2019a). The latter have initiated deliberations on the quality of teaching and learning with ICTs (Bates, 2015) and their integration in education systems in a way that takes into account technological developments. (Balyer & Öz, 2018). These topics came more strongly to the foreground during the COVID-19 pandemic since governments were forced to move to online teaching at all education levels (Daniel, 2020). Online teaching accelerated the use of digital technologies generating questions regarding digitalisation in schools (König, Jäger-Biela, & Glutsch, 2020). Specifically, many schools demonstrated a lack of experience and low digital capacity, which resulted in widening gaps, inequalities and learning losses (European Commission, 2020a). Such results have engendered the need for schools to learn and build upon the experience they gained during the pandemic by enhancing their digital capacity and preparedness (Costa et al., 2021; European Commission, 2020a).

Central in this discussion is the concept of digital transformation, which refers to "a series of deep and coordinated culture, workforce, and technology shifts and operating models" (Brooks, & McCormack, 2020, p. 3) that bring cultural, organisational, and operational change through the integration of digital technologies (JISC, 2020). A school's digital transformation process requires different stakeholders (school leaders, administration staff, teachers, students, parents) to be involved and act together at several organisational levels, such as school leadership, administration, development and teaching. Furthermore, tools for institutional learning (Hauge, 2016; Pettersson 2021) are also important to support the digital transformation process. More specifically, school leaders are expected to endorse a digital transformation vision and be responsible for formulating and communicating goals and agendas while building structures in which teachers feel safe and confident. Administration staff needs to be ready to support and manage the transformation, work effectively with suitable infrastructure, be digitally competent and qualified. Similarly, teachers need to develop digital competences and instructional skills in order to be able to plan, conduct and evaluate technology-supported teaching and learning. Students also need to acquire competencies that will allow them to use digital technologies and tools to access learning material or participate in learning activities. Lastly, the relationship between the school and the parents/carers is an integral part of the digital transformation process. Some elements of this relationship involve the flow of the necessary information and facilitation of a smooth collaboration in order to better support students at home and in school (Rott & Marouane, 2017; Balyer & Öz, 2018; Pettersson 2018; Delcker & Ifenthaler, 2021). Schools' digital transformation also involves organisational changes at the level of internal workflows, communication between the different stakeholders, and possibilities for collaboration (Rott & Marouane, 2018).

1.1.2 Digital capacity development and self-assessment

Digital capacity development is a critical component of digital transformation in the sense that it focuses on the development of those competences and organisational changes that will enable the school to carry out the envisaged changes required for its digital transformation. According to Costa et al. (2021), schools need to reshape what it means to be digitally capable. Even when they have an effective digital strategy in place, they still need to review and rethink their approach to teaching and learning as well as their organisational practices (European Commission, 2019a; Pettersson, 2018) especially because digital transformation is an ongoing process and not a fixed-term project (Lipsmeieret al 2020).

In this context, digital capacity development can be facilitated by tools that are designed to support schools to undertake self-assessment exercises on how they use digital technologies. The results of the self-assessment can then inform their decisions for the development or refinement of their digital strategy (Antoniou et al., 2016). Self-assessment can assist schools in formulating plans for digital development as well as to detect the main gaps that may jeopardise technology adoption (Kampylis et al., 2016). Such practices are extremely important because they provide a unique path to digital transformation for each school, which might have different needs, profile and digital capacity level (Assefa, Rorissa, & Alemneh, 2021).

The importance of self-evaluation to the schools' digital transformation has been documented by many organisations and researchers who have developed various frameworks and self-assessment instruments related to the integration of digital technologies in education. For example, in the European context, the need of providing schools with a comprehensive and easy-to-use tool for reflecting on their digital capacity resulted in the development of SELFIE (European Commission, 2020b). SELFIE follows a holistic approach based on the DigCompOrg framework, which aims to encourage self-reflection in educational organisations about their progress in ICT integration and enable policymakers to design and implement interventions to support the effective integration of digital technologies in education (Kampylis et al., 2015).

1.2 Policy context

The integration and use of digital technologies in schools is no longer a question, but it remains a difficult challenge. The technological landscape changes very quickly, the number of available technologies and resources is overwhelming, and schools even within the same educational system have different profiles, capacities and needs in relation to the use of digital technologies. The complexity of the phenomenon calls for a systematic approach to the use of digital technologies, the lack of which in the past has led to unused equipment and software due to the lack of trained personnel and/or due software unfit for the school's needs. This demonstrates the need for the development of a digital strategy at the school level, which will be focusing on an effective, pedagogically informed use of ICT tailored to the profile, needs and vision of schools. The recent pandemic demonstrated even more pressingly the need for digitally capable schools.

This need is also recognised at a European level. The broader policy context for this work is the policy priority "A Europe fit for the digital age". Acknowledging the transformational role of digital technologies in people's lives, it aims at strengthening Europe's digital sovereignty and setting standards rather than following others. Education is one of the policy areas under this priority focusing on inclusive, accessible and high-quality education and training for all.

1.2.1 Digital Education Action Plan

In 2021, the European Union published a renewed policy initiative aimed at setting out a common vision for high-quality, inclusive and accessible digital education in Europe: the Digital Education Action Plan (DEAP) 2021-2027 (European Commission 2020a). This policy initiative aims at supporting Member Stats in adapting their education and training systems to the digital age. The first strategic priority focuses on "Fostering the development of a high performing digital education ecosystem". Under this priority, it is stressed that "effective digital capacity planning and development is vital for education and training systems". Digital capacity planning is not only an issue involving education and training systems at the level of ministries only. Instead, the needs of schools and their role not only in implementing but also shaping the digital strategies is critical: "*even the best education minister cannot do justice to the needs of millions of students, hundreds of thousands of teachers and tens of thousands of schools. The challenge is to build on the expertise of teachers and school leaders and enlist them in addressing the challenges.*" (Schleicher 2020). The new DEAP acknowledges the agency of schools as institutions in the process of their digital transformation in Action 5 highlighting the "use of Erasmus Cooperation projects to support the digital transformation plans of primary, secondary, vocational education and training (VET), higher and adult education institutions" (European Commission 2020a).

1.2.2 Self-reflection tools

The Commission has created two self-reflection tools designed to support digital capacity planning and development: One is SELFIE, a self-reflection tool designed to support schools to reflect on their digital capacity and use this reflection as a basis for the development of a digital strategy. SELFIE covers general education and VET and includes a new model SELFIE for Work-Based Learning which links school education with in-company training. The other tool is SELFIEforTEACHERS which supports educators to reflect on their digital competences and plan their professional development and learning path.

SELFIE

SELFIE (https://education.ec.europa.eu/selfie) stands for "Self-reflection on Effective Learning by Fostering the use of Innovative Educational technologies". It is a free, web-based, self-reflection tool to help general and vocational schools develop their digital capacity, It is available in 40 languages and by November 2023 it has been used by 5.6 million users from 38,500 schools from 91 countries (https://schools-go-digital.jrc.ec.europa.eu/). It was developed by the Joint Research Centre and the Directorate-General for Education, Youth, Sport and Culture (DG EAC). The JRC has also collaborated with DG-EMPL in extending SELFIE to include a module that supports work-based learning.

The tool integrates three variations of a validated questionnaire, which is designed for the school community: school leaders, teachers and students. Given the different profiles and needs of schools in the different countries and regions, SELFIE is customisable allowing schools to integrate a number of questions relevant to their school and context. Responses to the questions are anonymous. Schools are expected to design their digital strategy using as a basis an aggregated data report generated by SELFIE. This report highlights what works and what needs improvement and is meant to be used as a basis for discussion in the schools. SELFIE has four distinguishing characteristics underlying its design. First, the digital capacity of the schools is not reflected in one person's views or responsibility. Instead, it is a concern of the whole school community. This is reflected in the SELFIE reports, which offer a multifaceted view on the use of technologies based on the data collected from school leaders, teachers and students. Second, SELFIE provides a structure to reflect on the digital transformation of schools having a pedagogical perspective, which is derived from a DigCompOrg, a conceptual framework (Kampylis et al 2015) on the digital capacity of educational organisations. Third, SELFIE approaches digital transformation as a process of continuous development and as such it is meant to be used iteratively for evaluating, planning, implementing, re-evaluating, re-planning, etc. This allows schools not only to monitor their progress but also to focus on different aspects in each iteration addressing in this way the rapidly changing landscape and the complex nature of using digital technologies in schools. The last characteristic is the adaptability and expandability of SELFIE, which takes two forms: one is that schools can add their own questions in the tool to address their particular needs, the second is that the SELFIE items can be expanded to include topics related to the well-being in digital education or blended learning.

SELFIEforTEACHERS

SELFIEforTEACHERS (https://educators-go-digital.jrc.ec.europa.eu) is an online self-reflection tool to support teachers to reflect on and further develop their digital competence. It is an action of the European Commission Digital Education Action Plan 2021-2027. It was developed by the Joint Research Centre (JRC) in collaboration with the Directorate-General for Education, Youth, Sport and Culture (DG EAC). SELFIEforTEACHERS aims to empower teachers to actively engage in their professional learning process and to support them in their use of digital technologies in their professional context. It is a learning journey rather than an assessment tool. At the same time, it provides a tool for education systems to support teachers in their professional development. Aggregated results generated by self-reflections within a group, support the planning of professional development programmes. The tool is based on the conceptual European Framework for the Digital Competence of Educators (DigCompEdu; Redecker, 2017). Through 32 self-reflection items organised in the DigCompEdu 6 competence areas, it guides teachers to reflect on their digital competence level. It follows a progression model with six levels of proficiency (A1, A2, B1, B2, C1, C2). Upon completing their self-reflection, teachers receive a feedback report with their results and suggestions on how to level-up. Teachers are prompted to design their professional learning paths based on their identified needs.

SELFIEforTEACHERS is available online for teachers across Europe and beyond. It is currently (May 2023) available in 29 languages, including all official languages of the European Union.

1.2.3 Quality investment and monitoring of progress in digital education

The health crisis in 2019 together with increasing technological developments have led to significant investments in Education. "*The EU has been channelling more funds into education and training than ever before*" (European Commission 2022a p 17). More specifically, in their Recovery and Resilience Plans, the Member States have committed almost EUR 23 billion to investments and reforms focusing on digital education and digital skills (European Commission 2023b)

In April 2023, the European Commission adopted a proposal for a Council Recommendation on the key enabling factors for successful digital education and training (European Commission 2023a). This recommendation emphasises the need for a coherent framework of investment, governance and capacity building. Core elements of this recommendation for the Member States comprise: the development of national digital education strategies, cross sectoral collaboration including cooperation with the private sector; digital training for all teachers, and adequate investment in equipment, infrastructure and content. The support measures include, among others:

- Mobilising several funding instruments from the side of EC

- Support in developing efficient digital education policies and investments (European Commission 2023b)
- Support in monitoring the progress in digital education and training

It thus becomes apparent that efficient investment in digital education as well as monitoring of the progress will play an important role in digital education policies. Furthermore, it is acknowledged that while Member States are taking important steps in promoting digital transformation, systematic monitoring of the digital transformation progress is a challenge and many struggle with how it should be addressed. For these measures, – i.e., monitoring and efficient investment – understanding the elements and the nature of the impact of digital technologies in teaching and learning is fundamental.

The impact of digital technologies, however, is a challenging concept. Specifically, more and more voices pinpoint that there is not sufficient evidence supporting cause and effect relationships between learning outcomes and technology use (European Commission 2022a, Facer &Selwyn 2021). Instead, the study of the impact of digital technologies on learning should acknowledge that the impact of digital technologies is an "*imprecise process subject to various influences"* (Facer & Selwyn 2021). Furthermore, this impact is described as "contextual", i.e., it depends on which context is used, and "procedural", i.e. it depends on how it is used (European Commission 2022a). These observations call for a reconsideration of how the impact of digital technologies is researched. Specifically, there is a need for the creation of a systematic framework, which takes into account the multifaceted nature of the integration of technologies in schools and identifies key contextual factors (ibid).

This report can provide insights that could be used to inform not only the monitoring of digital transformation but also the design of digital education policies and investments. By unpacking the impact of digital technologies on the various aspects of school activities, this report offers a comprehensive list of intended outcomes that the research has identified. Furthermore, building on the literature, which highlights the complexity of the impact and its dependency of contextual factors and activities, the report uses the theory of change (TOC) as a basis for the creation of an assessment framework which can be used for the assessment of self-reflection tools and can be adopted to monitor the impact of other technologies.

2 Research questions

In the previous sections it was shown that research reports conflicting results with respect to the impact of digital tools on education. Furthermore, it has been pointed out that impact of ICTs on teaching and learning is a complex concept subject to influences of various contextual factors. Given the need to find ways to monitor the digital transformation in education we need to better understand:

a) RQ1: What are the salient characteristics and trends identified by research studies on the impact of digital technologies in education, and how do these findings contribute to our comprehension of technology's role in educational settings?
b) RQ 2: What role do self-reflection tools play in the process of the digital transformation of education and how can we assess their impact?

3 Literature review methodology

The review covers the main theories and research published over the past 15 years on the topic. It was based on meta-analyses and review papers, which were found in scholarly, peer-reviewed content databases. It also included reports related to the concepts studied (e.g., digitalisation, digital capacity, digital technologies, self-reflection tools) from internationally established organisations. Namely, we utilised the Scopus database to collect academic peer-reviewed papers. Scopus indexes various online journals in the education sector with an international scope. Furthermore, we used the all-inclusive Google Scholar search engine to extend our searches or to include studies found in the reference list of the peer-reviewed papers. Lastly, we explored the publications office of the European Commission (https://op.europa.eu/en/home) and of other established international organisations to retrieve information on policies, studies and reports focusing on the digital transformation in education.[1]

The search followed two broad directions: (a) digital technologies in education, and (b) self-reflection/self-evaluation tools in education. Firstly, we searched resources on the impact of digital technologies in education by performing the following search queries: "impact" OR "effects" AND "digital technologies" AND "education", "impact" OR "effects" AND "ICT" AND "education". Next, in order to investigate the impact of self-reflection tools in education, our search was narrowed down to include the following queries: "impact" OR "effects" AND "self-reflection tools" AND "education", "impact" OR "effects" AND "self-evaluation tools" AND "education", "impact" OR "effects" AND "self-assessment tools" AND "education". Given the lack of literature on the impact of self-reflection tools, for the scope of this work we extended our search to include self-evaluation and self-assessment tools. These are considered as one category of tools relevant to supporting digital transformation in schools (Costa et al., 2021).

We further refined our results by adding the terms "meta-analysis" and "review" or by adjusting the search options based on the features of each database in order to avoid collecting individual studies concerning the use of one or more digital technologies in teaching and learning. Individual studies were excluded because they only provide limited contributions to a particular domain. For this reason, we turned to meta-analyses and review studies, which consider the findings of multiple studies providing important information about the state of research in a given area (Schuele & Justice, 2006). Moreover, the effect size information that is reported in meta-analyses provides important insights about the extent of the possible impact of the use of digital technology in education (Higgins et al., 2012). We mentioned earlier that our analysis included, policy documents and reports from international bodies (e.g., the OECD, UNICEF, United Nations, European Commission) in order to obtain insights on policies and international approaches to digital transformation in education. The inclusion and exclusion criteria are presented in Table 1.

