Education International Research

A Review of Technology in Teaching and Learning

Dr Alison Egan

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Education International represents organisations of teachers and other education employees across the globe. It is the world's largest federation of unions and associations, representing thirty million education employees in about four hundred organisations in one hundred and seventy countries and territories, across the globe. Education International unites teachers and education employees.

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Foreword

When the Education International Research Institute (EIRI) commissioned its research review of technology in teaching and learning no one could have predicted COVID 19 and its impact on technology and education. Yet its author, Dr Alison Egan, is remarkably prescient. Her analysis and prediction of trends in technology in education have been amplified by the effect of pandemic triggered school closures. The accuracy of her recommendations-that technology should not be introduced before the pedagogical reasons for it are made clear and that is was essential that there should be an awareness of the technological self-efficacy skills of teachers-have been validated by the effects of the pandemic on schools.

The education systems that have done best during the pandemic are ones that have included strong technological content in Initial Teacher Education. They have supported teachers with technological hardware and have provided good quality continuous professional learning and development. Many systems, however, have done little in these areas and they have struggled to help teachers and students to adjust to remote learning. In all systems, equity of access for students-and for teachers-to technology have come to the fore as major issues, with the digital divide between the digitally advantaged and disadvantaged being accelerated.

It has been clear from Dr Egan's study that a disparity of approaches to technology and pedagogy have been in existence for some time. The literature is opaque about what actually works, but frameworks for teacher capabilities in this area can certainly help. Government policy makers need to understand teachers' technological self-efficacy if they are to make sound decisions about teacher policy and this can only happen successfully with the involvement of teachers and their unions.

Teachers can only make informed decisions about how best to use technology pedagogically if they are well trained and well informed. They can then share their experiences within their own peer networks and make the right choices for the right situations. A profession which owns its professional standards and has the professional autonomy to make learning holistic is the only realistic way for the future.

This pandemic and Education International's ongoing work on the future of work in education has highlighted how rapidly the educational environment is changing. As Artificial Intelligence becomes a present day reality, opportunities for positive change are often undermined by IT companies data mining and using its results to influence subliminally student learning. This in turn fundamentally undermines the ability of high-quality education to produce students who are pro-active learners and critical thinkers. If technology is to help education, it must do so for all students and all schools.

Technology offers much promise but to realise this promise, governments need to work in partnership with the profession and its unions to enable teachers to show leadership in decision making. Professionally trained and well qualified teachers and education personnel must be given the tools to ensure that students are given universal access to digital technologies so that technology is not for the privileged few but for all.

David Edwards
General Secretary
Eduaction International

Table of Contents

Foreword 5
Table of Contents 7
Executive Summary 1
Technology in Education 3
Definition of Technology in Education 3
Pedagogies Associated with Technology 4
Technological, Pedagogical and Content Knowledge 5
Other Models of Technology Integration 6
Technology Standards & Curriculum 10
United Nations 10
OECD & UNESCO Influence 11
European Countries 12
North America 15
Latin America 16
Africa 16
Asia – Pacific Region 17
Australia and New Zealand. 18
Factors That Influence Technology Integration 19
First Order Factors 20
Physical environment 20
Technical support 21
Technocentricism 22
Second Order Factors 22
Cultural values & social context 23
Teachers' beliefs about technology 25
Self-Efficacy & Autonomy 27
Computer self-efficacy 28
Subsequent use of technology 28
Competence gaps 29
Role of Teacher Education 31
What can teacher education do to help? 32

Benefits and Risks of Technology in Education 34

Affordances of Technology **35**

Assistive technologies 36

Distance learning, micro-credentials and blockchain 36

Equity of access and 5G 38

Risks of Educational Technology 39

Wellbeing **39**

Commercial interests **40**

Artificial intelligence **41**

Conclusion and Recommendations 43

References 45

List of Figures

Figure 1. *TPACK Model* *5*

Figure 2. *The UTAUT Model-Venkatesh et al. (2003)* *7*

Figure 3. *Dicte (2019), Pedagogical, Ethical, Attitudinal and Technical dimensions of Digital Competence in Teacher Education.* *8*

Figure 4. *UN Sustainable Development Goals (2015)* *10*

Figure 5. *UNESCO ICT Competency Framework for Teachers* *11*

Figure 6. *DigCompEdu Competency Framework* *12*

Figure 7. *Digital Strategy for Schools, Ireland - Key Principles* *13*

Figure 8. *Visualisation of the Professional Digital Competence Framework for Teachers (Norway) by Kelentric et al., 2017* *14*

Figure 9. *ISTE Standards for Educators* *15*

Figure 10. *ICT in Education Asia-Pacific Region* *17*

Figure 11. *EDUCAUSE Horizon Report 2019* *34*

Figure 12. *Gartner Hype Cycle for New Technologies, 2019* *35*

Figure 13. *Learnovate explain how Blockchain will be used in education* *37*

Executive Summary

The objective of this review is to outline current thinking on the role of technology in education. This paper was written before the global Covid -19 pandemic that forced an "online pivot" (Weller, 2020) in educational settings. The "wicked problem" (Marshall, 2016) of technology integration in education is now a significant concern for many educators, due to the Covid "black swan" event (Taleb, 2007). This event makes the current review even more crucial as factors that impact integration of technology in educational contexts are discussed in detail. Hence, this paper favours a pedagogical rather than techno-centric approach to integration of technology in educational environments. The review outlines the various technology standards and policy documents available to EI member states, and then proceeds to discuss factors that influence technology integration in educational contexts. These integration factors include availability of technology, technical support, beliefs about technology, teacher autonomy, technological self-efficacy and cultural values related to technology. The theoretical models of TPACK, SAMR and PEAT are reviewed, and their application to technology integration in educational contexts outlined.

The final section analyses the benefits and risks of educational technologies. Assistive technologies, the affordances of distance learning and how mobile devices have changed the way students access education, are discussed. Concerns about over-reliance on technology are then examined, and a discussion of the risks associated with commercial interests, artificial intelligence and data privacy outlined. The report concludes with ***four key recommendations*** for EI members:

1. Technology should not be introduced to an educational environment if the pedagogical reasons for it are not clear. The *TPACK* and *PEAT* models of technology integration should be considered before making a decision to purchase and use any new technology in education.

2. An awareness of the technological self-efficacy skills of educators, staff and students is advised where often a *Dunning Kruger* effect persists. The value of *DigCompEdu* and other appropriate frameworks as a reliable method to identify digital competencies required for modern education cannot be underestimated.

3. Educators should be empowered to evaluate what educational technologies they can use in their school or teaching environments. This can be done by allowing them the time and space to share their experiences of technology with each other, to experiment with new technologies and to share their experiences amongst their peer network. Their "*emergency remote teaching*" (Hodges, Moore, Lockee, Trust & Bond, 2020) experiences using technology with their students during the recent pandemic provides a timely opportunity to undertake such reflection.

4. Members should review the annual *Gartner* and *New Media Horizon* reports on a frequent basis, to ensure they are aware of all technological development in education, and elsewhere. For example, AI, Blockchain and 5G technologies are on the horizon for educational environments, in the near future.

At the conclusion of this report it should be noted that education has been rooted in traditional pedagogical approaches for some time and a tipping point is imminent. Covid-19 may indeed have been such an event.

Technology in Education

This section provides an overview of the understanding of technology in education present in the literature. A definition of technology in education is provided, and how the concept of technology is understood in an educational context is outlined in this section.

Definition of Technology in Education

Neer (2014) defines technology in education as "*any tool a teacher uses to convey the lesson or interact with students…that can range from a whiteboard and marker (low-technology) to a tablet with a stylus (high-technology) and beyond*". Egan, FitzGibbon, Oldham, and Johnston (2014) established that educators did not differentiate between different types of hardware and software they used in a classroom context, and often spoke about technology in a wider sense, and used software and hardware terms interchangeably. Equally, Olszewski and Crompton (2020) noted that "*teachers often use technology for social purposes but do not use them in school for educational purposes*". Thus a lack of clarity around the term 'technology' in an educational context is further compounded when we consider educators often use their own 'personal' technologies (such as social media) in 'professional' contexts (Admiraal et al., 2017; Almerich

Orellana, Suárez-Rodríguez, & Díaz-García, 2016; Drabowicz, 2017; Hatlevik, Throndsen, Loi, & Gudmundsdottir, 2018; Koc, 2013; McGarr & Johnston, 2019; Prestridge, 2019). For this report, the term technology will be used in its widest sense to describe any software or hardware tool that is used in an educational setting, or a combination of both.

Pedagogies Associated with Technology

The main pedagogical domains associated with educational technology are behaviourism (Skinner, 1968), constructivism (Piaget, 1971), social constructivism (Vygotsky, 1978) and liberationalism (Freire, 1996). Each of these have contributed to how technology has been used in educational environments over the past fifty years where Skinner's behaviourism is synonymous with drill and practice type lessons and Vygotsky's approach considers that knowledge is constructed by learners through their social interactions with each other. Piaget's constructivist approach is based on the belief that learners construct their own knowledge by being actively involved in the learning process, for example when children learn how to code and a liberational approach suggests a 'problem posing pedagogy' based on a learner's current interests.

Content knowledge, curriculum knowledge and pedagogical knowledge have been outlined as key domains of knowledge required to be an effective teacher (Ball, Thames, & Phelps, 2008; Dewey, 1904; Dewey, Boydston, & Ross, 1983; Shulman, 1986). Looking at the concept of pedagogical content knowledge, Shulman (1986) established that teachers not only needed to know their subject matter, they needed a different level of knowledge to be able to teach this subject matter. So, while their content knowledge was a given, "*pedagogical content knowledge is a particular form of content knowledge that embodies the aspects of content most germane to its teachability (sic)*" (p. 7).

Generally, pedagogical knowledge domains for classroom technology integration are focused on constructivist approaches to education. Such a constructivist paradigm, as advocated by early educational philosophers (Dewey 1916, 1938, 1956, Piaget 1971 & Papert 1996), is evident in recent literature on technology integration (Ball et al., 2008; Feng, Ching Sing, Chin-Chung, & Min-Hsien, 2014; Koh & Chai, 2016; Lai & Bower, 2019; McGarr & Johnston, 2019; Mena, Hennissen, & Loughran, 2017; Meschede, Fiebranz, Möller, & Steffensky, 2017; Olofson, Swallow, & Neumann, 2016; Petko, 2012; Teo, Ching, David, & Beng, 2008). This literature has moved to question the requirement for new pedagogies to accommodate the use of digital technologies (Caro & Harvey, 2016; Ertmer & Ottenbreit-Leftwich, 2013; Fitzgerald & Adams, 2016; Heitink, Voogt, Verplanken, van Braak, & Fisser, 2016; Mama & Hennessy, 2013;

Spaulding, 2016). A focus on TPACK as a pedagogical approach to ensure successful technology integration in education, is the focus of the next section.

Technological, Pedagogical and Content Knowledge

The addition of technological knowledge to the pedagogical and content knowledge domains has led to the concept of TPACK (Technological, Pedagogical & Content Knowledge) (Mishra & Koehler, 2006) that has been a prevalent discourse in the literature for the past fifteen years (Banas & York, 2014; Campbell, 2012; Campbell et al., 2012; Caro & Harvey, 2016; Koh & Chai, 2014, 2016; Lehtinen, Nieminen, & Viiri, 2016; Olofson et al., 2016; Powers & Musgrove, 2016; Shinas, Yilmaz-Ozden, Mouza, Karchmer-Klein, & Glutting, 2013; Tondeur, van Braak, Siddiq, & Baran, 2016; Valtonen et al., 2020; Voogt et al., 2013). The TPACK model concentrates on "*the relationships between content (the actual subject matter that is to be learned and taught), pedagogy (the process and practice or methods of teaching and learning) and technology (both commonplace, like chalkboards, and advanced, such as digital computers)*" (Mishra & Koehler, 2006, p. 1026). Further, work by Klichowski and Costa

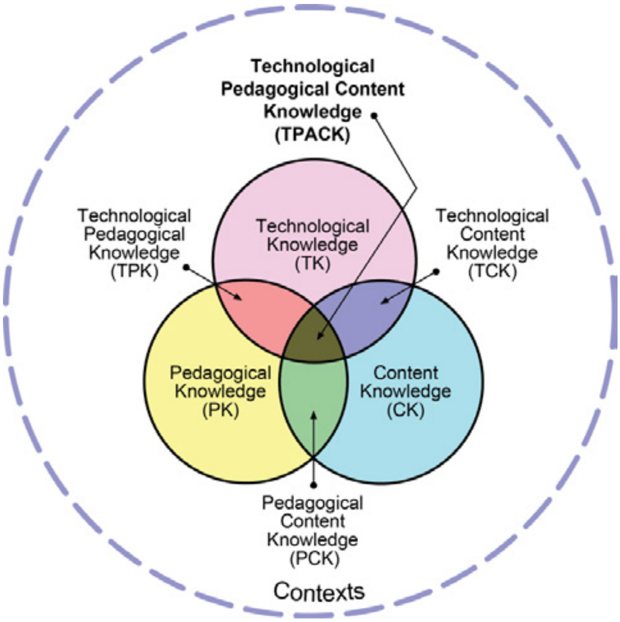

Figure 1. TPACK Model

(2015) contends "*there is no doubt that the education of teachers required many significant modifications in the context of ICT*" (p. 164).

This 'modified approach' [TPACK] can be difficult and is often based on a "*rational fear of having to adapt to a new technological environment in their educational setting*" (p. 166). Further, the requirement for new pedagogies was noted by the EU Commission (Bocconi, Kampylis, & Punie, 2013) as part of a European *Innovating Learning* Strategy and Creative Classrooms initiative. The EU Commission had "*acknowledged that a fundamental transformation of education and training is needed to address the new skills and competences that will be required if Europe is to remain competitive*" (p. 1). Fullan and Langworthy (2014) also recommended that new pedagogies were now required in education, as old pedagogies were no longer suitable in the digital age where,

> *the dawning digital era changes fundamental aspects of education. It changes the traditional role of teachers and textbooks as the primary sources of knowledge. It changes* what it is possible for students to do*, as technology enables them to discover, create and use knowledge in the real world faster, more cheaply, and with authentic audiences. In the past what most educators meant by the term "applying knowledge" was working on tasks or solving problems to demonstrate mastery of concepts. But the solutions remained within the boundaries of textbooks, classrooms and schools. Digital access makes it possible for students to apply their solutions to real-world problems with authentic audiences well beyond the boundaries of their schools (Fullan & Langworthy, 2014, p. 4).*

This is also advocated in recent literature by Heitink et al. (2016) and Mead (2019) where pedagogical control continues to be a concern for educationalists in this new digital environment (Drummond & Sweeney, 2017; Redmond & Lock, 2013). However, a recent comment by Mishra (2019), suggests use of technology in education should consider "*the what to the* why *in educational technology*" usage in educational contexts.

Other Models of Technology Integration

Other models have been proposed to measure integration of technology in education. For example, the Access *Competence and Motivation* (ACM) model (Viherä & Nurmela, 2001) queried whether communication capability was a determinant for technology use in Finland. Having access to technology (A) and competence in using technology (C), combined with a motivation (M) to be online was their central premise. Their research concentrated on what modern IT and communications systems require of their users. Their study veered into criticism of modern technology, as being "*a social trap*" (p. 263) and their ACM model was limited in its application. Wu, Chen, and Lin (2007) had proposed a model called "*end user computing acceptance (EUC) model*". Their results did state that "perceived ease of use (PEU), perceived usefulness (PU) and computer enjoyment (CE) all directly influenced actual usage of technology" (p. 173). The *Meta-Cognitive Model of Attitudes* (MCM) (Petty, Briñol, & DeMarree, 2007) was based on the presumption that attitudes had an impact on technology integration in educational settings. They explained that "*the number of prior positive and negative experiences, the recency (sic.) of those experiences and the context in which those experiences took place will matter*" (p. 662). The *Task Technology Fit Model* (TTF) (Dishaw & Strong, 1999; Goodhue & Thompson, 1995; Yen, Wu, Cheng, & Huang, 2010) queried whether the task for which the technology was used should be a good fit for the task it supported, in effect, was the technology appropriate for the task at hand. As there was plenty of literature about the applications of ease of use and perceived usefulness on technology integration, Birch and Irvine (2009) looked to create a "*unified view*" (p. 425) as "*information technology acceptance research has yielded many competing models, each with different sets of acceptance determinants*" (p. 425). In their work, they reviewed eight predominant

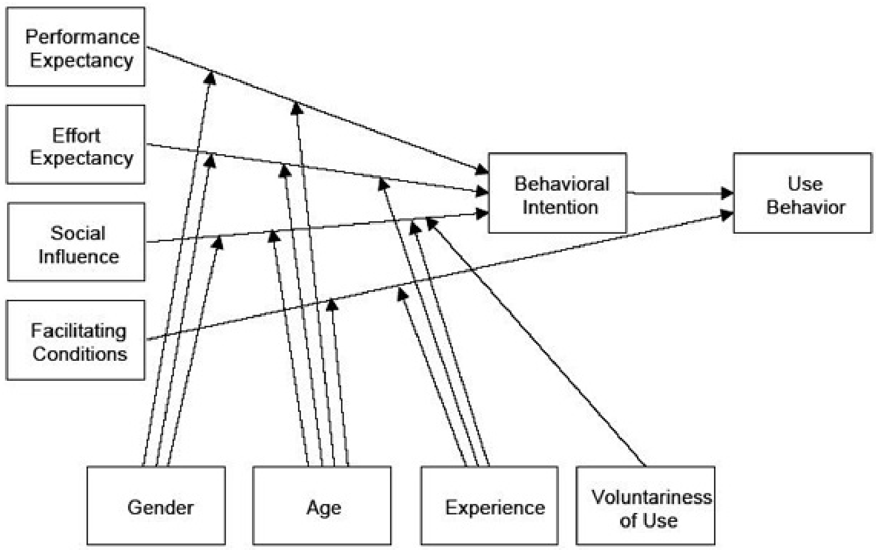

Figure 2. **The UTAUT Model-Venkatesh et al. (2003)**

models of measurement of technology acceptance. They mentioned social cognitive theory (Bandura, 1977, 1997; Compeau & Higgins, 1995), the theory of reasoned action (Fishbein & Ajzen, 1975), perceived usefulness (PU) & perceived ease of use (PEU) with subjective norms (SN) (Davis', 1989) motivational model; the theory of planned behaviour (Ajzen, 1991) and finally a combined TAM and TPB model (Venkatesh, Morris, Davis, & Davis, 2003). Having conducted four longitudinal field studies in different institutions, they arrived at the *Unified Theory of Acceptance and Use of Technology* (UTAUT) Model. What the UTAUT Model did establish was that "*attitude to technology is defined as an individual's overall effective reason to using a system*" (p. 455) and there were four constructs from existing models of attitude measurement that aligned with their newly proposed model.

Recently, Nistor, Göğüş, and Lerche (2013) and Nistor, Lerche, Weinberger, Ceobanu, and Heymann (2014) extended the UTAUT model to include specific cultural influences and how different cultures exhibit different attitudes to technology. With a large sample from Germany and Romania (n = 2866), they acknowledged that "*national and professional culture may shape use of computer based learning environments*" (p. 36) where facilitating conditions and computer anxiety featured strongly for German technology users, but not for their Romanian counterparts. Of note in their conclusion was the suggestion that future research should be mindful of cultural influences on acceptance of technology by users,

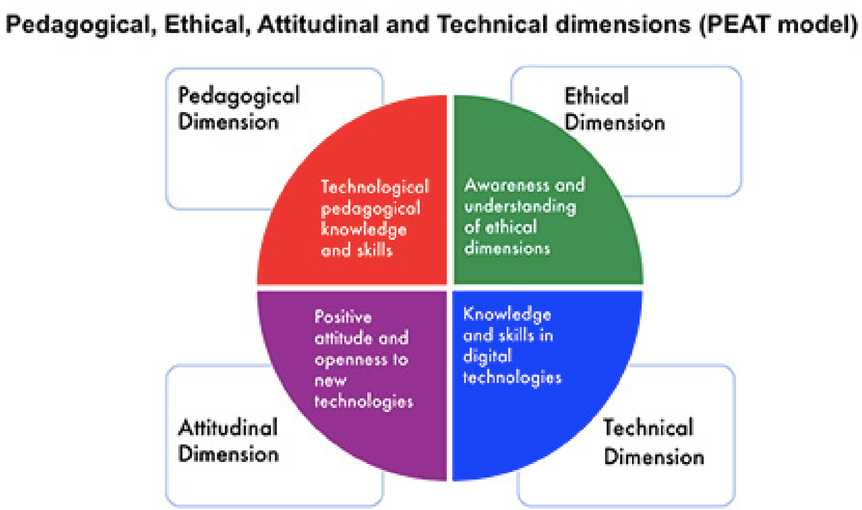

Figure 3. Dicte (2019), Pedagogical, Ethical, Attitudinal and Technical dimensions of Digital Competence in Teacher Education.

re-iterating the role of subjective norms and facilitating conditions outlined by Teo (2010). However, in a recent publication by McGarr and McDonagh (2019) the persistent value of TPACK was acknowledged, but their research added an '*ethical*' dimension in their PEAT model. This PEAT model identifies that educators using technology should also understand the complex relationship between technology and society, and should be aware of privacy, copyright and more general cyber-ethics, in combination with the more traditional technical, pedagogical and attitudinal skills established in TPACK (Figure 3).