Table 1. Inclusion and exclusion criteria on the impact of digital technologies in education and the impact of self-reflection tools in education

Inclusion criteria	Exclusion criteria
• papers since 2005 • review and meta-analysis studies • formal education K-12 • peer-reviewed articles • articles in English • professional/international bodies, and governmental reports • book chapters	• PhD dissertations and theses • poster papers in conferences • conference papers without proceedings • sources about higher education

[1] https://ec.europa.eu/info/research-and-innovation/knowledge-publications-tools-and-data_en

Out of the 92 papers considered, 71 matched the above criteria. Specifically, the final results consisted of 45 review and meta-analysis papers focusing on the impact of digital technologies in education, 7 review and meta-analysis papers focusing on the impact of self-reflection/self-evaluation tools in education, and 19 reports from international and governmental organisations (see Table 2)[2].

Table 2. Number of Documents Reviewed per Research Area

Research Area	Number of Papers
Impact of **digital technology** in education	45
Impact of **self-reflection and school self-reflection tools** in education	7
Policies and reports referring to key terminology on digitalisation, digital transformation and digital capacity from professional/international and policy making organisations	19
Total	71

To ensure a reliable extraction of information from each study and assist the research synthesis we selected the study characteristics of interest (impacts) and constructed coding forms. At first, an overview of the synthesis was provided by the principal investigator who described the processes of coding, data entry and data management. All the coders worked independently based on common instructions. To ensure a common understanding of the process between coders, the sample of ten studies was tested. The results were compared, and the discrepancies were identified and resolved. Additionally, to ensure an efficient coding process, all coders participated in group meetings to discuss additions, deletions and modifications (Stock, 1994).

Due to the methodological diversity of the collected documents, the first step was to group together studies with similar research methods. Specifically, most of the meta-analysis studies consisted of one group due to the fact that the impact was measured quantitatively in the form of effect sizes that were mostly referred to students' achievement (Hattie, Rogers, & Swaminathan, 2014). The studies employing qualitative research methodology formed a second group. The next step was to create thematic categories based on the topic of impact study (student achievement learning, teaching, assessment, etc.).

The process of paper selection, analysis and synthesis was informed by a previous impact study, which was conducted by Balanskat (2009) with a similar scope. This study investigated the impact of technology in primary schools. In this context, the impact had a narrower focus on ICT use and was defined as "a significant influence or effect of ICT on the measured or perceived quality of (parts of) education" (Balanskat, 2009, p. 9). In the study presented herein, the main impacts referred to learning and learners, teaching and teachers, as well as on other key stakeholders who are directly or indirectly linked to the school unit.

[2] The list of references for the meta-analyses and review papers can be found in the Appendix.

4 Impact of digital technologies in education

In this section we aim to answer the first research question, which focuses on the salient characteristics and trends of impact assessment studies. The section is organised in four themes. The first three group studies refer to the impact of digital technologies in different school activities: learning, teaching practices and school operation. The fourth theme focuses on the contextual factors that influence the impact of digital technologies in education.

Each subsection is organised as follows: first we present the different impacts derived from the thematic analysis and organised by the target group along with the factors that affect those impacts. In each subsection, we present a summary of the findings with reference to key conclusions derived from the reviewed studies. Then, we provide a detailed presentation of the scope, the effect and the results of each study.

4.1 The impact of digital technologies on learning

This subsection aims to answer RQ1, which refers to the impact of digital technologies on education. The review analysis showed that most studies explored the impact of ICTs on learning. Most interventions referred to the subjects of literacy, mathematics and science. At first, we explore the impact of ICT on students' achievement without emphasising a specific subject matter. Then we explore how ICTs have impacted students' learning on the subjects mentioned above.

4.1.1 Impact of ICTs on students' knowledge, skills and attitudes

Box 1. Summary

Studies conducted from 2005 to 2021 have documented various results on the impact of digital technologies on students' knowledge, skills and attitudes. Most quantitative studies reported positive effects between the use of ICT and students' achievement. However, the documented effect sizes on students' improvements were mainly small or moderate, and only a few studies reported moderate to large or large effect sizes. For this reason, several authors suggested that the impact is related to several other factors and not on technology per se. Two key outcomes emerged from this analysis. First, the impact refers to different concepts and is measured with different tools. Specifically, it might be related to students' performance, learning gains, attainment or achievement in different subjects. Some studies reported impacts based on national tests, while others reported pre- and post-tests or comparative tests measurements. Qualitative studies refer to impacts based on several resources, such as teachers' opinions or self-reports. Second, the impact of ICTs on students' knowledge, skills and attitudes depends on how ICTs are used for teaching and learning and to the context of their use (e.g., teachers' professional development, teachers' and students' digital skills, school culture). It is worth noting that while the impact of ICTs on student achievement has been thoroughly investigated by researchers, other aspects related to school life that are also affected by ICTs, such as equality, inclusion, and social integration, received less attention

Student achievement

The impact of ICT use in education has been reported early in the literature. A meta-analysis and large-scale mixed-method research on the impact of ICT on students' learning outcomes was conducted by Eng (2005) based on studies published as early as 1960 until the 2000s, mostly in the USA, the UK and Australia. Eng (2005) found **a small positive effect regarding the effectiveness of ICT on students' learning.** The results showed that the access to computers for each student can enhance learning when used in Computer-Assisted Instruction (CAI) programmes in simulation or tutorial modes, which are used to supplement rather than substitute instruction.

Liao et al. (2007) conducted a meta-analysis comparing the effects of computer application (computer-assisted instruction, computer simulations, and web-based learning) to traditional instruction on primary students' achievement in Taiwan. The results of this meta-analysis, drawing on quantitative data from 48 studies, indicated that **computer application instruction has moderate positive effects on elementary students' achievement** over traditional instruction in Taiwan, with the overall grand mean of the study having an effect size of 0.449. Similarly, in the second-order meta-analysis, which brought together more than 40 years of investigations (1985-2007) by synthesizing 25 previous meta-analyses, Tamim et al. (2011), reported effect sizes of **low to moderate in magnitude (the mean effect size ranged between 0.30 and 0.35) in favour of computer technology** in formal face-to-face classrooms as compared to classrooms that do not use technology.

Higgins et al. (2012) presented a synthesis of the evidence from meta-analysis about the impact of the use of digital technology in schools on children's attainment and academic achievement. The work included 48 studies that synthesised primary research studies on the impact of digital technology in schools on the academic achievement of school-age learners (5-18 years old). The authors reported that the research evidence over the last 40 years on the impact of digital technologies on learning consistently identifies positive benefits. First, studies tend to show consistent but **small positive associations between the use of technology and learning outcomes**. Also, research findings from experimental and quasi-experimental designs show that **technology-based interventions tend to produce just slightly lower levels of improvement when compared with other researched interventions and approaches** (e.g., peer tutoring, feedback provision). Furthermore, the authors reported that the overall effect size in the general analysis of the impact of ICT on learning is small and slightly below the overall average for research interventions in education (ES = 0.3 to 0.4, respectively). However, the range of the effect sizes reported in studies is very wide (ES = -0.03 to 1.05), suggesting that **the types of technologies used and how they are used may also affect students' learning.**

Learning aspects and technology use

Jewitt et al. (2011) adopting a qualitative approach, conducted a literature review and case study analysis in 12 primary and secondary schools, which involved in-depth interviews and focus groups with key stakeholders (e.g., managers and administrators, teachers, students, parents) to examine the different benefits of using Learning Platforms (LPs) (virtual learning environments, management information systems, communication technologies and information and resource sharing technologies) in education. They found that LPs provided more opportunities to primary and secondary students to access a **variety and quality learning resources**, **independent and personalised learning, increased opportunities for collaborative learning and interaction, and created opportunities for self and peer review, teacher assessment and feedback**. Similar findings were reported in a review by Fu (2013), who documented a list of benefits and opportunities that ICTs provide to students. Specifically, the authors noted that the use of ICT in education helps students to **access digital information and course content** effectively and efficiently, supports **student-centred** and **self-directed learning** and the development of a **creative learning environment** where more opportunities for **critical thinking skills** are offered and promotes **collaborative learning** in a distance-learning environment. Also, Harrison (2002) reported that the impact on **curriculum learning** was higher when the use of ICT was integrated in both classroom and home activities. Last but not least, Balanskat, Blamire and Kefala (2006) documented studies that reported additional positive gains for students on the use of ICT in schools, namely, **increased attention, engagement, motivation, communication and process skills, teamwork, and positive behaviour towards learning.** Based on qualitative studies, they also found evidence that teachers, students and parents recognised the positive impact of ICT on students' learning regardless of their competence level (strong/weak students).

Impact of digital technologies on learning outcomes in different age groups

Additionally, Chauhan (2017) conducted a meta-analysis integrating the quantitative findings of 122 works that measured the impact of technology on the learning effectiveness of elementary school students. The overall mean effect size was found to be 0.546 with a 95% confidence interval of 0.627-0.466, suggesting a **medium effect on learning effectiveness** of elementary school students. The author further investigated the variables that seem to affect the effectiveness of ICT on students' learning and found that the domain subject, the application type (e.g., e-learning oriented and general applications), the duration, and the learning environment (e.g., laboratory, classroom) shape the impact of technology on learning. These findings pinpoint the importance of teachers' **instructional practice and the learning context** in shaping the use of technologies and consequently their impact.

A review by Balanskat at al. (2006) documented that ICT use in the form of multimedia and interactive content in primary schools in the UK was found to positively impact performance in English. ICT use positively impacted English, science, and design and technology performance, between the ages of 7 to 16. Additionally, the authors reported that the use of interactive whiteboards improved students' performance in literacy, mathematics and science tests as well as the performance of low-achieving pupils in English.

Furthermore, Schmid et al. (2014) conducted a meta-analysis of experimental studies held from 1990 to 2010, which investigated the use of technology in post-secondary education. These findings suggested that **using technology has greater effects than not using technology or using technology partially (i.e., to varying degrees)**. The findings also suggested that learning is best supported when the student is engaged in active, meaningful exercises via **technological tools that provide cognitive support**.

Tablets, smart devices, one laptop per child, Augmented Reality and learning

The rise of mobile technologies and hardware devices has brought new investigations into their impact on teaching and learning. In their literature review, Friedel et al. (2013) examined the use of handheld digital devices to facilitate synchronous collaborative learning and deliver instructional content in schools. Their findings were drawn from empirical single studies, including qualitative, quantitative, mixed methods, and meta-analysis papers. Based on their investigations, the use of mobile devices by students enabled teachers to successfully **deliver content (e.g., mobile serious games), lessons and scaffolding**. The authors concluded that smartphones could be used by teachers to deliver content both in and out of classroom activities and to **facilitate synchronous collaborative learning**. The effects of **integrating mobile devices in teaching and learning** on students' performance were also investigated by Sung et al. (2016). Through their meta-analysis, which included 110 experimental and quasi-experimental studies for the period of 1993-2013, the authors documented that the overall effect of using mobile devices in education is better than when using desktop computers or not using mobile devices as an intervention, with a moderate mean effect size of 0.523.

Via a meta-analysis of 27 quantitative studies investigating the use of **tablets and other smart devices** (tablets vs. no tablets) on student achievement outcomes, Tamim et al. (2015) found a significant average effect size for studies comparing tablet use contexts with no tablet use contexts (g+ = 0.23, k = 28). For studies comparing two different **uses of tablets by students**, the average effect size (g+ = 0.68, k = 12) showed a significant **favouring of more student-centred pedagogical use** of technology. The authors went on with a qualitative literature review to deepen their understanding of aspects related to tablet integration. Per their findings, they reported that tablets offered additional advantages to **students; namely, they improved their note-taking and organisational skills, creativity and communication skills.**

Zheng et al. (2016) conducted a meta-analysis and a literature review to examine the impact of one-to-one laptop programmes on teaching and learning in K-12 schools from 2001 to 2015. The meta-analysis included ten studies and showed that the impact of **one-to-one laptop programs on academic achievement was generally positive across subject areas**, with an overall effect size of $\bar{d}$ = 0.16 (95% CI = [0.090, 0.231]). In order to further explore the effects of technology use, the authors reviewed an additional 86 studies and reported that **the use of one-to-one laptop programs significantly increased academic achievement in various subjects. The reported benefits include student-centred, individualised, and project-based learning, enhanced learners' engagement and enthusiasm and improved teacher-student and home-school relationships.**

Haßler, Major and Hennessy (2016) conducted a systematic review to examine the impact of **using tablets across the curriculum** on the learning outcomes of primary and secondary school children. They found that **16 out of the 23 interventions reported positive learning outcomes where tablets supported learning activities**. Five studies reported no differences, and two interventions reported a negative effect on students' learning outcomes with the use of tablets. However, the authors concluded that tablets should not be dismissed but rather educators, school leaders, and school officials should be encouraged to further investigate the potential of such devices in teaching and learning.

The effects of more advanced technologies on teaching and learning were also recently investigated. Specifically, two meta-analyses investigated the impact of **augmented reality** (AR) on students' learning gains (Garzón & Acevedo, 2019 and Garzón et al., 2020). First Garzón and Acevedo (2019) examined 64 research papers published between 2010 and 2018 and found that AR has a medium effect on students' learning gains, which implies that AR has a positive impact on education (the d value found in this meta-analysis was d = 0.68). The authors further compared AR applications, as a pedagogical resource, with other types of pedagogical resources including multimedia resources, traditional lectures, and traditional pedagogical tools. The results of this comparison indicated that the **learning gains are higher when the intervention involves AR resources.**

Similar findings were reported by Garzón et al. (2020). The main purpose of this meta-analysis was to identify how the pedagogical approaches affect the impact of AR on education. Based on the analysis of 46 quantitative empirical studies, the authors concluded that **AR has a medium impact on students' learning gains**. The overall Cohen's d effect size was found to be d = 0.72, which indicates that AR has a medium effect on student's learning gains.

Gamification – educational games

Recently, approaches that refer to the impact of gamification with the use of digital technologies on teaching and learning were also explored. Huang et al. (2020) provided findings from a meta-analysis that integrated the empirical, quantitative research on gamification in formal educational settings on student learning outcomes. The meta-analysis included 30 studies and showed that **gamification had a small to medium effect on student learning outcomes** in formal educational settings (effect size of g = 0.464 is a small to medium effect according to Cohen's (1992) criteria). Talan, Doğan and Batdı (2020) conducted a meta-analysis that included 154 empirical studies to examine the use of digital and non-digital games in education. Their findings suggested that **educational games have a positive effect on academic achievement and this effect is at a medium level** (g 1/4 0.695). The highest effect sizes were observed in foreign language courses (g = 0.87), small/less than 50 class sizes (g = 0.87) and in non-digital games (g = 0.90). Delgado et al. (2015) conducted a literature review about technology use in education from 1986 to 2014. Their review presented several studies that reported **small and moderate effect sizes in mathematics and reading gains, and studies that showed no positive associations in learning outcomes**. However, the authors documented several inherent methodological issues that might dampen the amount of variance in the effectiveness of technology in education shown by the studies.