However, national educational policies are often written without consideration of environmental factors, such a school culture and norms, that impact those educators charged with implementation of such reforms (Egan, 2018). These policy documents are considered briefly in the next section and will outline various countries' digital technology and education standards.

Technology Standards & Curriculum

"*Education systems around the world are now witness to a variety of educational changes and improvements, numerous social and economic disruptions, and the onset of rapid technological advances that were unimaginable in the past*" (Association, 2017, p. v). In this section a brief overview of the technology standards and technology competency frameworks, of some countries (in which there are EI members) are discussed. These standards and competency models are created by ministries and departments of education and have tended to focus on hardware and software acquisition and latterly on the pedagogies and skills associated with use of technology in educational settings. These policies are not written in isolation however, and a consultative process is usually part of their formulation, involving all education stakeholders such as teachers, unions and universities.

United Nations

Figure 4. **UN Sustainable Development Goals (2015)**

Also worth noting in this section are the United Nations' Sustainable Development Goals (SDGs), in particular Goal 4, in relation to Quality Education (Figure 4). The objective of this goal is to "*ensure inclusive and equitable quality education and promote lifelong learning opportunities for all*". A progress report in 2019 notes that while progress has been made regarding access to education and participation, over 262 million children remain out of school. Furthermore, minimum proficiency standards in literacy and numeracy were still lacking for nearly half of those in school environments (SDG 4.1.1). Goal 4 continues to address those in marginalised settings and is concerned with the proportion of youth and adults with ICT skills, by type of skill (SDG 4.4.1), in particular.

OECD & UNESCO Influence

	TECHNOLOGY LITERACY	KNOWLEDGE DEEPENING	KNOWLEDGE CREATION
UNDERSTANDING ICT IN EDUCATION	Policy awareness	Policy understanding	Policy innovation
CURRICULUM AND ASSESSMENT	Basic knowledge	Knowledge application	Knowledge society skills
PEDAGOGY	Integrate technology	Complex problem solving	Self management
ICT	Basic tools	Complex tools	Pervasive tools
ORGANIZATION AND ADMINISTRATION	Standard classroom	Collaborative groups	Learning organizations
TEACHER PROFESSIONAL LEARNING	Digital literacy	Manage and guide	Teacher as model learner

Figure 5. UNESCO ICT Competency Framework for Teachers

The United Nations Educational, Scientific and Cultural Organisation (UNESCO, 2011) created a set of competencies, skills and attitudes for teachers in the use of technology for learning. These skills were based on six principles of pedagogy, understanding the role of technology in education, technology skills, teachers' professional learning and technology in different contexts. What is interesting about the UNESCO framework is that the skills and competencies outlined would go on to form the basis of many European national educational policy documents.

The impact of the Organisation for Economic Cooperation and Development (OECD) on use of technology in education is also relevant (Ananiadou & Claro, 2009; Katerina Ananiadou & Rizza, 2010; Enochsson & Rizza, 2009; Huang & Kan, 2020; Istance & Kools, 2013; McGarr & Johnston, 2016; Meisalo, Lavonen, Sormunen, & Vesisenaho, 2010; Rizza, 2011; Schleicher, 2012). As noted in a recent editorial piece, "*local educational reform cannot be separated from a global context which is featured by a 'post national' policy environment and internationalisation of educational policies*" (Huang & Kan, 2020, p. 296). Indeed, a "*rhetoric of reform*" (Vrasidas, 2015) pervades many national policies on technology integration in education. In an Irish context, when the reports on literacy and numeracy skills were issued by the Programme for International Student Assessment (PISA) these "*findings form a significant contribution to policy development in Ireland*" (ERC, 2015). For example, as a result of PISA 2009 a new *Literacy and Numeracy Strategy for Learning and Life 2011 – 2020* was issued by the Department of Education subsequently (DES, 2011). The impact of a recent *Skills Outlook* publication (OECD, 2019) has yet to be determined, but it will be of interest for policymakers over the next few months and years, when developing their own local technology policy frameworks. This publication acknowledges that "*to thrive in a digital workplace, workers need a broad mix of skills – strong cognitive and socio-emotional skills, as well as digital skills*" (OECD, 2019, p. 3).

European Countries

Most of the European countries' technology frameworks are influenced by their membership of the European Economic Community, and their involvement in UNESCO. The DigCompEdu (Redecker & Punie, 2017) publication presents a framework for the development of educators' digital competence in Europe (Figure 6). "*This framework responds to the growing awareness among many European Member States that educators need a set of digital competencies specific to their profession in order to be able to seize the potential of digital technologies for enhancing and innovating education*" (Redecker, 2017, p. 8). The framework structure "*allows European citizens to better understand what it means to be digitally competent and to assess and further develop their own digital competence*" (Redecker, 2017, p. 12). Evident in this framework is a reliance on professional and pedagogic competencies, rather than a

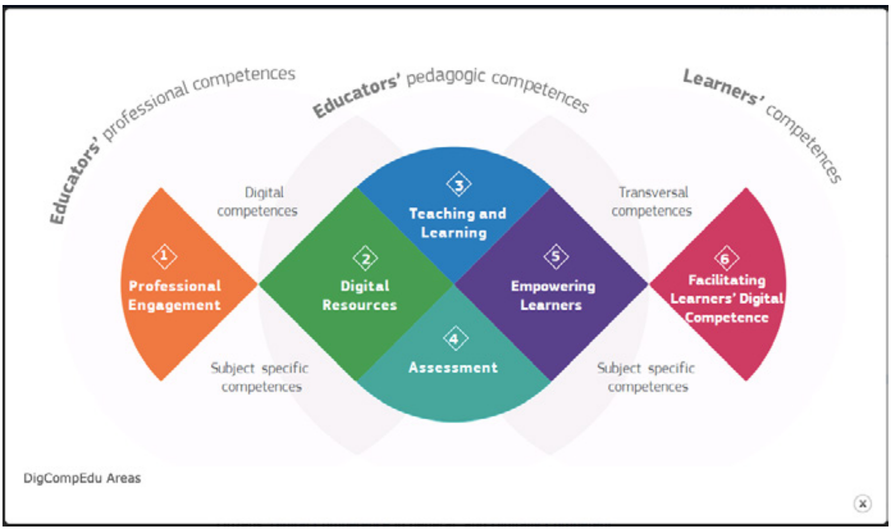

Figure 6. DigCompEdu Competency Framework

focus on technology specific skills associated with particular educational technologies only. The framework was based on a long consultative process with various educational stakeholders in Europe, before its publication.

An outline of different countries' approaches to technology integration is now outlined. In Ireland, for example, the Digital Strategy for Schools (DES, 2015) demonstrated an awareness of the skills that would be required in the future for educators in schools based on extensive consultation with teachers (Butler, Hurley & Hallissy, 2018). The Digital Strategy was notable for its move away from a "*technocentric*" (Selwyn, 2019) view of technology in education, to a focus on the pedagogies associated with effective technology integration. Indeed, the annual Action Plans for Education (DES 2016, 2017) have acknowledged the requirement for technological pedagogies to equip educators with the necessary skills to use technology effectively in their classrooms. In Figure 7 the key principles of the Irish Digital Strategy are outlined. The Digital Strategy was not without its critics, where some authors suggested the Department of Education was still focused on hardware and software acquisition for the first phase, without implementation and support structures required to allow for effective technology integration by educators (INTO, 2015; Marshall & Anderson, 2008; McDonagh & McGarr,

PRINCIPLES UNDERPINNING THE STRATEGY

In developing the Strategy, the Department engaged in an extensive research and consultation process, which is outlined in the next section. A number of key principles were identified during this phase of developing the Strategy and they will inform the goals and actions outlined in the Strategy.

TABLE 1: KEY PRINCIPLES INFORMING THE DIGITAL STRATEGY FOR SCHOOLS

Principle	Descriptor
1. A Constructivist Pedagogical Orientation underpinning the embedding of ICT in schools.	A constructivist pedagogical orientation supports teachers in effectively using ICT with their students i.e. learners are actively involved in a process of determining meaning and knowledge for themselves.
2. The use of ICT in teaching, learning and assessment can enhance the learning experiences of all students.	ICT plays an important role in supporting inclusion and diversity for all learners by enhancing learning opportunities for all students.
3. The use of ICT in teaching, learning and assessment is embedded in school curricula, Department policies and teacher education.	The Department and its agencies will play a proactive role in implementing the Digital Strategy for Schools.
4. ICT is used in an ethical and responsible way.	Schools and the Department enable all users to use ICT in an ethical and safe way.
5. ICT Planning is required to ensure ICT integration in teaching, learning and Assessment.	All levels of the education system are engaged in inclusive planning for the effective integration of ICT.

Figure 7. **Digital Strategy for Schools, Ireland - Key Principles**

2015). McGarr and Johnston (2019) have noted however, that recent technology policy documents have attained pedagogical maturity in their recognition of the "*complex and contextually bound nature*" of technology integration in educational environments, where the "*nature of ICTs has changed dramatically in the past two decades and Irish educational policy has tweaked its orientation in response to these changes*" (p. 21).

In the Nordic countries technology integration is well grounded in educational policy documents. The Norwegian approach to technology integration was to include technology in all subjects as a means of improving the teaching of that subject, and to open up new methods of teaching. Hence, technology was not seen as adjunct or separate but was seen as a competence required of teachers. Thus such digital competence is expected of all teachers, in all settings and is seen as a basic skill required to be a teacher (Ministry of Education, Norway, 2017). A visualisation of the Norwegian Professional Digital Competence Framework is relevant here (Kelentrić, Helland, & Arstorp, 2018) (Figure 8).

Figure 8. Visualisation of the Professional Digital Competence Framework for Teachers (Norway) by Kelentric et al., 2017

In Sweden, Gu (2011) noted that technology has been included in education since the mid-eighties (Fahrman & Gumaelius, 2015) and teachers have autonomy and freedom to integrate technology into subjects as they see fit, dependent on class sizes and teachers own competence using technology. In Finland, as a result of a review of the National Core Curriculum, the role of technology in learning is promoted to play a significant role in the Finnish classroom (Alamäki, 2000;

Vahtivuori-Hänninen, Halinen, Niemi, Lavonen, & Lipponen, 2014) where the curriculum emphasises technology competencies and skills, and technology is seen as integral to the process of teaching and learning. Hence, a recent publication acknowledged that in countries such as Finland, Norway and Sweden "*many people use the internet in complex and diverse ways… and these individuals are more likely to be able to adapt if digitalisation affects their daily activities, since they already have the well-rounded skills mix that is required for new working techniques, methods or technologies*" (OECD, 2019, p. 165). As a result, technology integration in education has been somewhat successful in these countries.

North America

The International Society for Technology in Education (ISTE) Standards are a framework for innovation in education and provide a roadmap for educators to re-imagine their classrooms and schools for digital age learning (ISTE, 2004). The standards are designed to work with a TPACK pedagogical approach to using technology in classrooms. There are plenty of resources available on the ISTE website to allow teachers to

1 Learner	Educators continually improve their practice by learning from and with others and exploring proven and promising practices that leverage technology to improve student learning. Educators:
2 Leader	Educators seek out opportunities for leadership to support student empowerment and success and to improve teaching and learning. Educators:
3 Citizen	Educators inspire students to positively contribute to and responsibly participate in the digital world. Educators:
4 Collaborator	Educators dedicate time to collaborate with both colleagues and students to improve practice, discover and share resources and ideas, and solve problems. Educators:
5 Designer	Educators design authentic, learner-driven activities and environments that recognize and accommodate learner variability. Educators:
6 Facilitator	Educators facilitate learning with technology to support student achievement of the ISTE Standards for Students. Educators:
7 Analyst	Educators understand and use data to drive their instruction and support students in achieving their learning goals. Educators:

Figure 9. **ISTE Standards for Educators**

integrate technology in their classrooms (ISTE, 2017). ISTE also created standards for students, administrators, coaches and computer science educators subsequent to the educator standards. Stoecki (2016) described the consultation process involved in the creation of these standards where "*a first full draft of the standards were released for public comment and we are seeking broad feedback from thousands of educators and other stakeholders", and teachers were assured that "everything was up for debate*", at that time.

However, these standards are not without their critics and some research has suggested (Shellhorn, 2019) that educators were lagging behind in implementation of the standards across all curriculum subjects. ISTE are due to issue updated Standards for Educators in 2020 and have recently revised their Standards for Computer Science educators. Recently, Foulger, Graziano, Schmidt-Crawford, and Slykhuis (2017) published new Teacher Educator Technology Competencies (TETCs) and identified 12 skills/competencies required to effectively integrate technology in classrooms. While a recent initiative, they hope their competencies will add to wider reform of teacher preparation programmes in the USA in the first instance when used in conjunction with the ISTE standards.

Latin America

Many Latin American countries have been slower to integrate technology into their curriculum than their Northern counterparts. National policies require formal definition of ICT integration into the education curriculum of 82% of Latin American countries (UNESCO, 2012). Adoption of Open Educational Resources (OERs) has also been successful, where national policies require them to be used in education. Furthermore, Uruguay's '*One Laptop per Child*' project has been instrumental in ensuring children get access to a computer from an early age. However, problems with internet access and the presence of a socio-economic digital divide are still a concern for some Latin American countries. Equally, policies continue to have a focus on technology acquisition and have yet to address the more pedagogical issues faced by those further along the technology integration path (Jassir, 2018).

Africa

Education in Africa is firmly rooted in the Sustainable Development Goals, as outlined earlier. Africa's main focus is on "education for all" to ensure children can complete a full course of primary education, in the first instance, for all genders. Lack of proper educational facilities continues to hamper progress towards this SDG, and access to technology continues to present problems for African schools. Educational technology programmes, such as "*One Laptop per Child (OLPC), 2005*", similar to South America, offered low cost personal laptops to schools. This project had some success where over 2 million low cost laptops were delivered to African schools. Eventually, the project was taken over by local governments who were charged with distribution of the equipment. However, access to technology for education in Africa is often based on a donor model, where machines from more developed countries are refurbished and then transported for use. Many high profile charitable organisations run such programmes, for example Camara (Ireland) and Computers 4 Africa (UK), and larger organisations such as Microsoft and Apple also provide donations through their philanthropical programmes.

M-learning, where educational services are delivered using a mobile phone, is the main growth area in that continent. Recent initiatives include video lessons delivered on mobile devices, where learning does not have to happen in a classroom environment. Kindle readers and tablet devices are used to deliver literacy and numeracy content and Lequentrec (2017) advises that such low-cost teaching resources "*means there is huge potential to reach those excluded from the education system*". As such, a review of Africa's progress towards SDG 4 in 2020, will be of interest for the current research project.

Asia – Pacific Region

As early adopters of technology the Asia-Pacific countries implemented a UNESCO funded *ICT in Education* programme in 2007. This strategy was funded by Japanese Funds in Trust and was an "*integrated strategy, with six interrelated focus areas*" (UNESCO, 2007).

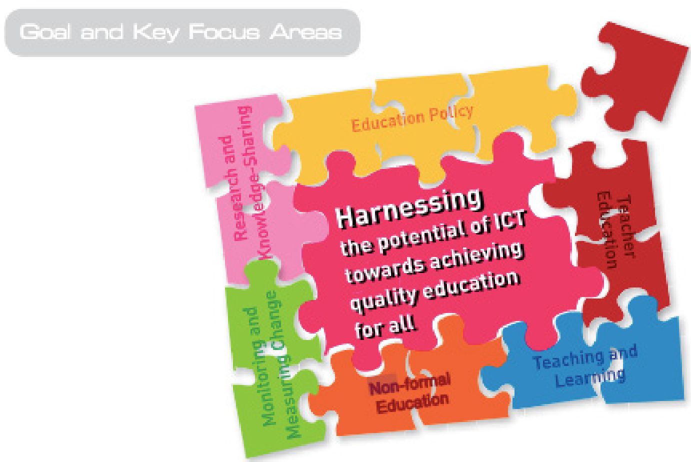

Figure 10. **ICT in Education Asia-Pacific Region**

ICT was defined for that programme, as any form of technology used to transmit, process, store, create, display, share or exchange information by electronic means. The ICT in Education programme funded projects all over that region, and this resulted in some successful integration of technology into educational content. For example, the website created for that project ensured a database of online resources was available for teachers to use in their own educational environments. However, despite having technology resources available, implementation was thwarted by some teachers' beliefs about using technology in a class environment (Marwan & Sweeney, 2010). Beliefs and attitudes to technology are discussed in the next section, in relation to barriers to effective technology integration in educational environments.

Australia and New Zealand.

Australia and New Zealand are well experienced in their standards of technology integration in education and have integrated technology across most of their curriculum standards. In Australia the Teaching Teachers for the Future (TTF) project was "*aimed at enabling all pre-service teachers at early, middle and senior levels to become proficient in the use of ICT in education*"(Australian Government, 2011). Albion (2011, 2012); Albion, Jamieson-Proctor, and Finger (2010); Buchanan (2011); Campbell et al. (2012); Redmond and Albion (2002) and Lane (2011) in various conference papers, have discussed how this TTF project in based on the TPACK model, and has been implemented with some success, in all 39 teacher education institutions in Australia.

In New Zealand digital technology is part of the core curriculum, where their *Digital Technologies & Hangarau Mathiko – National Digital Readiness Programme* learning strategy is about teaching students the theory of how technology works, and how they can use that knowledge to solve problems (Ministry of Education, New Zealand, 2017). This is an interesting strategy as it increases students' capabilities to use technology from an early age, and then students have technological self-efficacy embedded in their curriculum, from the early years. The concept of technological self-efficacy (Fanni, Rega, & Cantoni, 2013; McCoy, 2010; Moreira-Fontán, García-Señorán, Conde-Rodríguez, & González, 2019; Oddone, 2016; Teo, 2009b, 2015) is outlined in the next section, as one of the factors that can impede use of technology by individuals, so New Zealand's approach is noteworthy in this regard.

Factors That Influence Technology Integration

This section will examine a variety of external factors that influence use of technology in an educational environment. It will then explore the literature on specific internal factors that influence technology integration, including beliefs and attitudes to technology by teachers and educators. The reasons for lack of use of technology by teachers has been an area of discussion in the literature for some time. The seminal work on this area was conducted by Schunk and Ertmer (1999) and they established two main factors that impeded use of technology in an educational environment. These are known as first order (extrinsic) and second order (intrinsic) factors that aid or impede technology integration. Indeed, Ertmer (1999) and other authors (Goktas, Gedik, & Baydas, 2013; Kopcha, 2012; Kurt & Ciftci, 2012; van Braak, 2001; Weber et al., 2004; Wood, Mueller, Willoughby, Specht, & Deyoung, 2005) have continued to identify additional barriers to technology integration in educational environments, and exploration of these forms the basis of this section.

> *Educators' use of technology in the classroom has been the subject of debate in the literature as far back as the 1980s, when Cuban (2001) lamented, without attention to workplace conditions in which teachers labor (sic.) and without respect for the expertise they bring to the task, there is little hope that new technologies will have more than a minimal impact on teaching and learning (p. 197).*

Generally, the literature has remarked that educators, in particular teachers, tend to use technology in limited (Mama & Hennessy, 2013; van Braak, 2001); transmissionist (Sheil & O'Flaherty, 2006) or traditional ways (Teo, Sing, et al., 2008). Despite displaying confidence and enthusiasm for new technologies, researchers have continued to query why teachers, generally, still do not use technology in their classrooms (Bauer & Kenton, 2005; Morris, 2010; Verdegem & De Marez, 2011). Common themes have emerged in the literature, including external factors such as school policy, lack of computer hardware and lack of support and internal factors including teachers' pedagogical beliefs and their own technological self-efficacy (Drent & Meelissen, 2008; Hew & Brush, 2007; Ottenbreit-Leftwich, Glazewski, Newby, & Ertmer, 2010;

Wood et al., 2005). Previous bad experiences when using technology; feeling overwhelmed by technology and being "*time poor*" have also been identified as factors that had impeded teachers' use of technology in the classroom (Albion, 2000; Conole, de Laat, Dillon, & Darby, 2008; Mumtaz, 2000; Russell, Bebell, O'Dwyer, & O'Connor, 2003). Donnelly, McGarr, and O'Reilly (2011) questioned how teachers can be motivated to use more technology in the classroom when the "*contented traditionalist would not easily transition to becoming a selective adopter, to a creative adopter? (p. 1480)*". Furthermore, recent literature has started to question the merits of technology integration in education, where "*we have islands of success in an ocean of failure where there is little evidence to support the proposition that ICT and/or educational technology improve pedagogy or learning outcomes*" (Butler, 2015b, p. 3). Thus, the debate continues but problems associated with technology integration persist and these factors are discussed in turn.