4.1.2 Literacy, mathematics and science

Box 2. Summary

The literature revealed various results concerning the effects of digital technologies on literacy. Most of the studies reported small positive effects in language learning, some studies reported moderate to large effects, while one study documented negative effects. Some studies reported greater impact of technology use on writing than on reading and spelling while others documented higher effect sizes on reading and comprehension. It is worth mentioning that students' literacy learning gains were found to be influenced by how technology is used in the classroom. For example, the amount and quality of digital use, the instructional strategy and design of the material, and the familiarisation with digital media practices played a significant role in language learning outcomes.

The use of digital technologies in mathematics classrooms, such as computers, mobile devices, serious games, and multimedia, was beneficial for students' achievement, including students with mathematics difficulties. Additionally, the use of ICTs in the classroom seemed to positively affect students' confidence, interest, motivation and engagement with the subject matter. Furthermore, the instructional methodology and teacher's training in ICT use were factors that positively contributed to successful learning outcomes.

The results from the studies showed moderate positive effects of ICTs on science learning. ICTs provided more opportunities and time to students for post-experiment analysis and made science learning more interesting. The way digital technologies were used to support science learning affected their impact on students' learning outcomes.

The literature review analysis revealed a greater investment in ICT interventions to support learning and teaching in the core subjects of literacy, mathematics and science. It is important to stress that studies referring to science education do not include STEM because it is not a subject but rather an approach to the curriculum where the specific subjects are taught through multidisciplinary projects. Furthermore, the STEM approach may not have been necessarily applied by all schools. Literacy, mathematics and science were the most common subjects studied in the reviewed papers, often drawing on national testing results, while studies investigating other subject areas, such as social studies, were limited (Condie & Munro, 2007; Chauhan, 2017). That said, research still misses impact studies that focus on the effects of ICTs on a range of curriculum subjects. For this reason, this review focuses on the impact of digital technologies on those particular subjects.

<u>Literacy</u>

Several studies examined the impact of digital technologies on students' literacy. For instance, Grgurović, Chapelle and Shelley (2013) conducted a meta-analysis based on 37 studies from 1970 to 2006 to investigate whether pedagogy supported by computer technology can effectively promote second/foreign language development compared to pedagogy without technology support. Overall results **favoured the technology-supported pedagogy**, with a small, but positive and statistically significant effect size. **Second/foreign language instruction supported by computer technology was found to be at least as effective as instruction without technology**, and in studies using rigorous research designs the Computer Assisted Language Learning (CALL) groups outperformed the non-CALL groups. Similarly, in their review, Friedel et al. (2013) found that **mobile devices can facilitate English-language vocabulary acquisition in K-12 classes**.

Lee et al.'s (2020) meta-analysis examined the effectiveness of technology-integrated literacy instruction in the classroom context for English-language learners (ELLs) in Grades K-12. Based on 36 studies, the authors found that technology-integrated instruction produced a positive, **medium effect size** (ES g = 0.47 with a 95% confidence interval of 0.30 to 0.66.) **on literacy outcome as compared to traditional methods where no technology was involved**. It is worth noting that **the effects on writing outcomes were greater than on vocabulary and reading.**

Archer et al. (2014) conducted a tertiary meta-analytic review to re-assess outcomes presented in three previous meta-analyses. In total, there were 38 studies on computer-based information and communication technologies from the three previous meta-analyses. The current meta-analyses documented that **the overall effect size for literacy-based ICT interventions was positive but small**. Cheung and Slavin (2012) conducted a meta-analysis that included 84 studies to investigate the **effect of technology use** on K-12 students' reading achievement. The finding showed that **educational technology applications generally produced a positive, though small, effect** (mean Effect Size = +0.16) in comparison to traditional methods. However, the authors documented different impacts depending on the types of instructional programs. For instance, supplementary Computer Assisted Instruction **(CAI)** did not meaningfully affect students' reading (average ES = +0.11). On the contrary, **innovative technology applications and integrated literacy interventions with the support of professional development were more promising**. The authors concluded that technology use per se does not necessarily result in better outcomes. Higgins et al. (2012) emphasised that **digital technology had a greater impact on writing than on reading and spelling**, while Liao et al. (2007) reported **high effect sizes (ES = 0.7) on reading and language arts for CAI interventions**.

The impact of digital game-based learning on **English as a foreign language was** investigated in a meta-analysis by Kao (2014). Based on 25 studies, the author documented a positive effect size (d = 0.695, $p < .05$ under the fixed-effect model; d = 0.777, $p < .05$ under the random-effects model), suggesting **DGBL to be more effective than traditional instruction** such as grammar translation methods or audio-lingual methods in EFL contexts. In a more recent meta-analysis study, Chen, Tseng and Hsiao (2018) investigated the **effect of digital game-based learning on vocabulary learning**. The results of the random effects model indicated a large overall effect size (d = 5 1.027) with the confidence interval [0.509, 1.546] which **favoured the DGBL intervention** (the treatment group) rather than the conventional approach. The findings suggested a variation of the effects of digital game-based learning on vocabulary learning **which could be attributed to the game design**.

Delgado et al. (2018) conducted a meta-analysis to compare the reading outcomes of comparable texts on paper and digital devices in 54 research studies conducted between 2000 and 2017. The analysis yielded an **advantage of paper over digital reading** (Hedge's g = −0.21; dc = −0.21). That is, **the reading outcomes from digital-based devices were lower compared to respective outcomes from paper-based reading.** The authors concluded that students need to be trained on how to effectively adopt digital media practices, which presuppose the development of digital and cognitive skills.

Mathematics and Science

A large body of research has examined the impact of ICT on students' learning outcomes in mathematics in primary and secondary education. Fewer studies examine impacts on science along with mathematics. In a study commissioned by the British Educational Communications and Technology Agency (BECTA) to analyse the impact of information and communications technology (ICT) on the school sector across the United Kingdom, Condie and Munro (2007) found that ICT use was **beneficial in developing number skills, problem-solving skills, and pattern exploration. The authors also reported increased interest and motivation in mathematics** when students engaged in technology-enhanced mathematics lessons. A review by Higgins et al. (2012) of evidence from previous meta-analyses on the impact of digital technology use in schools on children's attainment, showed that the **impact of technology use on attainment was greater for mathematics than other school subjects**. Similarly, Huang et al. (2014)'s meta-analysis on gamification in formal educational settings on student learning outcomes, showed that **ICT can increase students' confidence in mathematics and their engagement** in technology integrated learning approaches.

Li and Ma (2010) conducted a meta-analysis that included 46 studies in order to investigate the impact of computer technology (software) on mathematics education in K-12 classrooms. Based on 46 primary studies, the authors found a **positive moderate effect (mean ES = +0.71) of computer technology on mathematics achievement**. According to the authors, **the positive effects of computer technology on mathematics achievement were greater when the computer technology was combined with a constructivist approach to teaching**. Li and Ma (2010) also reported that even though the impact of computer technology on mathematics achievement was small, **larger effects were reported on mathematics achievement for special needs students than general education students**. Seo and Bryant (2009) conducted a review of 11 mathematics CAI studies and examined their effectiveness for enhancing the mathematics performance of students with learning difficulties. The results showed that **there was no conclusive evidence to support that CAI in mathematics increased the performance of students with learning difficulties**. However, the authors reported methodological issues across the CAI studies, which prevented a clear analysis of the effectiveness of CAI. Another meta-analysis by Benavides-Varela et al. (2020) examined the effectiveness of digital-based interventions for students with mathematical learning difficulties. The meta-analysis based on 15 studies indicated that **digital-based interventions generally improved students' performance in mathematics for students with mathematics difficulties** (mean ES = 0.55), though there was a significant heterogeneity across studies. Ran et al. (2021) examined 31 empirical studies regarding the effects of computer technology (CT) on mathematics achievement in K-12 classrooms. They found a **statistically significant positive effect (d = 0.56) of digital technology on low-performing students' mathematics achievement.**

Hardman (2019) conducted a review that included 37 studies to investigate the use of ICTs in teaching and learning mathematics at the elementary school level for the decade 2008-2018. The results showed that the use of digital technologies in mathematics had positive and negative impacts on students' achievement. Based on the findings, the author suggested that the impact of ICT on students' achievement **depends on the pedagogical methods** used by teachers to integrate technology. Hillmayr et al. (2020) reviewed 92 studies from 2000 to 2017 to investigate the effects of digital technology (computer, tablet, smartboard, mobile phone, notebook or CAS computer) on secondary school students (grade levels 5-13) in science or mathematics classes. The overall effect showed that the use of **digital tools had a medium positive and statistically significant effect on student mathematics learning** (g = 0.65, 95% CI [0.54, 0.75]). Hence, secondary school **students who learned with the use of digital tools in science or mathematics classes had significantly greater learning outcomes** than students who were taught without the use of digital tools. The meta-analysis by Zheng et al. (2016) showed that **one-to-one laptop programs in science classrooms had a positive effect (d = 0.25 (95% CI = [0.024, 0.474]) on students' achievement.**

Verschaffel, Depaepe and Mevarech (2019) conducted a systematic review that included 22 studies to explore ICT-based learning environments and metacognitive pedagogies in mathematics learning from preschool until the end of secondary education. The results revealed that **all the reviewed studies reported positive effects on mathematical and metacognitive learning outcomes**. Most interventions involved **serious games, computer-supported collaborative and multimedia learning environments, intelligent tutoring systems, and drill-and-practice software** mainly for **algebraic or arithmetic problem-solving** and other mathematical topics.

Other curriculum areas

Most of the studies in the literature investigated the impact of ICT on achievement in literacy, mathematics and science. Though, some studies documented **positive impacts of digital technologies in achievement on other subjects, such as geography, history and arts** (Condie & Munro, 2007), **design and technology** (Balanskat et al., 2006) and **music and arts** (Chauhan, 2017).

4.1.3 Digital competences of students

Box 3. Summary

The use of digital tools in the classroom presupposes that students know how to use them to fully exploit the benefits of instruction. However, there is evidence that the frequent use of ICT in the classroom positively affects the development of students' digital skills.

The frequent use of digital technologies for learning purposes can support students to develop their digital skills. For example, Zheng et al. (2016) found that students in one-to-one laptop programs tended to use technology more frequently than in non-laptop classrooms, and as a result, they developed a range of skills (e.g., information, media and technology skills as well as organisational skills). Similarly, Higgins et al. (2012) suggested that skills training in the use of digital technologies is essential for learners to fully exploit the benefits of instruction.

4.1.4 Equality, Inclusion and social integration

Box 4. Summary

The impact of ICTs on student achievement has been thoroughly investigated by researchers. However, other aspects of school life that are also affected by ICTs, such as equality, inclusion and social integration, have received less attention. Specifically, a small number of studies analysed in this review showed positive effects from ICT integration in the areas mentioned above.

Although most of the reviewed studies focused on the impact of ICTs on learning performance, some reports also looked at other aspects that may be impacted in the school context, such as equality, inclusion and social integration. Underwood's (2009) review showed that the use of digital technologies could enhance social interaction and improve the academic performance of children with learning difficulties. Istenic and Bagon (2014) conducted a systematic review that included 118 papers published between 1970 and 2011 to examine ICT-assisted learning for people with disabilities and/or special needs. The authors found that the role of ICT in inclusion and the design of pedagogical and technological interventions was not sufficiently explored; however, some benefits of ICT were found in students' social integration.

Zheng et al. (2016) reported a statistically significant positive interaction between one-to-one laptop programmes and gender. Specifically, the results showed that both girls and boys benefitted from the laptop program, but the effect size for girls' achievement (0.04) was very small compared to the effect size for boys' achievement (0.55). Results from a systematic review by Cussó-Calabuig, Farran and Bosch-Capblanch (2018) suggested no evidence that intensive use of computers can reduce gender differences in computer anxiety, self-efficacy and self-confidence.

4.2 Impact of ICTs on teaching practices and digital competences

4.2.1 Teaching practices

Box 5. Summary

Several studies showed that the use of ICTs had positive benefits on teachers' professional and teaching practices. Specifically, the use of ICTs by teachers resulted in designing, delivering and assessing students' learning more efficiently. Additionally, it allowed teachers to enhance their professional practices by setting clearer targets and by improving their reporting to parents.

There is evidence from various research studies on the impact of ICT on teachers' instructional practices and student assessment. Friedel et al. (2013) found that the use of mobile devices by students enabled teachers to successfully deliver content (e.g., mobile serious games), lessons and scaffolding, and facilitated synchronous collaborative learning. Furthermore, ICT can increase efficiency in lesson planning and preparation by offering possibilities for a more collaborative approach between teachers. Additionally, the sharing of curriculum plans and the analysis of students' data led to clearer target setting and improvements in reporting to parents (Balanskat et al., 2006).

Moreover, the use of ICTs for online assessment benefits instruction. In particular, online assessment supports the digitalisation of students' work and related logistics, allows teachers to gather immediate feedback and readjust to new objectives, and supports the improvement of the technical quality of tests by providing more accurate results. Additionally, the capabilities of ICTs (e.g., interactive media, simulations) create possibilities for new methods of testing specific skills, such as problem-solving and problem-processing skills, meta-cognitive skills, creativity and communication skills, and the ability to work productively in groups (Punie, Zinnbauer, & Cabrera, 2006).

4.2.2 Teachers' digital competences

Box 6. Summary

Teachers' use of digital technologies had positive effects on the development of their digital skills. The greatest impact was found on teachers who had recently participated in professional development courses. The confident use of digital technologies by teachers is positively associated with students' use of digital technologies.

The use and application of digital technologies in teaching and learning can enhance teachers' digital competence. Balanskat et al. (2006) documented various studies that revealed that the use of digital technologies in education had positive effects on teachers' basic ICT skills. The greatest impact was found on teachers with enough experience in integrating ICTs in their teaching and/or who had recently participated in development courses for the pedagogical use of such technologies in teaching. Punie et al. (2006) reported that the provision of fully equipped multimedia portable computers and the development of online teacher communities had positive impacts on teachers' confidence and competence in the use of ICTs. Additionally, Delgado et al. (2015) reported studies that showed a strong positive association between teachers' computer skills and students' use of computers.

4.3 The impact of ICT on school operation

Box 7. Summary

The impact of ICT integration in schools goes beyond teaching and learning to include other aspects of the school environment closely related to organisational and communication practices. Specifically, the use of ICTs was found to positively impact school administration, such as attendance monitoring and assessment records. Additionally, it enabled smooth communications with external authorities and parents.