First Order Factors

First order barriers are external to the teacher and have often been cited in earlier literature on use of technology in educational environments. First order barriers include access to technology; technical skills needed to operate technology and local support when problems arise using technology. These, however, had no effect on an educator's fundamental pedagogical beliefs about the practice of teaching (Ertmer, 1999, 2005). Primarily concerned with creating efficiencies by using technology; acquiring skills needed to use technology and the presence of technology in the classroom, first order barriers are similar to the categories offered by the more recent SAMR Model (Puentedura, 2010). Substitution (S) and augmentation (A) were first level uses of technology and were concerned with enhancement of a lesson and offered no functional improvement or change to the content of the lesson. In the SAMR model technology integration meant technology was used as a replacement for something else and was used to obviate first order barriers as outlined previously by Ertmer (1999). For example, an Interactive Whiteboard being used as a direct substitution for a whiteboard and erasable marker.

Physical environment

The technology available to the teachers in their classrooms varies in terms of quantity and quality and the most frequently reported technological barrier noted in the literature is 'lack of technology', similar to Vrasidas' (2015) experiences in Cyprus. Other physical factors include lack of a reliable Internet connection, where access to broadband in some countries still remains a concern. As such, it was noted that the facilitating conditions, defined by Venkatesh et al. (2003) as "*the degree to which an individual believes that ... technical infrastructure exists to support use of the system*" (p. 445), are often not present in classrooms. However, Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, and Sendurur (2012) have reported that "*first order barriers have long since been removed in schools*" (p.434). Their study was conducted in the US, and while their statement may be true there, it is not a universally applicable statement. In Ireland, and other countries, first order barriers to technology integration persist as outlined in the recent ICT Census (Cosgrove et al., 2013) where only 54% of classrooms had a working computer, and even less had access to a working laptop (41%). That report also noted the prevalence of aged desktop machines in schools and were aware that "*40% of computing devices in primary schools ... are more than six years old*" (Cosgrove et al., 2013, p. 194). Teachers' access to technology had also been criticised where one of the key objectives of the Irish Digital Strategy (Butler, Leahy, Shiel, & Cosgrove, 2015) has been to allow grants for equipment purchase and to improve broadband connectivity for primary schools (p. 41). As such, first order barriers are still applicable in an Irish context.

These types of barriers to technology integration are prevalent in other countries too, including Taiwan (Liu, Li, & Carlsson, 2010) Greece (Kopcha, 2012); Turkey (Goktas et al., 2013); Australia (Prestridge, 2012) and Malaysia (Umar & Hussin, 2014). Thus, the notion of 'facilitating conditions' defined by Venkatesh et al. (2003) as "*the degree to which an individual believes that ...technical infrastructure exists to support use of the system*" (p. 445), are not present in educational environments according to the literature. However, as noted by Trucano (2005) there is little research on the cost implications of removing such first order barriers. Latterly Bajracharya (2017) has argued there is an "*urgent demand for a solid strategy for the development of a cost-effectiveness integration model to integrate ICT in education*" especially in developing countries.

Technical support

Another factor that impedes use of technology in a teaching and learning environment is lack of access to technological support. Frequently, in the literature, it is apparent that despite having technology in a classroom, there are shortcomings in maintenance of that technology (Kurt & Ciftci, 2012; Nistor et al., 2014; Venkatesh et al., 2003). A lack of technical support had been noted in the *Digital Strategy for Schools* document (DES, 2015) where "*the challenge of attaining reliable and timely technical support*" (p. 43) continues to be a major issue for schools.

Technocentricism.

Generally, ICT policies tend to be focused on technology acquisition primarily, only then followed by supplemental policies addressing the pedagogical practices associated with using technology in the classroom (Selwyn, 2013). Technology integration has not yet moved on to "*technology-enabled learning*" (Ertmer & Ottenbreit-Leftwich, 2013, p. 175) as advocated in the literature. Many countries follow a similar technocentric pattern in their approach to technology integration (Perkmen, Antonenko, & Caracuel, 2016). McDonagh and McGarr (2015) had used the term "*technology somnambulism*" (p. 55) to describe the nature of ICT integration, and they identified that, generally, a school's impetus for technology integration was driven by a view of progress as "*hardware acquisition*" (p. 55). This techno-centric focus viewed technology as the impetus for change, rather than as a facilitator, best expressed by Papert (1987, p. 23) where "*it is not drill and practice, or Logo, that will achieve this or that result; it is* how *we use things*". The nature of 'how' is discussed in the next section, where despite technology being available, often a variety of internal factors inhibit technology use in educational environments.

Second Order Factors

The literature on second order barriers is focused on two main thematic concerns: teachers' beliefs about using technology (self-efficacy, teacher's pedagogical beliefs) and a variety of school factors (autonomy, context, environment and influence of peers). These second order factors are explored in this section and demonstrate the effect such intrinsic motivation has on teachers' use of technology in a teaching and learning environment. As noted by Selwyn (2011a, 2011b) the complexity of context and beliefs about technology, have continued and have persistent relevance for the literature on technology integration in education.

A report of the British Educational Communications and Technology Agency (BECTA, 2004) identified that "*a very significant determinant of teachers' levels of engagement in ICT is their level of confidence in using* *technology*" (p. 3) and that "*there is a close relationship between levels of confidence and many other issues which themselves can be considered as barriers to ICT*" (p. 3) citing access to technology, training and technical support as examples of these. Equally, second order factors, such as social norms in the school, affect whether technology is perceived as useful, and these factors are often harder to overcome according to the research (Ertmer, 1999, 2005; Ertmer & Ottenbreit-Leftwich, 2013; Ertmer et al., 2012):

> *If pre and in-service teachers are to become effective users of technology, they will need practical strategies for dealing with the different types of barriers they will face (Ertmer, 1999, p. 1).*

As such, second order factors, including computer self-efficacy and personal beliefs and attitudes about using technology in the classroom are relevant here (Ertmer, 2005). A publication by Ertmer and Ottenbreit-Leftwich (2013) outlined a concrete suggestion as to how these barriers to technology integration could be overcome in the future:

> *We suggest that the best way to achieve technology integration is by shifting our focus from promoting technology integration, per se, to promoting technology enabled learning, aimed at preparing students for their 21st century careers (p. 181).*

Cultural values & social context.

Cultural values are described as the core principles and ideals upon which an entire community exists (Hofstede & Bond, 1984). For example, in education often there are cultural norms about 'what is good teaching' (Devine, Fahie, & McGillicuddy, 2013) and these common values are shared across an education community.

Valtonen et al. (2015) suggested that subjective and cultural norms had the largest influence on a teachers' attitudes toward and subsequent decisions to use technology in education. Further, van den Beemt and Diepstraten (2016) noted the importance of a Bronfenbrenner (1979) learning ecology model approach, as applied to technology integration in education. Their research noted that where "*teachers develop dependence on others, or when they are not encouraged to use ICT, they appear less open to innovation and less eager to look outside school for possible educational uses of ICT*" (van den Beemt & Diepstraten, 2016, p. 168). As discussed by Jones et al. (2016) often teachers are "*in receipt of conflicting advice in schools*" (p. 110), where the theories they have learned during their college course, cannot be put into practice in a school placement classroom. As such, the literature has continued to highlight the impact of social models around using technology (Ell et al., 2017; Trevethan, 2017). Referred to as 'institutionalised use' by Vanderlinde et al., (2015) the influence of a school environment has also been viewed as a strong predictor of "*adoption intent*" (Sawang, Sun, & Salim, 2014) to use technology in education.

Examples of technologies teachers do use include Interactive Whiteboards (IWBs), Learning Management Systems (LMS) and mobile phones (Egan, 2018). Nikleia (2008) remarked that teachers used IWBs in "*ways that are restricted and traditional, more like high tech chalkboards, than educational tools*" (p. 681). Slay, Siebörger, and Hodgkinson-Williams (2008), re-iterated this point, and found lack of "ICT literacy displayed by teachers and learners and the cost of technology" (p. 1321) as limiting the use of this IWB technology. De Smet, Bourgonjon, De Wever, Schellens, and Valcke (2012) questioned adoption of an LMS by teachers and suggested that teachers should be supported in their use of technology as they found this support valuable and inspirational. However, an example in the US reflects the reality of technology use in a classroom. In an exploration of teachers' perceptions of mobile phone use (Thomas, O'Bannon, & Britt, 2014) their results "*indicated that teachers are using the same old tools (clock, alarm timer, calculator, internet for research)…avoiding the newer technologies like educational apps, podcasts/vodcasts and QR codes*" (p. 386) on their mobile devices, and were as such, still using technology in traditional ways. Egan (2019) noted that "*confident use of personal technologies by teachers, such as social media and the internet, was not translating into competent use of professional technologies available in school environments*" (p. 154) where teachers still relied on display technologies (such as MS PowerPoint) to deliver content rather than allow students use their mobile devices to share content with each other, in a classroom enviroment.

The role of cultural influence was established empirically in a recent study on teachers' intentions to use technology in China and Spain (Huang, Teo, Sánchez-Prieto, García-Peñalvo, and Olmos-Migueláñez, 2019). In that research, Chinese teachers were concerned about their students' thoughts on their use of technology which "*echoes the highly promoted student-centred pedagogy*" (p. 78) whereas in Spain, teachers there showed a preference for a more traditional, teacher-led pedagogical approach. In effect, "*culture influences people's perceptions* *and decision making and suggest that researchers should consider cultural factors when conducting studies on technology acceptance*" (p. 79). These social norms, when considered in conjunction with teachers' beliefs about technology can impact use of technology in educational settings. Beliefs are discussed in the next section.

Teachers' beliefs about technology.

Teacher beliefs were defined by Kagan (1992) as "*assumptions about students, learning, classrooms, and the subject matter to be taught*" (p. 66) and she suggested "*teachers use these beliefs as filters through which they view and interpret the teaching performances of others*" (p. 68). Mumtaz (2000) has noted that teachers' pedagogical beliefs had a large role to play in their decisions to use technology in the classroom. They suggested for successful implementation of ICT in the classroom, three factors that needed to change were "*the teacher, the school and policy makers*" (p. 319). Doering, Hughes, and Huffman (2003) queried whether teachers were actually "*thinking with technology*" (p.342) and administered a "*technology integration model*" survey. While a small study, the participants' initial responses "*to technology integration and use in schools were full of scepticism*" (p. 348). The teachers initially saw technology as a way of delivering information, and offered traditional transmissionist type examples of how technology was used in their educational environment.

Ertmer (2005) further queried the relationship between teachers' pedagogical beliefs and their technology practices in the classroom and discovered very few teachers had seen technology used while they were in school (during their education), so were unlikely to have a preconceived idea about how technology should be used. Yet, this study had identified a lacuna in the literature where "*few researchers have examined the relationship between teachers' pedagogical beliefs and their classroom use of technology*" (p. 36). Further work by Plomp, Pelgrum, and Law (2007) on pedagogical practices in various European countries and the use of technology by teachers therein, has established that "*while the use of ICT in education is increasing, for the majority of teachers, this (ICT) is still a tool that is used in the margins of the educational process*" (p. 85). Over ten years later one would question whether this is still of relevance.

Early work by Teo, Lee, and Chai (2007) research sought to establish a link between the concept of a teacher's "*attitude*" and their beliefs about teaching with technology, as research in this area was "*limited and inconsistent*" (p. 165). The impact of a teacher's belief system cannot be underestimated, and Teo, Ching Sing, et al. (2008) then began a period of extensive research into the beliefs teachers had about using technology. Teo's research has continued to explore "*intention to use*" and application of the seminal Technology Acceptance Model (TAM) with various cohorts of in-service, pre-service and other types of teachers in a Singapore context (Teo 2009a; Teo, 2009b, 2010, 2011, 2012; Teo & Noyes, 2011, 2012). Teo's central thesis (Teo, Chai, Hung, & Lee, 2008) is based on the exploration of the relationship between teachers' beliefs about technology and their subsequent use of technology in the classroom. His research established that "*if teachers practice constructivist teaching, they are likely to use technology in a constructivist manner whereas if teachers believe in more traditional teaching, there is a strong likelihood that technology will be used in a traditional way*" (p. 170). Yet he was aware that beliefs were often intransigent and difficult to change, as they had been formed over many years of teachers' experiences in their classrooms, during their own education. Hermans, Tondeur, van Braak, and Valcke (2008) had questioned the impact of primary teachers' educational beliefs on the classroom use of computers, with a large sample (n= 525). Their study "*shed light on the mediating role of primary teachers' educational beliefs in the resistance and receptiveness of primary school teachers to integrate computers in their classroom practice*" (p. 1506). Indeed, those with traditional beliefs about teaching had a negative impact on use of technology in the classroom; whereas those with a more constructive and positive attitude had a more positive predisposition towards computer use in their classrooms (Hermans et al., 2008). The research conducted by Teo and his colleagues (Teo, 2010; Teo, Ching Sing, et al., 2008) over the past ten years has continued relevance.

Hammond, Reynolds, and Ingram (2011) drew attention to the factors that influence how and why teachers use ICT, and found ICT use was seen as emerging from a mix of factors, namely: "*teachers access to ICT; their feelings of self-efficacy when using ICT and their belief that ICT had a positive impact on learning*" (p. 191). Prestridge (2012) (n = 48) explored teacher beliefs that influence the ways ICT are used in the classroom and the findings re-iterated previous literature on teacher beliefs about using technology:

> *Beliefs…can be idealistic and desirable, however, when the reality of the classroom is encountered, beliefs may not inform practice… further research is needed to examine actualised practices that stem from stated beliefs, and at what point in practice do beliefs transform (p. 458).*

Traditional, transmissionist beliefs about technology, and their influence on the intrinsic motivation to use technology in the classroom, remains an ongoing area of research in the literature (Funkhouser & Mouza, 2013; Koc, 2013). The link between intrinsic barriers, such as attitude and self-efficacy, to successful technology integration in the classroom, and whether these have an effect on use of technology are, therefore, well established concerns in the literature (Farjon, Smits, & Voogt, 2019).

Self-Efficacy & Autonomy

This section will outline the concepts of self-efficacy, as it is especially relevant when discussing teachers' pedagogical concerns about technology integration. Self-efficacy acts as a proxy for second order (intrinsic) barriers discussed earlier.

To gain an understanding of teachers' use of technology in the classroom, the psychological concept of self-efficacy is key to understanding their intrinsic motivation. Based on the theory of social cognitivism, self-efficacy is defined as "*people's (sic.) beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives*" (Bandura, 1977, p. 191). Bandura (1977) explained the concept of self-efficacy further, where a strong sense of self-efficacy meant one approached difficult tasks as challenges to be mastered rather than as "*threats to be avoided*" (p. 192). He outlined that those who doubted their capabilities shied away from difficult tasks and often viewed them as personal threats. Thus, a teacher in a classroom is unlikely to use technology if they are not confident of their own technological capabilities to do so, which was noted earlier in the section on TPACK. One of the main roles of teacher education colleges is to ensure teachers are confident and competent users of technology, and this is discussed shortly.

Bandura (1997) specifically looked at four ways in which perceived self-efficacy, or belief in ones' capabilities, regulated human functioning. In the cognitive domain, those with higher self-efficacy were more likely to set themselves "*difficult challenges, and commit themselves firmly to meeting those challenges*" (p. 4). Bandura's area of interest was based on the motivational element of self-efficacy, where "*it determines the goals people set for themselves, how much effort they expend, how long they persevere and how resilient they are in the face of failures and setbacks*" (p. 4). Motivation was regulated by the expectation that a given course of behaviour produced a certain outcome. As such, self-belief, or a high level of self-efficacy, partly governs the motivating influence of outcome expectancies. To put it plainly, when faced with obstacles and failure, people who doubt their capabilities give up quickly, whereas those with strong self-efficacy persevere and exert greater effort when faced with challenges (Bandura, 1997). The influence of school culture must also be noted here where often social norms in a school do not allow for experimentation (Egan, 2018), and teachers do not have opportunities to overcome such "*setbacks*". This concept of self-efficacy was extended to include technology, and a person's belief about their ability to use technology, and is outlined in the next section.

Computer self-efficacy.

Computer self-efficacy was explored by Compeau and Higgins (1995) when discussing the role of an individual's belief about their own abilities to competently use computers. A group of business managers and professionals (n=2000) were questioned to assess their computer self-efficacy and a ten-item instrument for measurement of computer self-efficacy was devised. This ten-item instrument looked at variables such as encouragement by others; peers' use of technology; support of others; self-efficacy; outcome expectations; affect; anxiety and use. Their findings suggested that "*individuals in this study with high self-efficacy used computers more, derived more enjoyment from their use, and experienced less computer anxiety*" (p. 203). Schunk and Ertmer (1999) had explored whether there was any relationship between use of computers, self-efficacy and achievement of goals with a group of undergraduates (n=44). Their findings supported the concept of self-efficacy for acquisition of computer skills, as "*self-efficacy bore a strong, positive relation to achievement and perceived self-regulation competence*" (p. 258).

Subsequent use of technology.

Whether a teachers' technological self-efficacy has an effect on their subsequent use of technology in their classroom has been explored in the literature. In Australia a variety of studies have been undertaken looking at pre-service teachers and the skills needed to effectively integrate technology into their teaching, primarily led by Dr. Peter Albion and his colleagues in the Teaching for the Future initiative. Applying the concept of self-efficacy, as described by Bandura (1994), to his work, Albion established that "*teachers' beliefs in their capacity to work effectively with technology are a significant factor in determining patterns* *of classroom use*" (Albion, 1999, p. 2) re-iterating the link between beliefs about computers and self-efficacy using technology. In a follow up study, Redmond and Albion (2002) analysed "*discussion forum postings*" relating to pre-service teachers' experiences of using technology "*in their own words*" (p. 2426) while out on their placement block. The findings were interesting as this group had grown up with technology, were learning about technology in their education course and had been introduced to technology as an integral part of their course. The online discussions focused on the need for integration of ICT as an "*important issue in their future careers as teachers*" (p. 2429), but there were marked comments on the lack of observation of good examples of technology integration observed, while out on teaching practice. The paper queried how teachers could "*imagine how they might engage in behaviours for which they have few models*" (p. 2430), if good role-models were lacking during their pre-service teacher education (akin to the behaviour modelling literature described earlier). In further research on this topic, Albion (2007, p. 1244) questioned the ability of these millennial learners to integrate technology and outlined that,

> *first year university students while reporting high levels of confidence (self-efficacy) when using the internet, do not necessarily manifest matching levels of competence (p.1244).*

In a final evaluation of the impact of the TTF project, Albion (2011) argued that "*students should graduate with relevant knowledge and skills for using ICT, and that ICT should be integrated to improve student learning*" (p. 74). He concluded that "*Australia's digital education revolution is still in its early stages and it is not entirely clear what it will mean in the typical classroom*" (p. 80). Ten years into the TTF initiative, there had been some improvement in pre-service teacher education in relation to using computers in the classroom, and the confidence and self-efficacy of these students had improved (p. 80). Yet, "*their experiences and resulting skills appear to be balanced more towards consumption of digital content than creation*" (p. 80) and as such, their skills using technology remained limited.

Competence gaps.

Lack of technological competence has been noted in recent literature (Alexander et al., 2019; Huang et al., 2019; Instefjord & Munthe, 2017; Leger & Freiman, 2016; Moreira-Fontán et al., 2019; Røkenes & Krumsvik, 2016; Uerz, Volman, & Kral, 2018) in relation to use of technology by students entering higher education.

Gross and Latham (2012) noted that often "*students [are] coming to higher education without needed information literacy skills*" (p. 581), and the issue is still the subject of frequent debate in the literature (Lai & Hong, 2015; Senkbeil & Ihme, 2017; Teo, 2013; Wang, Hsu, Campbell, Coster, & Longhurst, 2014). Computer self-efficacy was based on prior experiences of pre-service teachers (Varma & Marler, 2013) where a pre-service teachers' beliefs and previous experiences using technology were material influences on subsequent use. Bandura (1997) had considered the most effective way of creating a "*strong sense of self-efficacy was through mastery experiences where successes build a robust belief in one's personal efficacy*" (p. 3) and this has continued relevance where teachers' beliefs about using technology in an educational environment are relevant (Rohatgi, Scherer, & Hatlevik, 2016; Scherer, Siddiq, & Teo, 2015; Turel, 2014).

Current literature has also associated lack of competence using technology with the seminal work by Kruger and Dunning's (1999) that "*skills that engender confidence are often the same skills you need to evaluate your competence in that particular domain*" (p. 1121), where Kruger and Dunning suggested that often confidence did not necessarily equate to competence, in a particular field. Mahmood (2016) had tested this "*Dunning-Kruger*" effect with information technology literacy skills, where "*there was no match between self-efficacy and actual performance* [using IT] *where people generally inflate their perceived levels of skills in a particular domain*" (p. 205). Akin to Maderick, Zhang, Hartley, and Marchand's (2016) findings who suggested the teachers in their study were,

> *either not aware of how much they do not know about the technologies that they will need to carry to their respective classrooms or they are indeed, cognizant of their gap in knowledge without having an accurate understanding of its magnitude (p. 342).*

As such, Maslow's (1962) early model of learning competencies has continued relevance for the current literature on technology integration where it rests at the 'unconscious incompetence' stage of psychological awareness, and may not yet have moved to the 'conscious incompetence' stage of learning in relation to the skills needed to effectively use technology in teaching and learning environments. Ultimately Tondeur, van Braak, Ertmer, and Ottenbreit-Leftwich (2016) remarked that when deciding what technology to use it was down to the individual where "*the qualitative evidence [in their review] supports the idea that the technology integration process* *is an individual process, unique to each teacher*" (p. 10) and as such, was related to an individuals' own beliefs about the benefits of using technology in a classroom. More recent literature in Finland has suggested "*most teachers reasons for using technology were related to the realisation of educational goals and facilitation of the learning process*" (Heitink et al., 2016, p. 81) rather than just technology for technology's sake. Hence, a move away from technology focused interventions to concern about the pedagogies associated with effective use of technology, in an educational environment has continued relevance for this review.