There is evidence that the effective use of ICTs and the data transmission offered by broadband connections helped **improve administration** (Balanskat et al., 2006). Specifically, ICTs provide better school management systems that enable data gathering procedures. Condie and Munro (2007) listed school improvements with the use of ICTs in the following areas: **attendance monitoring, assessment records, reporting to parents, financial management, and creation of repositories for learning resources and sharing of information amongst staff. Such data can be used strategically for self-evaluation and monitoring purposes which in turn can contribute in planning school improvements.** Additionally, ICTs provided more efficient and successful examination management procedures, namely **less time-consuming reporting processes** compared to paper-based examinations and **smooth communications between schools and examinations authorities** through electronic data exchange (Punie et al., 2006).

Zheng et al. (2016) reported that the use of ICTs improved home-school relationships. Specifically, Escueta et al. (2017) reported **several ICT programmes that improved the flow of information from the school to parents**. The authors documented that the use of ICTs (Learning Management Systems, email, dedicated websites, mobile phones) provided **opportunities for personalised and customised information exchange between schools and parents**, such as attendance records, upcoming class assignments, school events, students' grades, which can impact students' learning outcomes and attainment. Specifically, information exchange between schools and families prompted parents to encourage their children to put effort into school.

The above findings suggest that the impact of ICT integration in schools extends beyond students' performance. Specifically, it touches on several school-related aspects, such as equality and social integration and it affects different stakeholders. Table 3 summarises the different impacts of digital technologies on school stakeholders based on the literature review.

Table 3. The Impact of Digital Technologies on Schools' Stakeholders

School stakeholders	Impacts
Students	**Subject Matter Knowledge** — *Literacy*: Vocabulary acquisition, writing, spelling reading — Mathematics: Problem solving, pattern exploration, interest and motivation, students with difficulties in learning mathematics, students with special needs, number skills, metacognitive learning outcomes — Geography — History — Arts — Sciences **Skills:** Creativity, collaboration, communication skills, organisation skills, note taking, meta-cognitive skills, ICT-technical skills Attitudes: Attitude towards learning **Inclusion:** Gender, students with special needs, students with learning difficulties in specific subject matters (language, mathematics, etc.), social interaction
Technology use for teaching and learning	**Software** Subject-matter-related technologies (e.g., ed-tech for mathematics, sciences, etc.)| Mobile devices| Serious and educational games| Augmented reality| Virtual reality| Drill and practice| Intelligent tutoring systems| Systems for Computer Assisted Instruction (CAI)| Collaborative learning environments (synchronous – asynchronous)| Multimedia learning environments **Hardware** One laptop per child| Computers| Tablets| Smartboards| Mobile phones| Notebook
Teachers	**Resources – preparation and professional development** Lesson planning| Content delivery| Sharing and creation of resources| Collaboration between teachers| Online teacher communities| Professional development| Parent reporting| **Use of ICT in the classroom** New methods for assessing skills (e.g., problem solving, problem processing, metacognitive skills, creativity, communication, ability to work in groups)| Scaffolding| Data analytics for student support| Feedback and assessment | **Skills – beliefs** Teacher basic ICT skills| Teachers' confidence| Teacher beliefs
Teaching practices – pedagogical approaches	Project-based learning| Game-based learning| Collaborative learning| Personalised learning| Teaching for students with learning difficulties| Blended and online learning
School leaders	Administration| attendance monitoring| assessment records| reporting to parents| financial management| repositories for learning resources| sharing

	information| communication between schools, parents, and examining authorities|
Parents- Carers	Flow of information from schools to parents| Personalised communication between schools and parents: e.g., attendance records, upcoming class assignments, school events, students' grades

As mentioned, the table above provides a summary of the topics addressed in the literature review in relation to the impact of digital technologies in schools. While the topics recorded in the table are not exhaustive, they demonstrate two key aspects that are critical in the study of impact:

a) The documentation of learning outcomes in relation of the use of technology follows a fragmented approach. The studies focus on a subject matter, and often specific aspects of this subject matter (e.g., patterns in math), which are linked to specific software/hardware and a specific teaching approach. Consequently, different software and a different teaching approach in the same subject might have had different results – should all else remain the same and putting aside the dynamic character of teaching and learning.

b) The topics addressed above not only demonstrate the numerous aspects of school practice affected by technology use, but all of them are interwoven and contribute to learning achievements along with a number of other socioeconomic factors and factors related to the school profile.

Both of these observations point to the procedural nature of technologies (European Commission 2022a), i.e., their effectiveness depends on the context and the way in which they are used/implemented, and as such their impact on learning outcomes is only indirect and depends on various factors.

4.4 Factors affecting the impact of digital technologies on school's digital capacity

Box 8. Summary

The review provided useful insights regarding the various factors that affect the impact of digital technologies on education. These factors are interconnected and play a vital role in the digital transformation process. Specifically, these factors include: (a) digital competencies, (b) teachers' personal characteristics and professional development, (c) school leadership and management, (d) connectivity, infrastructure, and government and other support, (e) administration and data management practices, (f) students' socioeconomic background and family support, and (g) socioeconomic school context. It is worth noting that we observed factors that affect the integration of ICTs in education and may also be affected by it. For example, the frequent use of ICTs and the use of laptops by students for instructional purposes positively affects the development of digital competencies and at the same time, digital competencies affect the use of ICTs in schools

This section aims to answer RQ2, which refers to the factors that might affect a school's digital capacity and digital transformation.

Several authors suggested that the impact of technologies in education depends on several factors and not on technology per se. For example, Liao et al. (2007) suggested that future studies should carefully investigate which factors contribute to positive outcomes by clarifying the exact relationship between computer applications and learning. Additionally, Haßler, Major and Hennessy (2016) suggested that the neutral findings regarding the impact of tablets on students learning outcomes should encourage educators, school leaders and school officials to investigate further the potential of such devices in teaching and learning. Several other researchers argued that various variables play a significant role in the impact of ICTs on students' learning which could be attributed to the context, teaching practices and professional development, curriculum, and learners' characteristics (Underwood, 2009; Tamim, 2011; Higgins et al., 2012; Archer & Savage, 2014; Sung et al., 2016; Haßler, Major, & Hennessy, 2016; Chauhan, 2017; Lee et al., 2020).

4.4.1 Digital competences

One of the most common challenges reported in studies that utilised digital tools in the classroom was the lack of students' skills on how to use them. Fu (2013) found that students' **lack of technical skills is a barrier to the effective use of ICT** in the classroom. Tamim et al. (2015) reported that **students faced challenges when using tablets and smart mobile devices, which were associated with technical issues or the expertise needed for their use and the distracting nature of the devices**, and highlighted the need for teachers' professional development. Higgins et al. (2012) reported that skills training in the use of **digital technologies is essential for learners to fully exploit the benefits of instruction**. The International Computer and Information Literacy Study (ICILS) also documented the need for digital competencies development since in most of the participating countries, **most of the eighth-grade students have not sufficiently developed their digital competence** as their score level was 2, which refers to the basic use of computers as information resources (Fraillon et al., 2020).

On another note, Delgado et al. (2015) reported studies that showed a strong positive association between teachers' computer skills and students' use of computers. In this sense, teachers' lack of ICT skills and familiarisation with technologies could become a barrier towards effective technology use in the classroom (Balanskat et al., 2006; Delgado et al., 2015). It is worth noting that the way teachers are introduced to ICTs affects the impact of digital technologies on education. Previous studies have shown that **teachers may avoid using digital technologies due to limited digital skills** (Balanskat, 2006), **or they prefer applying "safe" technologies,** namely technologies that their own teachers have used and with which they are familiar (Condie & Munro, 2007). In this regard**, the provision of digital skills training and the exposure to new digital tools might encourage teachers to apply various technologies in their lessons** (Condie & Munro, 2007). Apart from digital competence, technical support in the school setting has also been shown to affect teachers' use of technology in their classrooms (Delgado et al., 2015). The provision of support can reduce time and cognitive constraints, which could cause limited ICT integration by teachers in school lessons (Escueta et al., 2017).

4.4.2 School leadership and management

Management and leadership are important cornerstones in the digital transformation process (Pihir, Tomičić-Pupek, & Furjan, 2018). Zheng et al. (2016) documented leadership as being among the factors that positively affected the successful implementation of technology integration in schools. Strong leadership, strategic planning and systematic integration of digital technologies are prerequisites for the digital transformation of education systems (Ređep, 2021). Management and leadership play a significant role in formulating policies that are translated into practice and ensure that developments in ICT become embedded into the life of the school and the experiences of staff and pupils (Condie & Munro, 2007). Chirichello (1999) highlighted the importance of the *transformational leadership model*, which is defined as the "influencing relationship between inspired, energetic leaders and followers who have a mutual commitment to a mission that includes a belief in empowering the members of an organisation to effect lasting change" (p. 1). Based on mixed-method research about principals' preferred leadership styles and teachers' perceptions of organisational climates, the author concluded that a transformational leader can bring change and support new models of school governance. Stewart (2006) noted that a transformational leader is one who inspires, creates an excellent climate and sets high expectations. A transformational leader can promote various collegial activities for the teaching staff involving various aspects, such as reflective study, professional development and the integration of digital technologies in their lessons. According to Phillip (2021), transformational leadership could lead to positive outcomes for stakeholders (such as satisfaction and performance) and "improve macro-level outcomes like organisational performance and innovation climate" (p. 116). The transformational management model could help in the digital transformation of the school through a general transformation of the school's climate and the behaviour of stakeholders. Another school management model that could help the schools' digital transformation strategy is the *effective school management model*. According to Elmore (2002), an effective school is characterised by a strong and professional leadership that focuses on learning and teaching, shared goals and vision with high expectations, the creation of learning communities and a secure learning environment.

Leadership and policy support entail the provision of an overall vision for the use of digital technologies in education, guidance for students and parents, logistical support, and teacher training (Conrads, 2014). Unless there is a commitment throughout the school with accountability for progress at key points, it is unlikely for ICT integration to be sustained or become part of the culture (Condie & Munro, 2007). For this purpose, the principals need to adopt and promote a whole-institution strategy and build a strong mutual support system that enables the school's technological maturity (Eurydice, 2019). In this context, the school culture plays an essential role in shaping the mindsets and beliefs of all school actors towards successful technology integration. Condie and Munro (2007) emphasised the importance of the principal's enthusiasm and work as a source of inspiration for the school staff and students to cultivate a culture of innovation and establish sustainable digital change.

Digital technology integration in education systems could be challenging and leadership needs guidance to achieve it. Guidance can be introduced by adopting new methods and techniques in strategic planning for the integration of digital technologies (Ređep, 2021). Even though the role of leaders is vital, their training is not as frequent as it should have been. Specifically, only one-third of the education systems in Europe have put in place national strategies that explicitly refer to the training of school principals (Eurydice, 2019).

4.4.3 Connectivity, infrastructure and support

The effective integration of digital technologies at all levels of education presupposes the selection of proper resources, the development of infrastructure, and the provision of digital content (Voogt et al., 2013). Higgins et al. (2012) argued that positive associations between the use of digital education and students' learning outcomes may be attributed to the fact that **high performing schools might be better technologically equipped, or more prepared to invest in technology, or more motivated for improvement**. There is evidence that high-quality broadband connection in the school increases the quality and quantity of educational activities that can be undertaken and the collaboration between teachers. Also, ICT increases and formalises cooperative planning between teachers and cooperation with managers, which in turn has a positive impact on teaching practices (Balanskat et al., 2006). The International Computer and Information Literacy Study (ICILS) showed that teachers who were working in schools where ICT use was supported through a planned and collaborative approach were more likely to use ICT in their teaching and emphasise the development of student's computer and information literacy (European Commission, 2014, p.6).

Additionally, ICT resources, including software and hardware, increase the opportunity for teachers to integrate technology into the curriculum to enhance their teaching practices (Delgado et al., 2015). For example, interactive whiteboards allowed teachers to make a difference to aspects of classroom interaction (Balanskat et al., 2006). Additionally, Zheng et al. (2016) found that the use of one-on-one laptop programmes resulted in positive changes in teaching and learning, which would not be accomplished if no infrastructure and technical support were provided to teachers. Although investing in digital infrastructure does not guarantee any progress in digital education or the development of digital competences, it is a prerequisite for the use of digital technologies in education. For example, allowing students to use their own devices in school settings affects how education authorities plan their investments in school IT infrastructure (Eurydice, 2019).

Delgado et al. (2015) reported that limited access to technology (insufficient computers, peripherals and software) and lack of technical support are significant barriers to ICT integration. Access to infrastructure refers to both the availability of technology in a school and the provision of the proper amount and right types of technology in locations where teachers and students can use them. Along with the provision of infrastructure, effective technical support is also a central element of the whole-school strategy for ICT (Underwood, 2009). The rapid and constant evolution of digital technologies and their uses requires up-to-date infrastructure (Eurydice, 2019). Poor quality and inadequate maintenance of hardware, as well as unsuitable educational software, may discourage teachers from using ICTs in education (Balanskat et al., 2006; Bingimlas, 2009). It is worth noting that about half of the European education systems have policies to support the appointment of a digital coordinator, also known as an ICT coordinator, in schools. ICT coordinators generally have responsibilities that cover both technical and pedagogical aspects (Eurydice, 2019). Those aspects are critical as data from the second survey on schools on ICT (European Commission, 2019b, p. 48) showed that a lack of pedagogical and technical support is one of the most important obstacles teachers face in the use of digital technologies. The role of ICT coordinators varies considerably between schools, and they can be responsible for coordinating and organising professional development activities or providing in-house training on-demand. They can also be responsible for managing teachers' networks and digital platforms and ensuring that the school is integrated into digital communities. They may also assist and advise school heads and support the school management in providing digital education events and activities (Eurydice, 2019).

Government support can also impact the integration of ICT on teaching. Specifically, Balanskat et al. (2006) reported that government interventions and training programmes increased teachers' enthusiasm and positive attitudes towards ICT and led to the routine use of embedded ICT.

Lastly, another important factor affecting digital transformation is the development and quality assurance of digital learning resources. Such resources can be support textbooks and related materials or resources that focus on specific subjects or parts of the curriculum. Policies on the provision of digital learning resources are essential for schools and can be achieved through various actions. For example, some countries are financing web portals that become repositories, enabling teachers to share resources or create their own. Additionally, they may offer e-learning opportunities or other services linked to digital education. In other cases, specific agencies of projects have also been set to develop digital resources (Eurydice, 2019).

4.4.4 Administrative aspects and digital data management

The digital transformation of schools involves organisational improvements at the level of internal workflows, communication between the different stakeholders and possibilities for collaboration. Vuorikari, Punie and Cabrera (2020) presented evidence that digital technologies supported the automation of administrative practices in schools and reduced administration overload.