To try and improve teachers' skills using technology, literature has advocated an approach that they should be equipped with strategies to use a wide range of technologies (Banas & York, 2014; Celik & Yildirim, 2016; Roy, Giraldo-Garcia, Mathew, Matias, & Bommisetty, 2016; Teo, 2015). However, such strategies to deal with a wide range of technologies are but one approach; there are many others advocated in the literature. Other strategies mentioned in the literature discuss the influence of role models in teacher education (Scherer et al., 2015; Tondeur et al., 2012; Young, O'Neill, & Simmie, 2015), and provision of pedagogical methods associated with technology use (Campbell et al., 2012; Lehtinen et al., 2016; Reyes, Reading, Doyle, & Gregory, 2017; Depaepe & König, 2018; Hatlevik et al., 2018; Huang et al., 2019; Lai & Bower, 2019; Moreira-Fontán et al., 2019) as noted earlier in the section on TPACK.

Role of Teacher Education

A focus on traditional uses of technology and the question of how teacher candidates are trained to use technology arises, more generally, in the literature. A lack of ability to integrate technology effectively in the classroom persists despite teacher students being members of the "*net generation*", and they have a continued reliance on a transmissionist approach to teaching (Egan, FitzGibbon, Girvan, & Oldham, 2012; Egan, FitzGibbon, & Oldham, 2013; Egan, FitzGibbon, Oldham, et al., 2014). Criticism of teacher education courses has long been noted in the literature, and in a European report, Enochsson and Rizza (2009) detailed "*few teacher training programmes that target the teaching or development of 21st century skills*". More recent OECD publications (Rizza, 2011, OECD, 2020) have reviewed the quantity and quality of pre-service teacher education ICT courses, and have noted there were few similarities in the amount of hours delivered or the type of courses undertaken across various European countries. Tondeur et al. (2012) were also critical of pre-service teacher education courses and remarked that a gap still existed between what pre-service teachers see in college and actual use of technology in classrooms, while out on school placement. Tondeur et al. (2012) argued that teacher training institutions should be acting as agents of change, and are still lacking in this regard. In the New Media Horizon report for Schools, Johnson et al. (2014) suggested that a "*fast trend – 1 to 2 years*" away was "*rethinking the role of teachers*" and they suggested that "*integrating ICT into teacher education and low digital competence*" were solvable challenges (p. 24). To do this they outlined how teacher education programmes needed to integrate technology in a way that was not superficial but was meaningful and the authors suggested that digital learning should permeate teacher education at all levels; but were quite vague as to the specifics of how this would happen. In Ireland, for example, the "*Digital Strategy for Schools*" (Butler et al., 2015) primary objective was to "*ensure that ICT is embedded in the planning, design and delivery of all teacher education courses*", and while aspirational the influence of teacher education on pre-service teachers' technological skills continues to be a "*wicked problem*" to overcome (Alexander et al., 2019).

What can teacher education do to help?

Rovai and Childress (2002) suggested that pre-service teacher education should focus on "*building computer confidence and expanding students' knowledge about computers*" (p. 226). Equally, Pierson and Cozart (2004) advocated that "*the more and varied the technological experience, the more and varied the use they (teacher candidates) could imagine*" (p. 60) and this approach, adopted by the technology lecturer in particular, was remarked on favourably by interviewees. However, exposure to a wider range of technologies should also be accompanied with explicit demonstrations on how those technologies can be integrated in a classroom setting, as suggested by a variety of authors on this topic (Lee & Lee, 2014). Therefore, using technology in pedagogically meaningful ways, where teachers can see *how* the technology is used, in conjunction with demonstrations of content appropriate technologies, can affect teacher candidates' intentions to use technology for teaching and learning (Mena, Hennissen, & Loughran, 2017; Uerz, Volman, & Kral, 2018), as noted in the *DigCompEdu* framework (Redecker & Punie, 2017). Tondeur et al. (2017) have all acknowledged latterly, the difficulties experienced by pre-service teacher education colleges when helping teacher candidates design technology rich lessons. Indeed, Powers and Musgrove (2016) acknowledged that the digital tools teacher candidates used would always be changing and it was critical that teacher candidates were equipped with the ability to adapt to a rapidly changing global information society (p. 3048) as noted earlier. Equally, while McGarr and McDonagh's (2019) PEAT model advocates a strong pedagogical focus to technology integration, they also argue that an "***awareness and understanding of cyber-ethics***" in any teacher education technology course is imperative, similar to DigCompEdu's (2017) competence in relation to responsible use of technology.

Benefits and Risks of Technology in Education

The benefits of technology in education are well documented in the literature where technology allows access to educational content in a myriad of new and innovative ways (Andrade, 2015; Livingstone, 2012; Lai & Bower, 2019; Unwin, 2019). Selwyn (2016) has noted that the "confluence of technology and education is complicated, contradictory and messy" (p. vi) and queried "*to what extent is digital technology really changing education*" (p. 2). He concluded that "for better or for worse, digital technology means that many of the cornerstones of education are altering rapidly" (p. 133) and this section will proceed to comment on some of the positives and negatives associated with technology use in educational contexts. McGarr and Johnston (2016) have noted the "*prevalence of positivity regarding the potential of technology in education, and the role of media in mediating such messages*" (p. 7152) where, akin to Papert's (1987) early work, technology's role in education was seen as unassailable.

This section is also written in consideration of the annual *Gartner Research and New Media Horizon* reports. These reports should also be on the agenda of all educational organisations who have an interest in technological advances and their future impact. These annual reports predict what will be important over a five year cycle (Cearley, Jones, Smith, & Burke, 2019) and are noteworthy for their analysis of the time to adoption for new technologies. Equally, the annual *New Media Horizon Report* (Alexander et al., 2019) has been a reliable predictor of technologies in use in education for the past seventeen years (Figure 11 and Figure 12).

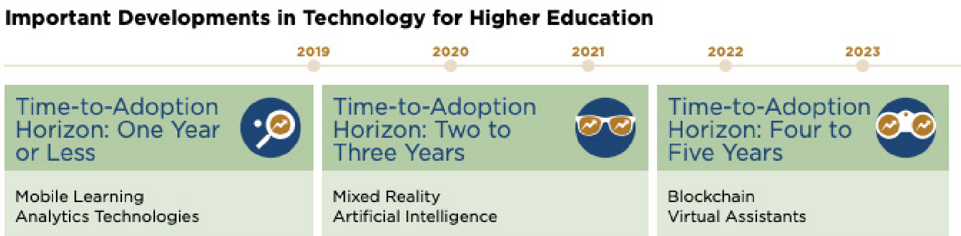

Figure 11. EDUCAUSE Horizon Report 2019

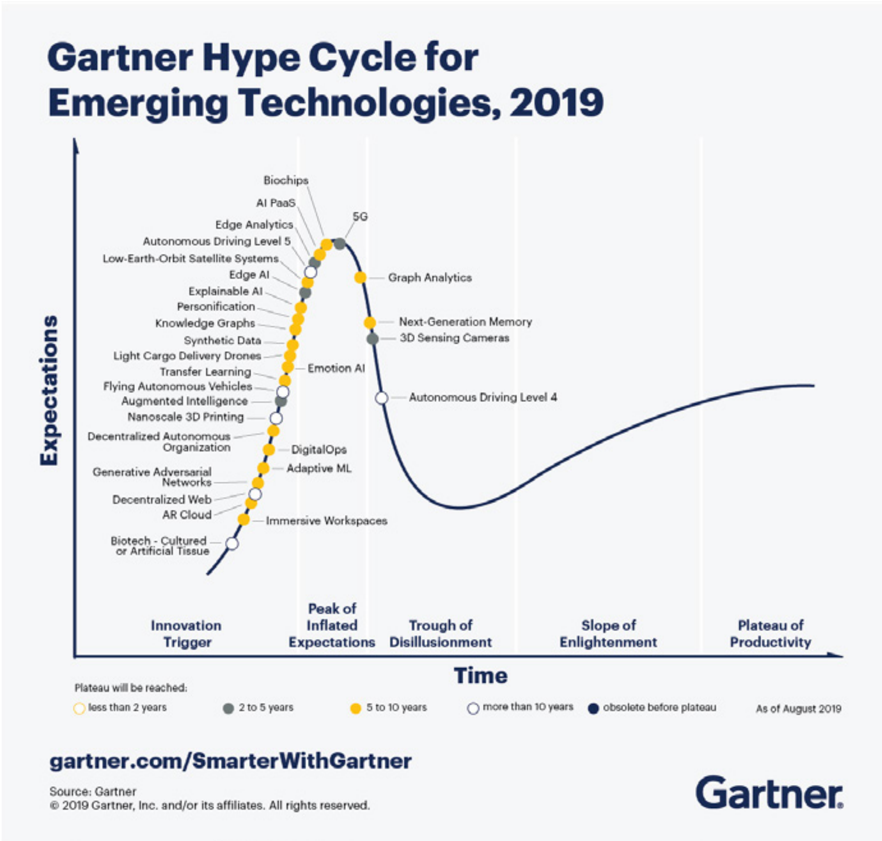

Figure 12. **Gartner Hype Cycle for New Technologies, 2019**

Affordances of Technology

Access to technology in education has allowed students and parents to connect to schools in innovative ways (Bordalba & Bochaca, 2019), to visit other countries without leaving their classroom (Vega-Hernandez, Patino-Alonso, & Galindo-Villardon, 2018) and have access to information (Hartmann, Braae, Pedersen, & Khalid, 2017), at the touch of a button. In Australia, for example, Dawson (2008) commented on virtual excursions being of benefit in a science classroom, and in Ireland, access to a virtual 3D physics laboratory (Bogusevschi, Muntean, & Muntean, 2019) ensured students could conduct experiments without having access to full laboratory facilities. Other positive uses of technology, such as eportfolios, by pre-service teachers to document their learning journey are widespread (Egan, FitzGibbon, & Oldham, 2014) and the affordances of such a multi-media tool are well documented (Botterill & Warren, 2010;

Briggs & Jensen, 2013; Chang, Tseng, Liang, & Chen, 2013; Chen, Chang, Chen, Huang, & Chen, 2012; Hanbridge, McMillan, & Scholz, 2018; Oakley, Pegrum, & Johnston, 2013; Ring & Ramirez, 2012; Tzeng & Chen, 2012; Watson, 2012). A brief synopsis of positive and negatives associated with technology in education are outlined in this section.