There is evidence that digital data affects the production of knowledge about schools and can transform how schooling takes place. Specifically, Sellar (2014) reported that data infrastructure in education is developing due to the demand for "*information about student outcomes, teacher quality, school performance and adult skills, associated with policy efforts to increase human capital and productivity practices*" (p. 771). In this regard, practices, such as "datafication", which refers to the *translation of information about all kinds of things and processes into quantified formats,* became essential for decision-making based on accountability data reports concerning school quality. The use of data can provide insights on teaching and learning with the use of ICTs. For example, measuring students' online engagement with learning materials can help teachers inform and refine their educational interventions (Vuorikari, Punie, & Cabrera, 2020).

As a final note in this section, it is important to recognise that, while data, such as the examples provided above, can offer valuable insights, we should remain mindful that data are not cognitive authorities (Jarke & Breiter 2019). Instead, they serve as proxies and indicators, as they do not directly measure the quality of a skill or performance. That is because data are neither neutral nor objective as they are influenced by various factors including which data are collected, the data collection methods, the perceived representations, and the intended uses.

4.4.5 Teachers' profile, training approaches and professional development

Teachers' personal characteristics and professional development affect the impact of digital technologies in education. Specifically, Cheok and Wong (2015) found that teachers' personal characteristics (e.g., anxiety, self-efficacy) are associated with their satisfaction and engagement with technology. Bingimlas (2009) reported that lack of confidence, resistance to change and negative attitudes in using new technologies in teaching are significant determinants of teachers' levels of engagement in ICT. The author reports that the provision of technical support, motivation support (e.g., awards, sufficient time for planning) and training on how technologies can benefit teaching and learning can eliminate the above-mentioned barriers to ICT integration. Archer and Savage (2014) found that comfort with technology is an important predictor of technology integration and argued that it is essential to provide teachers with appropriate training and ongoing support until they are comfortable using ICTs in the classroom.

Hillmayr et al. (2020) documented that teachers' training on ICT had an important effect along with the use of ICTs on the students' learning. According to Balanskat et al. (2006), the impact of ICT on students' learning is highly dependent on the teacher's capacity to exploit it efficiently for pedagogical purposes. Results obtained from the Teaching and Learning International Survey (TALIS) revealed that although schools are open to innovative practices and have the capacity to adopt them, only 39% of teachers in the European Union reported that they are well or very well prepared to use digital technologies for teaching (European Commission, 2020a).

Li and Ma (2010) and Hardman (2019) showed that the positive effect of technology on students' achievement depended on the pedagogical practices used by teachers. Schmid et al. (2014) reported that learning was best supported when students were engaged in active, meaningful activities via technological tools that provided cognitive support. Tamim et al. (2015) compared two different pedagogical uses of tablets and found a significant moderate effect size when the devices were used in a student-centred context and approach rather than within teacher-led environments. Similarly, Garzón et al. (2019) and Garzón et al. (2020) reported that the positive results from the integration of AR applications could be attributed to the existence of different variables which could influence AR interventions (e.g., pedagogical approach, learning environment and duration of the intervention). Additionally, the authors suggested that the pedagogical resources that teachers used to complement their lectures and the pedagogical approaches they applied were crucial to the effective integration of AR in education.

Hattie (2009) reported that the effective use of computers is associated with teachers' training in using computers as a teaching and learning tool. Zheng et al. (2016) noted that in addition to the strategies teachers adopt in teaching, ongoing professional development was also vital in ensuring the success of technology implementation programmes. Sung et al. (2016) found that most of the research on the use of mobile devices to support learning reported that the insufficient preparation of teachers was a major obstacle in implementing effective mobile learning programmes in schools. Friedel et al. (2013) found that providing training and support to teachers increased the positive impact of the interventions on students' learning gains. Trucano (2005) argued that positive impacts occur when digital technologies are used to enhance a teacher's existing pedagogical philosophies. Higgins et al. (2012) found that the types of technologies used and how they are used could also affect students' learning. The authors suggested that training and professional development of teachers that focuses on the effective pedagogical use of technology to support teaching and learning is an important component of successful instructional approaches (Higgins et al., 2012). Archer et al. (2014) found that studies that reported ICT interventions during which teachers received training and support had moderate positive effects on students' learning outcomes, which were significantly higher than studies where little or no detail about training and support was mentioned. Fu (2013) reported that the lack of teachers' knowledge and skills regarding the technical and instructional aspects of ICT use in the classroom, in-service training, pedagogy support, technical and financial support, as well as the lack of teachers' motivation and encouragement to integrate ICT on their teaching were significant barriers to the integration of ICT in education.

4.4.6 Students' socioeconomic background

Research shows that the active engagement of parents in the school and their support towards the school's work can make a difference in their children's attitudes towards learning and, as a result, their achievement (Hattie, 2008). For example, OECD (2016) reported that parental involvement is essential for the development of students' digital competencies since young children spend more time on internet activities outside school than in school. Hence, parents have an important role in encouraging their children to become critical and confident technology users. Additionally, parents' attitudes and abilities can also determine whether they help or hinder their children's development of digital competencies (OECD, 2016). The second survey of schools on ICT education showed that the younger the child, the more frequently parents share their ICT-related activities (European Commission, 2019b).

In recent years, digital technologies have been used for more effective communication between school and family (Escueta et al., 2017). More digitalisation in schools may improve the flow of information between schools and parents, reinforcing the school consultation and participation processes and helping parents become more familiar with digital devices and the benefits technology brings. Support for parents can be given through guidance materials, organised trainings or outreach campaigns (OECD, 2016). The European Commission (2020) presented data from a recent Eurostat survey regarding the use of computers by students during the pandemic. The data showed that younger pupils needed additional support and guidance from parents. The challenges were greater for families where parents had lower levels of education and no or low-level digital skills.

In this regard, learners' socioeconomic background and their socio-cultural environments also affect educational achievements (Punie et al., 2006). Trucano documented that the use of computers at home positively influenced students' confidence and resulted in more frequent use at schools compared to students who had no access to a computer at home (Trucano, 2005). In this sense, the socioeconomic background affects the access to computers at home (OECD, 2015a), which in turn influences the experience of ICT, which is an important factor for school achievement (Punie et al., 2006; Underwood, 2009). Furthermore, parents from different socioeconomic backgrounds may have different abilities and availability to support their children in their learning process (Di Pietro et al., 2020). Although parents play a role in their children's education, only a few countries have policy measures in this area. Yet, such measures were very rarely featured among the main objectives of their digital education strategies (OECD, 2016).

4.4.7 Socioeconomic school context and emergency situations

The socioeconomic school context is closely related to a school's digital transformation. For example, schools in disadvantaged, rural or deprived areas are likely to lack the appropriate digital capacity and infrastructure required to adapt to the use of digital technologies during emergency periods, such as the COVID-19 pandemic (Di Pietro et al., 2020). Data collected from school principals confirm that in several countries, there is a rural/urban divide in connectivity (OECD, 2015a).

Emergency periods also affect the digitalisation of schools. The COVID-19 pandemic led to the closure of schools and forced them to seek various appropriate and connective ways to maintain working on the curriculum

(Di Pietro et al., 2020). The sudden large-scale shift to distance and online teaching and learning also raised various challenges about the quality and equity in education, such as the risk to increase learning, digital, and social inequalities, and the difficulties teachers had in coping with this demanding situation (European Commission, 2020a).

Looking at the findings of the above studies, we can conclude that there are various factors that affect the impact of digital technologies on schools' stakeholders within the school ecosystem (See figure 1 for a graphic representation). It must be noted that each of these factors consists of various dimensions, the analysis of which is beyond the scope of this report.

Figure 1 Factors affecting the impact of ICTs in education

Source: Authors' elaboration

5 Assessing the impact of self-reflection tools

Digital capacity of schools is defined as "*the extent to which culture, policies, infrastructure as well as digital competence of students and staff, support the effective integration of technology in teaching and learning practices*" (Costa et al 2021, p. 163). As such, it focuses on creating the conditions for enhancing the impact of digital technologies. Self-reflection tools designed to support the development of the digital capacity of schools are treated here as a separate category of digital tools because they operate on a meta-level in the sense that they are not technologies used directly in teaching and learning. Instead, they aim at structuring **how technologies** are used for teaching and learning, introducing a critical, strategic and pedagogically informed decision-making in the digital transformation of schools.

Self-assessment is strongly documented as a critical element in a process of change and development (Brown & Harris, 2014). For the scope of this work, we extend the study of self-reflection tools to self-evaluation and self-assessment tools. As mentioned in Costa et al. (2021), self-assessment is often used synonymously with self-evaluation. It involves an examination of pupils' knowledge, skills and attitudes rather than the processes involved in self-evaluation – both summative and formative. Self-evaluation is a term with growing currency in many countries. It is a formative process embedded into the day-to-day practices of schools and should be linked to pupil learning and achievement (Chapman & Sammons, 2013). Taking into account that the digital transformation and development of schools is a learning process, we offer insights on the concept drawing from its use in the classroom.

5.1 Background

5.1.1 Self-Assessment in education

Box 9. Summary

The literature review revealed that self-assessment practices can be important enablers for improvement of students' learning outcomes. Self-assessment (summative or formative, provided via pre- and post- questionnaires tests, checklists, portfolios or rubrics) was found to affect positively students' performance (e.g., in language) and skills (e.g., writing skills, self-regulation skills). Additionally, positive results were found on students' engagement, motivation, attitudes and independence. Students' self-evaluation also helps teachers document their performance and better understand the way they learn. These results demonstrate the relevance of self-assessment in the process of the digital transformation of schools.

The use of self-assessment in education is based on theories about self-regulation, which identifies the process of setting goals and evaluates the process via criteria to achieve improved learning outcomes in various contexts (Zimmerman, 2008). Self-assessment tools are used not only to evaluate students' work and processes (as a classroom practice) but also to evaluate the factors that contribute to improving students' learning outcomes (as a school practice). Students' self-assessment refers to the students' evaluation of their work and processes (Brown & Harris, 2014) and aims to improve the quality of their learning by becoming active participants in this procedure. Throughout self-assessment, students are educated towards self-directed learning with the ultimate goal of setting their own goals and controlling their learning. Self-assessment can serve as a "formative assessment", allowing students to reflect on specific and clear objectives to assess the quality of their work (Andrade & Valtcheva, 2009).

Research has shown that students' self-assessment during their lessons can lead to improvements in performance. The impact of self-assessment on language performance was explored in a meta-analysis by Li and Zhang (2021) based on 67 studies and more than 68,500 participants. The authors found that self-assessment has a moderate effect on language performance. This effect was significantly related to other factors, such as self-assessment criteria, instruments criteria, and the total number of items of the instruments. A number of smaller, qualitative or mixed method, studies also demonstrated a positive impact of self-reflection tools in **students' performance and educational outcomes over the years** (Panadero, Brown & Strijbos, 2016; Panadero, Jonsson, & Botella, 2017).

Self-assessment is also associated with self-regulated learning and self-efficacy. Panadero, Jonsson and Botella (2017) conducted a meta-analysis that included 19 studies and 2,305 participants to investigate the effects of self-assessment on students' self-regulated learning (SRL) and self-efficacy. The results showed that self-assessment interventions positively affected self-regulated learning, ranging from small to medium effects. The study also documented that self-assessment components (such as self-monitoring) and gender were significant moderators of the impact on self-efficacy.

5.1.2 The role of Digital Competence frameworks in the development of the digital capacity of educational institutions

This section aims to analyse the ways in which self-reflection tools can play a role in the development of schools' digital capacity. Assessment is a key feature of education which can support the modernisation of education systems and impact how teaching and learning take place in an increasingly digital society and economy. In recent years, various assessment methods have been implemented in education (Kapsalis et al., 2019). Among the assessment methods that enable a whole-school overview and can be a fundamental force in achieving school improvement is self-evaluation (Chapman & Sammons, 2013). Self-evaluation in schools allows the staff members to reflect on their practice, identify areas of improvement and take action in the areas of pupil and professional learning (Chapman, & Sammons, 2013, p.2). Kampylis et al. (2016) noted that self-assessment tools can enable schools to understand the meaning of a "digitally competent organisation" and support them in developing their improvement plan.

Ređep (2021) conducted a literature review to investigate frameworks designed to assess the digital maturity of educational institutions. The author identified 16 frameworks; three apply only to higher education (ePOBMM, HEInnovative, JISC), and eight are country-specific (eLearning Roadmap, eLEMER, LIKA, NACCE SRF, OPEKA, SCHOOL MENTOR, VENSTRESS, FDMS). The remaining five frameworks have a more general scope and have been applied across the EU. Their impact on the school unit is briefly described as follows. The Assessing the e-Maturity of your school (Ae-MoYS)[3] is a framework and an online self-evaluation questionnaire is divided into five areas with 30 descriptors. The areas include: Leadership and Vision, ICT in the Curriculum, School ICT Culture, Professional Development, and Resources and Infrastructure. It employs qualitative and quantitative development approaches and can be applied at the elementary and high school levels. The framework focuses on strengths and weaknesses in the use of ICT for teaching and learning. The results can be used to assist schools to create an action plan.

Scale CCR[4] is a framework is organised around eight areas and 28 elements. The areas include: Content and Curricula, Assessment, Learning Practices, Teaching Practices, Organisation, Leadership and Values, Connectedness, and Infrastructure. It follows a qualitative development approach with application areas in elementary and high schools and best practice examples throughout Europe. It focuses on upscaling ICT-enabled learning innovation and was used to identify implications for policy, leadership and practice that are related to particular challenges which could impede technology adoption.

The Future Classroom Maturity Model (FCMM)[5] is a framework that consists of five dimensions corresponding to key elements at play in the future classroom: learners, teachers, learning objectives and assessment, school capacity, and technology resources. Each dimension includes five levels. As a school moves from one stage to the next, its capacity to be innovative in technology-supported learning and teaching increases. However, good practice and effective learning can be found at all levels, and level five does not imply that further innovation is impossible. The framework is accompanied by a self-assessment tool that automatically calculates the school's overall level. Each dimension suggests what should be included in a Future Classroom Scenario for further development. The results and suggestions are a starting point for discussion. They offer data for schools and teachers to develop a strategy to innovate. The school's Innovation Team can use the results for benchmarking and future actions.

Microsoft IF & SRT is a framework and online self-evaluation questionnaire which consists of four areas, 16 elements and 96 descriptors. It uses both qualitative and quantitative development approaches with application

[3] Assessing the e-Maturity of your school: http://e-mature.ea.gr/
[4] Scale CCR: http://eimwiki.fefmont.es/ccr/
[5] Future Classroom Toolkit: https://fcl.eun.org/toolkit

areas in elementary and high schools and best practice examples worldwide. The framework assists schools to create a vision and to manage the change process.

Lastly, the Framework for Digitally Competent Educational Organisations (DigCompOrg)[6] supports educational institutions to develop organisational strategies to take full advantage of all aspects of digitalisation for learning. Specifically, the Framework promotes self-reflection and self-assessment in three fundamental dimensions in the process of the digitalisation of education – namely, pedagogical, technological and organisational – and it defines seven key elements within these dimensions: infrastructure, collaboration and networking, content and curricula, teaching and learning practices, assessment practices, professional development, leadership, and governance practices. SELFIE constitutes the practical implementation of DigCompOrg and allows the operationalisation and assessment of the digital capacity of schools by providing initial evidence concerning how the Framework can be used in practice. Its primary purpose is to generate a snapshot of the digital capacity of individual schools. This snapshot can then be used by schools to prepare a strategy focusing on potential areas for improvement. SELFIE offers schools the possibility to monitor their progress over time (Ređep, 2021).

Based on a qualitative analysis of the results,Ređep (2021) concludes that the only framework which *"best describes the comprehensive field of the digital maturity of schools"* is DigCompOrg (p. 26). Kampylis, Punie and Devine (2015) reported that DigCompOrg was developed from the need to address the lack of a systemic and common conceptual approach regarding digital maturity (p. 16). The authors analysed nine existing school self-assessment tools, which are also included inReđep's (2021) review, and reported several key elements for improving schools' digital capacity that include: the need to make a strong emphasis on leadership and governance practices, infrastructure and resources; the recognition of the role of teachers and the need of developing strategies to improve their digital agency; the need for the integration of digital technologies across the curriculum; and the importance of adopting capacity-building strategies based on self-assessment, towards the design of guidelines and actions plans to improve digital teaching and learning.

5.1.3 Implementation of digital competence frameworks

Box 10. Summary

The frameworks that focus on digital maturity are based on different approaches; some follow either qualitative or quantitative approaches, while others use both. Most of the frameworks include an online self-assessment questionnaire or a matrix. The questionnaires are completed by school teachers and students, ICT teachers, school leaders or the headmaster. Various self-assessment tools are accompanied by a Toolkit or Tutorial, which explains the tool's purpose and provides valuable information on how to conduct the self-evaluation process and interpret the results. The summary of the results is used to assist schools in creating their digital action plans or as advice for further work on the planning and execution of pedagogical use of ICT. Some frameworks also include separate action plan questionnaires. There are also some impact evaluation methods or approaches (e.g., Theory of Change, expected return), which can be used for the development of specific frameworks to support the schools' digital transformation process.

As the literature review has shown, the impact of digital technologies in education depends among other factors on how these tools are used. In this section we present methodologies supporting the use of frameworks for assessing the digital maturity of organisations.Ređep (2021) reported that the frameworks focusing on digital maturity are based on different approaches; some follow either qualitative or quantitative approaches, while others use both. Kampylis et al. (2015) analysed 15 self-assessment frameworks used by educational organisations to assess the integration and effective use of digital technologies and inform policy initiatives. Their results showed that most of the frameworks included **a self-assessment questionnaire or a matrix**. The majority of the questionnaires/matrices were offered as **online tools**. The questionnaires are completed by school teachers and students (e.g., eLEMER), teachers (e.g., Opeka), school coordinators (e.g., Ae-MoYS), school leaders (e.g., School Mentor) or the headmaster (e.g., LIKA).

[6] European Framework for Digitally Competent Educational Organisations: https://joint-research-centre.ec.europa.eu/european-framework-digitally-competent-educational-organisations-digcomporg/digcomporg-framework_en

Various self-assessment tools are accompanied by a Toolkit or Tutorial, which explains the tool's purpose and provides valuable information on how to conduct the self-evaluation process and interpret the results (e.g., FCMM). Some tools offer comparisons with the national average and involve researchers in the evaluation process (e.g., eLEMER, LIKA) or offer comparisons with the results on a local level or with teachers who teach the same subject (e.g., Opeka). The summary of the results is used to assist schools in creating their digital action plans (e.g., Ae-MoYS) or as advice for further work on planning and execution of pedagogical use of ICT (e.g., School Mentor). Some frameworks also include separate action plan questionnaires (e.g., Ae-MoYS).

According to Costa et al. (2021) SELFIE, which is based on the DigCompOrg framework, does not focus only on teachers or school leaders but it also includes the voice of the students. Furthermore, SELFIE adopts a holistic approach to the digital transformation of schools, through a 360-degree view which includes key organisational aspects involved in technology use in schools. This holistic approach aims at looking what happens in the classroom and beyond including leadership practices, infrastructure, collaboration and networking, teacher and student digital competence. One important challenge for SELFIE was the need to address schools across educational settings, cultures and contexts. To this end SELFIE has integrated functionalities that allows customisation of the tool to address their specific needs and profiles.

To conclude, all the aforementioned frameworks and their accompanying instruments can provide information on the impact of digital technologies in school practice. Central to their design and implementation are methodological and theoretical approaches such as the Theory of Change, the expected return (or social return on investment) method and the mission alignment method (Liang, Fernandez, & Larsen, 2022).

5.2 Theory of Change in schools

Change lies at the core of the digital transformation of an organisation in general and of schools in particular. As a result, the theory of change plays a critical role in the exploration of the topic (see e.g., Chapman & Sammons, 2013; De Silva et al., 2014; Aromatario et al., 2019). The Theory of Change (ToC) allows to gain a holistic perspective of the effectiveness of the activities employed to bring about change emphasising the need to understand how they are "*expected to lead to the desired results*" (Mayne, 2015, p. 121). For the purposes of this work we employ ToC to inform the framework for the assessment of self-reflection tools for digital capacity development. Specifically, we focus on: (a) the pathway from activities to outputs, to outcomes and finally to impacts, and (b) a set of assumptions with respect to what conditions are needed for the various links of the pathway to work (Mayne, 2015).

5.2.1 Pathway: from actions to impact

To document the pathway from actions – input to impact – a backwards process was followed. This process focuses on the end results in order to document the actions and strategies needed for these results (see Figure 2).

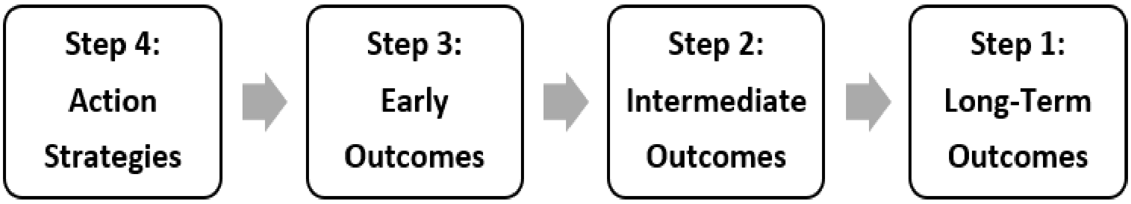
Step 4 (Action and Strategies) refers to inputs and specific activities planned to support the envisaged outcomes (e.g., products, communications, and networks; the use of digital technologies and self-assessment tools; teachers' training and professional development; the management model used).

Step 3 concerns the short-term changes (e.g., direct influence awareness and engagement of stakeholders; changes in short-term knowledge, attitude and skills).

Step 2 involves the medium-term outcomes (e.g., shifts in practices, policies, strategies and budget allocations; in knowledge, attitudes and skills).

Step 1 refers to the long-term outcomes – the impacts (e.g., changes in knowledge, attitudes, mind-set, practices, values, health or living conditions, or policies) (Connell & Klem, 2000; Vogel, 2012). The analytic four-step change process is presented in Table 4.

Figure 2 Steps in articulating a theory of change



Source: (Connell & Klem, 2000, p.95)

The pathway from actions, to outputs, to outcomes and impacts was adapted for the purposes of this study to the characteristics of self-reflection tools (table 4). Specifically, the literature review on the impact of digital technologies in education along with the analysis of self-reflection frameworks and tools informed this adaptation in identifying key actors and critical aspects of school activity involved in the integration of digital technologies. Furthermore, the adaptation of the pathways also took into account the affordances of SELFIE and its implementation method as they are described in the web page of SELFIE (https://education.ec.europa.eu/selfie) and in the school – coordinator's guide (https://europa.eu/!bk4XPR).

The first column of the adapted pathways, refers to all actions and strategies that are related to the production of an output. In fact, the "actions and strategies" column contains the inputs, the activities and the contextual aspects within a school's digital transformation procedure. At this point they are recorded in the same category, since the main aim of the creation of the table is to document the results chain from outputs to impacts. The other columns/categories, which include "Outputs", "Outcomes" and "Impacts", refer to the level of the impact of a self-reflection tool to the development of the digital capacity of a school, from short-term changes to impacts.

Table 4. The pathway from short-term to long-term outcomes

ACTIVITIES–INPUTS–CONTEXT	OUTPUTS	OUTCOMES	IMPACTS
Activities: School management level Take a decision at school level to use SELFIE Put in place a SELFIE coordinator and small supporting team Explain to the school the role of SELFIE and the process that will be followed Involve the school community not only in taking the questionnaire but also in communication actions such as: discussing the results, taking follow up actions Devote time and resources Connect with other schools **Activities: Teachers and students** Participate in the self-reflection exercise and to the follow up actions	Short-term changes (*direct influence awareness and engagement of stakeholders, changes in short-term knowledge, attitude and skills*) Awareness raising on how the school is using digital technologies – at the: • Personal level (i.e., individual teachers, students, school leaders) • School level (through discussions of the school community on the SELFIE results) Attitude: self-reflection as an instrument for growth Skills: identification of weak and strong points.	Medium-term changes (*shifts in practices, policies, strategies, and budget allocations, in knowledge, attitude and skills*) Knowledge: • Consensus building on the weak and strong points on the use of digital technologies • Solutions and new knowledge on digital technologies at schools **Practices**: Undertake responsibilities for the digital development of the school (school leaders, teachers, students) Take action on the teaching and learning practice on an individual level based on the results	Long-term outcomes *Changes in knowledge, attitudes, mindset, practices, values, policies* **Knowledge**: Strategic planning on the use of digital technologies in education Pedagogical guided integration of ICT in schools **Practices** School leadership and teaching practices informed by the results of the self-reflection and action planning Student practices: participation in the

Participate and support the actions towards the digital development of the school **INPUTS:** Self-reflection exercise School data from the self-reflection exercise School's digital strategy **CONTEXTUAL ASPECTS** Policy initiatives (e.g., proposal to use SELFIE, emphasis on the digital strategy) Policy structures supporting the initiatives – priorities (e.g., teacher training centres) School existing strategy School management style Available resources (human, time, budget) Available expertise (data analysis and strategy development) Staff culture Self-assessment culture Attitude towards technologies (teachers and students) School network and collaboration with other schools School vision		of the self-reflection (teachers) **Budget allocation**: in supporting the priorities for school development **Skills**: data informed decision-making, strategic planning, prioritisation, communication, collaboration, networking	digital development of the school. Monitoring of the implementation of the schools' digital strategy **Values**: collective responsibility, inclusivity, using technology to support high-quality education **Mind-set:** growth **Policies:** Revision of the school policy regarding the use of ICT based on the results of the self-reflection and the strategic planning

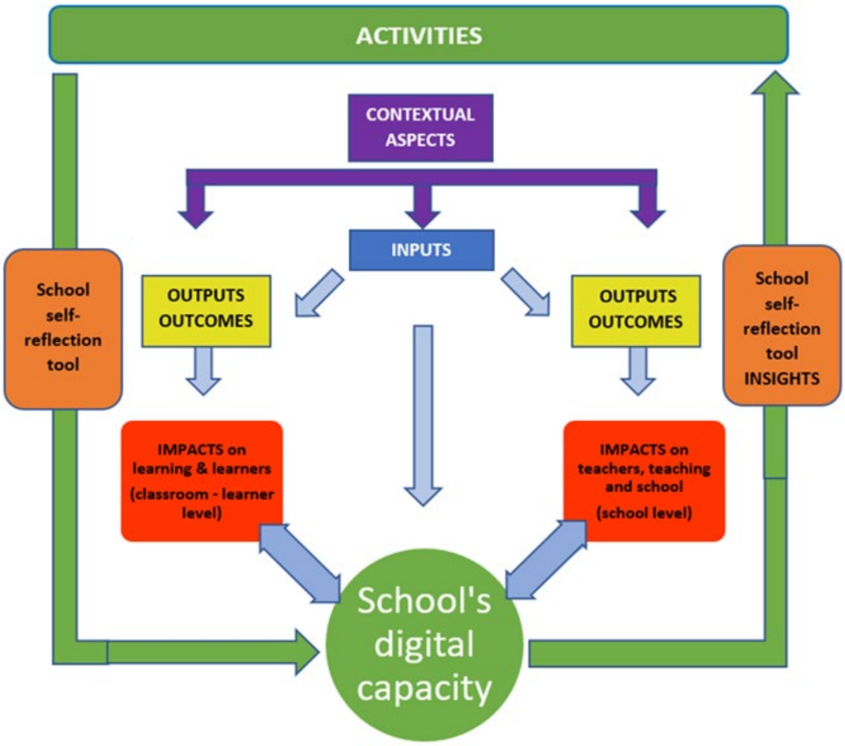
It is worth noting that, based on the analysis above, the impact of SELFIE is not directly linked to improved learning outcomes and digital competences. The literature review demonstrated clearly the problems in this approach highlighting the conflicting research results and the importance of contextual factors as well as of the process of the implementation of the tools. As a result, the pathways analysis approaches the impact of self-reflection tools as enablers for:

a) The creation of rich learning environments with the use of technologies so that they will support a high-quality, inclusive education for all students
b) Appropriate conditions in place for teachers to integrate digital technologies as a means to empower and enrich their practice: professional development, time, leadership model, collaborations, communication and collaboration with parents
c) School community commitment to collective reflection practices and to sustainable digital development
d) School management models, strategies and vision supporting strategic and pedagogically driven integration of digital technologies that empower teachers and students.

5.2.2 Assumptions

After the development of Table 4 we further categorised the items from the first column into the three categories: *inputs, activities and contextual aspects*, in order to adapt the general characteristics of the *Theory of Change* into the case of self-reflection tools designed to support digital transformation in education. In Figure 3 we offer a visualisation of the adapted Theory of change which includes the key elements of the pathways from activities to impact as well as a set of assumptions which involve the necessary conditions that can enable the transition from one step of the pathways to the next.

Figure 3 : A theory of change for self-reflection tools focusing on schools' digital capacity development



Source: Authors' elaboration

In this adaptation of the theory of Change illustrated above (Figure 3), the **school self-reflection tool** is provided by the stakeholders at the beginning of the procedure of the digital development, to document the **digital capacity** of the school. The data derived from the integration of the self-reflection tool also provides the stakeholders with **insights** about areas for change and improvement. After that, the school is expected to organise the **activities, which** include devising and implementing an action plan and activities related to ICT integration. During these activities various **contextual aspects** should be considered since they affect the **inputs** related to the use of the digital technology, the **outputs,** the **outcomes,** and the **impacts** of digital technologies in the specific school. As depicted in Figure 3, this process of digital capacity development as mediated by the self-reflection tools, is continuous and cyclical aiming to empower schools to guide their digital transformation. Below we further elaborate on the key elements of this process.

Within the digital transformation process various ***contextual aspects*** assume a significant role. Drawing from the literature review we further analysed the contextual aspects to a set of constituent elements:

- Educators: profile, professional development, and digital competencies
- Teaching, learning and evaluation practices
- Infrastructure: Equipment, software, digital content, materials, connectivity
- School management model
- School's vision and culture in general but also in relation to digital technologies
- Government support and regional – national policies policy
- Digital technologies developments
- Other (unexpected) situations, such as the COVID-19 pandemic.

The contextual aspects previously mentioned exert an influence on the **inputs,** which refer to all the human and non-human resources which are employed to support the digital development of the school with the mediation of self-reflection tools.

- Human resources pertain to various stakeholders within the education ecosystem including students, the teachers, ICT coordinators, administrative staff, parents..

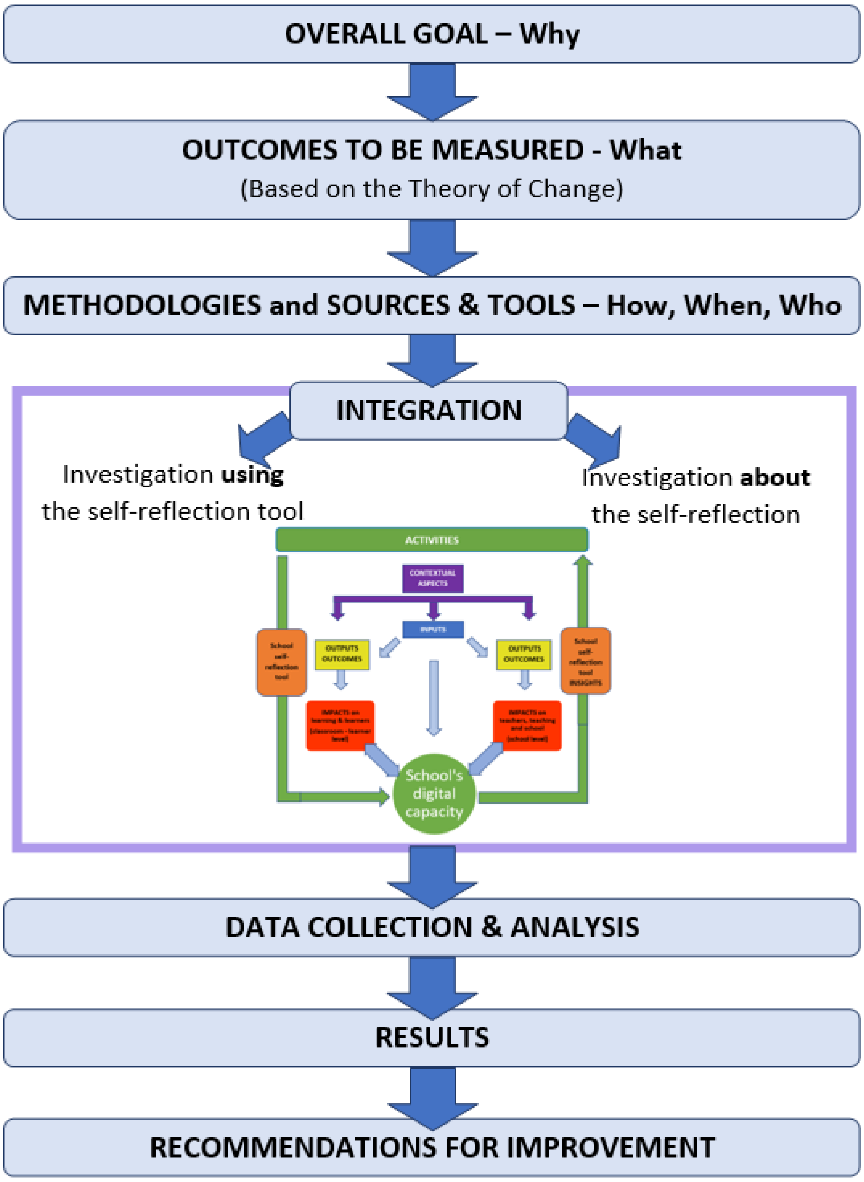
- Non-human resources encompass aspects such as: financial, material and temporal investments allocated to the digital transformation process. Furthermore, they involve the existence or creation of appropriate structures (e.g., a team devoted on the digital transformation, mechanisms to involve the school community) as well as collaborations within and outside the school.

The inputs reflect on the ***activities***, which concern all the actions taken in order to reach the intended outcomes, such as administering the self-reflection exercise, designing an action plan for digital capacity development, putting together actions to communicate and support the implementation of the plan, coordinated or grassroots teacher initiatives, etc.

5.3 A framework for the impact assessment of self-reflection tools

The *Theory of Change* (Figure 3) adapted to focus on understanding the impact of self-reflection tools in a digital education improvement strategy emphasises the circular character of schools' digital capacity development, the relationship among the contextual aspects, inputs, outputs, outcomes, impacts and the mediating role of self-reflection tools. This adapted theory of change is integrated now in a framework which aims at supporting the impact assessment of self-reflection tools. This framework consists of seven steps (see Figure 4) which are described in more detail below:

Figure 4 Framework for the assessment of the impact of self-reflection tools in schools' digital capacity and digital transformation



Source: Authors' elaboration

5.3.1 Step 1: Set the overall goal of the study – *Why*

First, the overall goal of the study should be documented, answering the question *"Why is this study being undertaken and why is it important?"* For instance, this framework aims to support a study, the goal of which is to assess the impact of SELFIE in the digital transformation of schools.

5.3.2 Step 2: Define what outcomes will be measured – *What*

After setting the overall goal, the study/research team should decide which outcomes to measure and should define indicators of these outcomes. For the purposes of the SELFIE impact assessment study, the outcomes (or impacts) will be derived from the *Causal pathway from short-term to long-term outcomes* table (Table 4) where outputs, outcomes and impacts were listed. The project team should document the outcomes (intended changes) that they will measure during the assessment of the self-reflection tool. Indicators will help to measure the outputs, outcomes or/and impacts. Indicators might be quantitative (measures of quantity, number, percentage, ratio) or qualitative (perception, opinion, judgements). For example, a quantitative indicator could be "the number of times (weekly) each teacher uses a piece of software to assign homework to the students" and a qualitative indicator could be "the degree of teachers' confidence in using one or some of the available technologies of the school in their lessons".

5.3.3 Step 3: Choose the methodologies, sources and tools – *How, When, Who*

This step concerns the methodology (How) that the research team will choose, as the "most appropriate" for the purposes of the study (step 1: Overall goal). When deciding on the methodologies, the participants (Who) should be also identified. The time of the implementation of the study (When) is also important and has to be part of this step including identification of factors that might cause disruptions (e.g., exam periods, holidays, periods especially busy for the participants, etc.).

Digital transformation of education is a research topic characterised by special traits. One of them is the wide range of factors (beyond students and learning outcomes) are connected to the school and need to be taken into account (Chirichello, 1999; Rikkerink, et al., 2016; Navaridas-Nalda, et al., 2020). These factors, as our literature review showed, affect the outcomes and impacts that are intended to be assessed and/or measured.

The goal of the study (i.e., impact assessment of digital technologies) and the its characteristics (complex and highly contextualised phenomenon) contribute into determining the research method to be employed. Our literature review demonstrated that both quantitative and qualitative methodologies are used for documenting impact. Quantitative methods are important, because they provide numerable/arithmetic data and an overview of what happens at large scale. Qualitative methods on the other hand, can address complex phenomena, offering a nuanced, deeper understanding of the phenomenon including underlying motivations, processes and contextual influences. The research instruments used in most of the studies included in our review primarily involved questionnaires, individual or focus group interviews, and tests (especially for content knowledge achievement). This includes also the primary research studies included in the meta-analyses papers. However, our analysis revealed the utilisation of additional methodologies and instruments for data gathering and analysis, such as collaborative action research, critical incident technique, drawing tasks, symbolic interactionism, and thinking aloud protocols. These last approaches were employed to facilitate in-depth and detailed data recording.

The analysis of the literature review data revealed that the assessment of a self-reflection tool follows three dimensions, which should be considered while choosing the methodology:

a) Assessment of the content of the tool

The aim of this part of the assessment is to evaluate whether the self-reflection tool covers the three elements of the Theory of Change which concern ICT integrations: the contextual aspects that impact digital technology in education, the inputs which are involved within the integrations, and the activities which concern digital technology. The most important is to assess whether the tool can document the impacts of digital technology in education.

b) Assessment of the links between the elements

The four elements of the Theory of Change are interconnected. The self-reflection tool which assesses the links between the content of the elements might provide a relationship between the elements (e.g., professional development and schools' self-evaluation results (Blaik Hourani, & Litz, 2019).

c) Assessment of the areas for improvement

During this part of evaluation, the aim is to document whether the tool can identify areas for action to stimulate improvement (Chapman, & Sammons, 2013) and how the tool helps the staff to make the changes in order to provide improvement.

The above three dimensions of the SELFIE assessment can be achieved through two different research foci: "investigation using the self-reflection tool" and "investigation about the self-reflection tool". "**Investigation using the self-reflection tool**" refers to an exploration of how the self-reflection tool is used within the procedure of digital transformation (see Figure 3). This means that an external organisation is involved and there might be a research team who enters a school and works collaboratively with the staff to integrate the self-reflection tool in the school's practice, i.e., case study or exploratory study. The purpose is to document whether and how the tool works, to assess its content (maybe some questions are difficult for the students), to document how the tool can be used to make connections between the four elements of the Theory of Change (actions, outputs, outcomes and impacts), and to check whether it can identify areas for improvement within the digital transformation procedure. The implementation can also provide insights about the self-reflection tool's impact in the development of the school's digital capacity. "**Investigation about the self-reflection**

tool" refers to identify the key stakeholders involved in the implementation of the tool, investigate their opinions and perceptions about the self-reflection tool and its impact in the school's digital transformation and capacity. For both kinds of investigations ("investigation using the self-reflection tool" and "investigation about the self-reflection tool") data sources can include: surveys, questionnaires, interviews, focus groups, observations, documents, data on tool use, etc.

5.3.4 Step 4: Integration

The fourth step refers to the integration of what is decided during the previous steps, such as the implementation of the self-reflection tool, interviews, questionnaires, etc.

5.3.5 Step 5: Collection and analysis of data

After organising the integration, the project team will collect the data and organise their analysis. Depending on the methodology followed, the extent of the study as well as the specific characteristics of the study in case of qualitative methodologies. Specifically, a qualitative study taking place in various countries requires coordination and fine-tuning on various levels, which might be different from a study taking place in the same country. Specifically, common protocols for the data collection process should be created, translations made of the research instruments, considerations produced of the differences of the school cultures and the education systems in the process of data collection, etc. Similarly, for data analysis the methodology should be agreed and identified, as with the instruments that are going to be used to support the data analysis, the focus, the reporting of data analysis, and finally the coordination between the researchers implementing the data analysis.

5.3.6 Step 6: Results

This step involves the description and presentation of the results of the study, methodologies and processes for their validation as well as the communication means (reports, scientific publications, communication to the stakeholders, etc.).

5.3.7 Step 7: Recommendations

This step involves the extraction of recommendations based on the research results. These recommendation will aim not only at improving the tool per se, but also at providing information that can help the different stakeholders to harness the potential of self-reflection tools in supporting the digital transformation in education. The recommendations will address the different stakeholders involved in the design and the implementation of the tool. The stakeholders also contribute into determining the different levels/types of recommendations. Specifically, recommendations regarding the tool per se (i.e., content, usability, etc.) address the designers; recommendations regarding the use and implementation of the tool address (a) schools, (b) policymakers (regional, national and European level), and (c) the research team and governance body of the tool.

6 Discussion and concluding remarks

The present work drawing from research and policy analysis that highlight the lack of robust evidence regarding the impact of digital technologies in education, has attempted to cast light on the characteristics of these studies by analysing a corpus of 92 papers. Specifically, we analysed meta-analysis studies and reviews that reported on the impact of digital tools in education. In the papers analysed we identified the following trends. The impact of different digital technologies is explored in relation to: (a) different stakeholders (i.e., students, teachers, school leaders and parents – care givers, (b) learning, (c) teaching, and (d) the overall school operation (i.e., administration, communication, information sharing, etc.).

Specifically, the impact of digital technologies in **learning** has adopted two viewpoints. One approaches learning as learning **outcomes – student achievements**, while the other explores **learning as a process** with distinct elements. The latter involves aspects such as: collaboration, creativity, problem solving, critical thinking, autonomous – personalised learning, attention, communication, motivation and attitudes towards learning and towards technologies. The subject matter in which the technology is used (i.e., mathematics, language learning, sciences, arts, history, etc.) and the type of technology used (smartphones, XR, games, subject-specific software, Computer Assisted Instruction programmes, multimedia, data analytics, etc.) appear as cross-cutting themes in the two viewpoints mentioned above. Usually, the studies analysed combine one of the two viewpoints and emphasise one or both crosscutting themes. For example, a study might focus on student achievements in mathematics with the use of a specific software. Student age also appears as a crosscutting theme.

In examining the impact of digital technologies on education, research has also concentrated on educators. This inquiry has revealed four primary areas of focus: **(a) teaching practices, (b) pedagogical approaches, c) digital skills and d) teacher beliefs**. Research on teaching practices delved into the role of technology in supporting teacher preparation for the classroom. This encompasses aspects such as lesson planning, resource sharing and creation, teacher collaboration, professional development, participation in online teacher communities, and parent communication. Additionally, it explores how technology facilitates teaching practices such as assessment, scaffolding, and feedback supported, for example, by learning analytics. Studies on pedagogical approaches concentrate on how technology mediates blended and online learning, game-based learning, collaborative learning, project-based learning, and tailored instruction for students with learning difficulties. Finally, a substantial body of research investigates both the development of teachers' digital competencies, confidence levels, and beliefs concerning technology as well as their potential impact on the teaching and learning process.

Another strand of work explores the impact of digital technologies on the overall **operation of schools**, reporting improvements in several dimensions, such as administration, attendance monitoring, parent reporting, the management of assessment records, financial management, the management of repositories for learning resources, sharing of information, and communication among schools, parents and examining authorities. Improvement of these processes can contribute to creating an environment for students that offers them rich learning opportunities.

Considering the multitude of topics presented above in summary and in detail in the report, the multifaceted nature of the impact digital technologies can have in education becomes apparent. The contextual nature of technology use in education (i.e., depending in which context it is used and how), adds to this complexity. To better understand the role of context, we identified a number of key factors that encompass the digital competences of staff and students, the management and leadership model, aspects related to connectivity and infrastructure, administrative operations and data management, the teacher profile, and socioeconomic background. While this list is neither exhaustive nor analysed in detail, it can help to better understand what we mean when we refer to contextual factors and how they relate to the impact of digital technologies in teaching and learning.

This report provides a comprehensive – not exhaustive – record of key elements of impact assessment studies, offering an overview of the technologies researched, the main stakeholders and their characteristics (e.g., digital skills, attitudes and beliefs), the learning processes, the subject matters, the pedagogical approaches, the teaching practices, and the contextual factors. This account is useful because it supports **a mapping between the impact studies and the various aspects of school education**. Furthermore, it contributes in the re-conceptualisation of impact assessment beyond learning outcomes and in documenting its complex nature. Finally, our work reaffirms previous research (Facer & Selwyn 2022) and policy analyses (European Commission 2022a) that emphasise the conflicting results reported from the impact studies. During the last few years, however, **research seems to report slightly higher effect sizes**. Based on the complex nature of technology use, this shift cannot be attributed solely to the effect of digital technologies. Instead, a complex relationship between different factors seems to be at play here: e.g., proliferation of digital technologies, student and teacher digital competences, teacher professional development, new management practices which facilitate integration of technologies in schools, etc.

When we view the impact of digital technologies through the lens of the school activities they mediate, we gain a unique perspective as compared to studies that focus on specific topics, such as learning outcomes. The broad spectrum of technology-mediated school activities indicates that digital technologies can have a **profound impact in education**. This observation does not merely stem from the multitude of activities but also from the transformative capacity of digital technologies to reshape these activities and introduce new dynamics. These emerging dynamics encompass not only improvements but also unforeseen consequences (Facer & Selwyn, 2021), warranting further investigation in the studies of impact assessment.

The second part of this report – corresponding to the second research question – explores the impact assessment of digital technologies in education in relation to policies focusing on the digital transformation of schools. Self-assessment at the school level can be a fundamental vehicle to achieve school improvement (Chapman & Sammons, 2013), a concept linked to the digital transformation of schools. The prominence of digital transformation in education has grown over the last decade, with a significant acceleration during the COVID-19 crisis, which resulted in increased technology use in education. Findings from the studies we analysed indicate that schools' self-reflection can contribute to improving their digital capacity, enabling a comprehensive assessment of critical factors related to technology use and informed decision-making.

The concept of change is central to the process of impact assessment, digital capacity development and school improvement. Hence, in order to assess the impact of self-reflection tools in education, we adopted a "Theory of Change" approach, which explores the affect in relation to inputs, outcomes and impacts. We drew from the literature review to adapt the pathway "from inputs to outputs, and impacts", to the characteristics and the implementation of self-reflection tools. Our work culminates in the development of a framework for assessing the impact of self-reflection tools in documenting schools' digital capacity and supporting their digital development. This framework is adaptable for assessing any self-reflection tool for school development, and can result in insights and research-driven recommendations about improving the tool and the way it is applied.

7 Policy Recommendations

The assessment of the impact of digital technologies entering schools is an important policy topic. This topic is related not only to the funds spent on supporting digital transformation in education but also to how these technologies support school practices and are tailored to the needs of teachers and students. The study of the impact of these technologies has received less attention in comparison to the body of research on the use of digital technologies (European Commission 2022a). A recent analysis of 1,618 Ed-Tech programmes used in schools in the United States demonstrated that only 11% were externally evaluated and 18% internally evaluated. From this calculation, 70% of digital technologies used in schools were either not evaluated or the data of their evaluation were not made publicly available (Vegas, et al, 2019 cited in Vanbecelaere, et al 2023).

The limited research on the impact of digital technologies can be attributed, in part, to the ambivalence of their results, especially concerning learning outcomes (European Commission, 2022). In essence, however, these results might also reflect that what works in one school may not work in another. The answer to the question why this happens is that the impact of digital technologies is a complex concept. It depends on who is involved in the implementation (actors), what activities are taken to support the implementation of these technologies (e.g., national-regional policies), and a number of other contextual factors (i.e., school profile, socio-economic status, digital competences, etc.). The impact of digital technologies is not determined separately by each of these elements but by their interactions as a whole. In each school, each of these elements may have a different weight, leading to varying relationships among them, and consequently, influencing as a complex system, the impact of digital technologies. This means that even similar contextual factors, actions and profiles of actors can develop different dynamics as a whole. Investment in education is linked to monitoring the development of digital transformation, part of which involves the impact assessment of digital technologies in education. Based on this, our proposals below can inform both monitoring and investment policies. Specifically, for the impact assessment of digital education policies we would like to highlight two points:

- The impact of digital technologies in education should be conceptualised as a **complex entity** where the effectiveness of technologies touches upon many different aspects of school education and it is not restricted only to the learning outcomes, although this is the overall purpose. This approach is aligned with the view that the role of digital technologies in the learning process is procedural, i.e., their effectiveness depends on how they are used and in what context (European Commission 2022a). As a consequence, the impact of digital technologies should be explored in relation to the **degree they enable** the creation of rich learning environments providing **opportunities for high-quality and inclusive education**.
- Based on the point above, our analysis has shown that impact assessments that aim at documenting linear causal relationships between different types of digital technologies and learning outputs (i.e., use of this technology will result in better learning outcomes in mathematics or in digital competence development) leave out many other aspects involved in the process. This explains the conflicting results of research on the topic. More focus in the same direction is unlikely to produce different results.

7.1 Proposed Actions

Beyond learning outcomes: The enabling role of technologies and their unintended consequences

This analysis highlighted how linear causal relationships between digital technologies and learning outcomes cannot capture the complexity of the impact of digital technologies. Instead it was demonstrated that digital technologies should be viewed as enablers for more and better learning opportunities for all learners. As a result, in order to document their impact, the evidence gathering should focus on this enabling role[7] which is different from and not restricted to learning outcomes. Specifically, in order to be able to define and revise current digital education policy actions, impact evaluation should first identify **what this enabling role of digital technologies entails** and how technologies can enhance learning opportunities in different contexts. The latter point implies a **reverse context analysis**: instead of analysing only how the context impacts the

[7] The role of digital technologies not as directly responsible for learning outcomes but as enabling instruments is aligned with the definition of successful digital education included in the Council Recommendations on "The key enabling factors for successful digital education and training": "Successful digital education and training is about creating more and better opportunities for learning and teaching for everyone in the digital age" (pp 5. European Commission 2023b). While successful digital education is broader from the impactful use of digital technologies in education, the latter is a crucial element contributing to the overall objective of digital education.

use of digital technologies to also understand how technologies can change the limiting conditions of a context to offer more/better learning opportunities. Another important dimension of the evidence needed for the analysis of impact is the unforeseen– **unintended consequences** (Facer &Selwyn 2021) in the school operation, in the role of the school as a whole, in the role of teachers, in teaching tasks and their workload (to name a few).

Evidence gathering methods: A systems approach

To address the complex nature of the impact of digital technologies in education it is important to use appropriate methods to gather evidence that in turn can inform policies focusing on the monitoring and evaluation of the digital transformation in education. This analysis showed how the impact is affected not only by various –separate- contextual factors but of a **system of interacting contextual factors**. Consequently the processes and methodologies for gathering evidence for the impact assessment of digital technologies should adopt a **systems approach** (see for example Bapna et al 2021) in addition to evidence collected through qualitative, quantitative and mixed methods. .

Evidence base focusing on the impact assessment of digital technologies

This analysis confirmed the research finding on contradicting results regarding the impact of digital technologies in education. It also demonstrated how this impact is affected by the interaction of different contextual factors and how digital technologies touch upon a wide range of school activities. Both points indicate the need not only for appropriate methodologies but also of appropriate data. The importance of contextual factors point to the need for gathering a wide range of data in order to achieve a holistic understanding. To this end and given the importance of impact assessment of digital technologies in the monitoring and evaluation of the digital education policies, it would be beneficial to add this dimension in the evidence base of the digital education[8]. This evidence base can take advantage of the growing body of data on education, generated from schools, various policy initiatives (e.g. trainings, use of self-reflection tools like SELFIE), researchers and Ed-tech platforms (to name a few). This dimension of the evidence base, requires apart from the appropriate infrastructure at regional, national or even European Level, a definition of what constitutes evidence for impactful use of digital technologies (see first proposed action), types of data supporting this evidence, identification of existing data and of gaps, instruments and methods for collecting the data (e.g. national data collections, investment in research etc.).

School agency

Impact assessment of digital technologies has been conducted by now mainly by researchers and research institutions with the aim to inform the research community and the policy makers. However, more and more schools are acknowledged as a critical stakeholder in the digital transformation of education because of the nuanced practical, tacit knowledge they hold and their crucial role in integrating digital technologies in teaching and learning. This has resulted in proposals for schools to take a more active role in the process of the digital transformation of education[9]. Impact assessment, as pointed out several times in this report, is affected significantly by factors related to practical educational contexts. Schools are well positioned – in terms of the knowledge they hold- to inquire on these factors helping to obtain a more nuanced understanding of the impact of digital technologies in education. This way schools from subjects of the impact analysis will become part of the discussion **contributing to the evidence base**. This evidence can have a dual purpose: to inform the relevant policies but also to help schools to reflect on and revise the way they implement digital technologies aiming towards a more impactful use.

To this end, drawing from a common framework for describing and measuring education contexts like the one proposed by the Ed-Tech Evidence Exchange (2021), schools should be provided with evaluation criteria that can employ in assessing the impact of the technologies they use. Furthermore, tools like SELFIE and SELFIEforTeachers can be adapted accordingly, to address the impact of digital technologies so that to facilitate

[8] The European Commission (2023a) has highlighted the need to strengthen the evidence base so as to support the monitoring and evaluation in education. This recommendation does not suggest the creation of a different evidence base if there is already one in place. Instead it proposes the addition of the dimension of impact assessment of digital technologies in education

[9] For example in the Council recommendations on "The key enabling factors for successful digital education and training" (European Commission 2023b), it is proposed that education institutions should engage in a continuous dialogue with the industry, exchanging experience and providing feedback on products and technologies used for teaching and learning. Furthermore in the "Ethical Guidelines on the use AI and data in teaching and learning for Educators" (European Commission 2022b) it is recommended that schools run a small pilot with the AI systems they wish to apply in their practice

a regular flow of information from schools to policy makers, and the industry. Last but not least, schools should be given the time, human resources (expertise), and collaborations with other schools, policy makers and research institutions (to name a few) that will allow them play this role.

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Glossary of Terms

Digital capacity is "*the extent to which culture, policies, infrastructure as well as digital competence of students and staff support the effective integration of technology in teaching and learning practices*" (Costa, et al 2021, p.163).

Digital competence is one of the eight key competences for lifelong learning which can be defined as "*the confident, critical and creative use of ICT to achieve goals related to work, employability, learning, leisure, inclusion and/or participation in society*" (Ferrari, 2013, p.2). It consists of a list of 21 competencies in terms of knowledge, attitudes, and skills in five areas: (a) information and data literacy, (b) communication and collaboration, (c) digital content creation, (d) safety and problem solving, as being described in the DigComp framework (Ferrari, 2013). Teachers' digital competence is the confidence and skills to use technology effectively and creatively to engage and motivate their learners, support the acquisition of digital skills by learners and to ensure that digital tools and platforms used are accessible to all learners (European Commission, 2020a). Based on the European Framework for the Digital Competence of Educators it consists of 22 competences organised in six different areas: a) professional engagement, b) digital resources, c) teaching and learning, d) assessment, e) empowering learners, and f) facilitating learner's digital competence (European Union, 2017).

Digital maturity refers to the high level of integration of ICT in the daily operations of schools. Such schools *"operate in a supportive environment, with adequate resources, systematically and purposefully using ICT in planning and management, educational and management processes, and developing the digital competence of educational staff and students*" (UNESCO, 2019, p. 6).

Digital transformation refers to "*a series of deep and coordinated culture, workforce, and technology shifts and operating models*" (Brooks, & McCormack, 2020, p. 3) that bring cultural, organisational, and operational change through the integration of digital technologies (JISC, 2020).

Digitalisation "*refers to the adoption or increase in use of digital or computer technology (by an organisation, an industry, or a country) and therefore describes more generally the way digitisation is affecting economy and society*" (OECD, 2017). According to Eurydice (2019) digital transformation and digitalisation are used interchangeably and refer to a broad concept affecting politics, business, and social issues (p. 110)

Self-assessment tools are "*instruments that assist professionals in evaluating the effectiveness of their performance and help them determine what improvements are required*") (Eurydice, 2019).

Self-evaluation "*refers to an activity in which schools systematically review the quality of the instruction and education services provided, as well as school outcomes*" (OECD, 2015b, P. 484). It involves internal evaluation that is formative (OECD, 2015b).

Self-reflection tools are structured tools which are used to help in the process of reflection in practice with the aim of improvement (Costa et al., 2021). Costa et al. (2021) consider self-reflection as a synonym of self-evaluation.

The definitions which follow are specifically related to the QUASI Theory of Change:

Inputs are the resources used for the development of interventions, namely financial, human, material, technological, and information resources. For instance, the budget, the amount of staff time required, and the relationships with other organisations (UNDG, 2011; Harries, Hodgson, & Noble, 2014).

Activities are "*actions taken, or work performed through which inputs, such as funds, technical assistance and other types of resources, are mobilised to produce specific outputs*" (UNDG, 2011, p.8).

Results "*include outputs, outcomes, and impacts*" (Mayne, 2015, p.121).

Outputs are the products, services or facilities that result from the implementation of activities within an intervention. These are often expressed in the quantity of what is delivered; for example, the number of users, how many sessions they receive and the amount of contact you have with them (Harries, Hodgson, & Noble, 2014, p. 4).

Outcomes represent changes in the institutional and behavioural capacities, such as policy, law, behaviour, attitude, knowledge, state of the environment (UNDG, 2011; Taplin, Clark, Collins, & Colby, 2013). They include long-term and intermediate/short-term outcomes (Taplin, Clark, Collins, & Colby, 2013).

Impact describes all the (positive or negative **long-term effects**) changes in knowledge, skills, behaviour, mindset, practices, values, attitudes, health or living conditions for all the actors related to a school community (students, teachers, administrative staff, parents) produced by a development intervention (e.g., integration of digital technologies and self-reflection tools in education), directly or indirectly, intended, or unintended. The definition of impact is derived from the combination of the definitions given from three relevant sources (https://youmatter.world/en/definition/impact-definition/; UNDG, 2011, p.7; Hyttinen & Kazoka, 2020).

Impact pathways refer to causality and show the linkages between the sequence of steps in getting from activities to impact (Mayne, 2015).

Assumptions are the underlying beliefs about how a project will work, the people involved and the context. These are sometimes implicit in a logic model or theory of change, but it can be useful to state them explicitly (Harries, Hodgson, & Noble, 2014)

Annex

In this section we provide the list of references used for the literature review organised in themes.

I.Meta-analyses

Archer, K., Savage, R., Sanghera-Sidhu, S., Wood, E., Gottardo, A., & Chen, V. (2014). Examining the effectiveness of technology use in classrooms: A tertiary meta-analysis. Computers & Education, 78, 140-149. https://doi.org/10.1016/j.compedu.2014.06.001

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