Assistive technologies.

Assistive technologies form an integral part of the daily life for those students with general learning difficulties, accessing and attending educational courses. The concept of digital literacy for those with general learning difficulties is defined as "*the creation, communication and interpretation of meaning through multi-modal digital formats, leading to fuller participation*" and ensures those with learning difficulties are assured of their own ability to make choices thereby allowing full participation in all aspects of an educational setting. (Anderson & Putman, 2020; Cagiltay, Cakir, Karasu, Islim, & Cicek, 2019). Assistive technology can refer to low technology (laptop stands), medium technology (adapted computer peripherals such as keyboards) and high technology (sophisticated voice activated computer control systems, audio readers and voice recognition tools, NCSE). All of these technological tools have a specific purpose, and are based on a strong pedagogical need, and benefit those with learning difficulties in a positive manner (Valencia, Rusu, QuiÒones, & Jamet, 2019).

Distance learning, micro-credentials and blockchain.

Distance learning can be defined as a formalised teaching system designed to be carried out remotely (King, Young, Drivere-Richmond, Schrader, & Kelly, 2001). Courses and modules can be completed by correspondence (e.g. Open University) or latterly, by accessing content via the internet, a learning management system or by participation in a Massive Open Online Course (MOOC) (Buchanan, 2011; Ellis, Hughes, Weyers, & Riding, 2009; Jiaosheng, 2019; Lai & Bower, 2019; Luik et al., 2019; Plomp et al., 2007; Shapiro et al., 2017; Thompson, 2013; Vega-Hernandez et al., 2018; Weber et al., 2004). By allowing such remote access to educational content, in an asynchronous manner, courses are now accessible by anyone with an internet connection. Morpeth, Creed et. al. (2009) noted the benefits of distance learning for children in conflict and disaster areas, where it can provide "*para-formal or alternative schooling systems, raise quality by providing ready-made resources and provide networks for teachers*" involved in delivery of these courses. However, not all online content has been successful where completion rates for MOOC type courses are typically less than 10% (Clow; Luik et al., 2019) as often MOOC participants do not require certification at the end of a course and are completing the content for their own development only. Indeed, Milheim (2013) noted that "*perhaps MOOCS will become simply another useful technological option available for the benefit of learners and students*" (p. 42), and such access to free resources while revolutionary in its own right, does not claim any quality of content therein. Equally, recent literature has noted that lack of instructor presence and lack of the instructor-student relationship has proven to be a barrier to the learning experience in a MOOC environment (Raza, 2020).

Online courses with ability to award digital badges for completion of tasks and skills retain continued value to students. Interest in such micro-credentials is on the horizon for education, where course participants can earn digital badges for completion of certain tasks (Alexander et al., 2019; Pierce, 2018), or acquisition of skills, in their online course. This gamification of online learning has been criticised where often the focus is on gaining the reward only, rather than on the learning process itself (Lai & Bower, 2019; Roy et al., 2016).

The addition of blockchain technology as a repository for such micro-credentials is a new development that education needs to be aware of. Traditionally, students had to rely on educational institutions to manage and retain data about their learning achievements, certificates and course grades. With the advent of blockchain technology, such data can be stored securely using a distributed ledger technology approach. This technology will eventually remove the need for an intermediary education organisation to retain and verify awards (Walsh, 2019). Figure 13 demonstrates how Blockchain could be

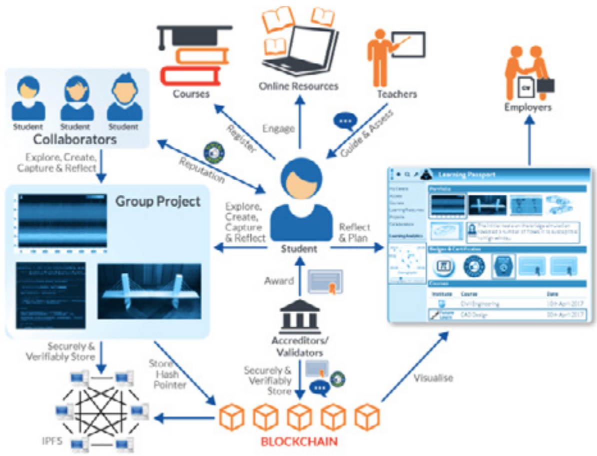

Figure 13. Learnovate explain how Blockchain will be used in education

used by education institutions in the future and demonstrates a real challenge to traditional accreditation models, where colleges, schools and universities held details of your awards and achievements. The implications of this technology for national accreditation systems is also an area for consideration.

Equity of access and 5G.

In the past twenty years, technology has allowed a "***democratisation of education***" (Selwyn, 2016) where access to education has been possible for anyone with an internet connection as noted earlier. With the imminent arrival of 5G connectivity, this is touted as the "next generation of mobile technology, [and] is envisaged to bring about a 'Networked Society', providing an unlimited access to information and data at anytime, anywhere by anyone and anything" (Peters & Besley, 2019, p. 2). The implications of this for education are widespread and 5G is noted in the recent *Gartner Report*, mentioned earlier (Figure 11).

Risks of Educational Technology

Recently, literature has begun to question the validity of using technology in educational settings at all, where despite the "*prevalent positive rhetoric, few independent evaluations comparing educational settings about ICT intervention have been conducted, and those that exist are rather equivocal in their conclusions*" (Livingstone, 2010).

Wellbeing.

The effects of over-use of technology on wellbeing is a concern in the literature. Most literature has focused on negative side-effects associated with over-use of technology generally, citing "screen time" (Kirk, 2017; O'Brien, 2016; Pollak, 2015), "*cyber-bullying*" (Aftab, 2015; Harrold, 2016; O'Brien, 2017; Pope, 2015) and overall "*wellbeing*" issues (George et al., 2020; Moreira-Fontán et al., 2019) as problematic by-products of a reliance on technology by children, and adults alike. Burns and Gottschalk (OECD, 2019f) noted that while access to digital technologies was useful, such access presented many "*pressing challenges*", including cyber-bullying, internet addiction, exposure to harmful content and excessive use concerns, in a digital age.

Literature has noted some negative associations of use of technology for educational purposes where "sleep deprivation, distraction and multitasking all of which directly impact on learning" (Butler, 2015a; 2015b, p. 3). As such, certain technologies are beginning to reach the "*trough of disillusionment*" (Smith, 2016, p. 9), as referred to in Gartner's hype cycle of technology adoption (Linden & Fenn, 2003), where media discourse is beginning to dissuade people from using technology 24/7. Indeed, it has been noted that in Silicon Valley "*digital gurus are shielding their children from technology*" (Harris, 2019) and moving back to more traditional educational methods and are concerned about the impact of over-use of technology more generally (George et al., 2020; Orben & Przybylski, 2019).

The presence of a digital divide is also a concern in the literature where an inequality of access to technology exists between communities due to regional, demographic and socio-economic differences. This digital divide exists in terms of inclusion and access to technology for those with learning needs (Livingstone & Helsper, 2007), in terms of lack of skills using technology (Bennett, Maton, & Kervin, 2008; Waycott, Bennett, Kennedy, Dalgarno, & Gray, 2010) and for those with no access to technology at all (Okunola, Rowley, & Johnson, 2017). This negative aspect of technology integration persists, despite advances in terms of connectivity and access to digital devices.

Commercial interests.

Jones (2019) notes that "*education is a consumer of technologies developed for other purposes... where systems are provided by global corporations who extract data and expertise from the institutions and aggregate the data across the world*" (p. 3). The reliance of education on hardware and services provided by Microsoft, Google and Apple is commonplace, where students access 'free tools' for the duration of their studies, but then have to pay for ongoing services, as soon as they finish their course. Indeed, privacy and ethical concerns as to what these corporations are doing with the data they collect are noted in the media and academic literature (Alexander et al., 2019; Pardo & Siemens, 2014). Selwyn (2003, 2010, 2011a, 2011b, 2013, 2016, 2019) has been discussing the sociological impact of technology since the turn of the century, and note digital technology is now woven so tightly into the fabric of everyday life there can be few areas of education that go untouched by 'digital' in one form or another. Selwyn & Facer (2014) further contend there is a need for a new view of technology in education that encompasses the sociological dimension, where

> *understanding the appropriation of technologies in education as informed by context, as a process of contestation, practice and resistance and as a site through which power relations are enacted, opens up room for sociological analyses that bring to the surface the tensions that exist between the homogenising discourses and the messy reality of digital technologies in education (p. 492).*

As such, an interrogation of commercial interests in education must be considered in a wider sociological context, in future research but is noted here due to the commercial interests prevalent in educational environments.

Artificial intelligence.

The OECD (2018, 2019a, 2019b, 2019c, 2019d) have published five overarching principles to ensure "*responsible stewardship of trustworthy AI*" (OECD website) and these have been adopted by 42 OECD countries. These are listed here, for ease of reference:

1. AI should benefit people and the planet by driving inclusive growth, sustainable development and well-being.
2. AI systems should be designed in a way that respects the rule of law, human rights, democratic values and diversity, and they should include appropriate safeguards – for example, enabling human intervention where necessary – to ensure a fair and just society.
3. There should be transparency and responsible disclosure around AI systems to ensure that people understand AI-based outcomes and can challenge them.
4. AI systems must function in a robust, secure and safe way throughout their life cycles and potential risks should be continually assessed and managed.
5. Organisations and individuals developing, deploying or operating AI systems should be held accountable for their proper functioning in line with the above principles.

In an educational context, data analytics and use of AI in online environments to personalise learning experiences for students, have recently become the norm. For example, Collings and McMackin (2019) note that artificial intelligence has the ability to augment learning management systems, where personalised learning paths can be created based on each individual users' requirements. They acknowledge that AI has already moved seamlessly into our homes, where we use voice activated personal assistants (such as *Siri*, *Cortana* and *Alexa*) to perform simple tasks for us. Indeed, Luckin and Cukurova (2019) note the ability of AI to "*help us leverage faster, more nuanced and individualised scaffolding for learners, but that most commercial AI developers know little about … learning or teaching*" (p. 2824).

The use of AI in educational contexts is yet to be explored fully, and we look forward to more research in this regard. However, as noted by Holmes, Bialik, and Fadel (2019), AI in education is being funded by companies such as Google, Facebook and Amazon who are creating products specifically for the education sector. Their focus is on automation of many administrative type functions in schools, such as attendance and predicting which students might fail (using data analytics), based on the intelligence built into their systems. They also comment on Carnegie Learning tools that build personalised learning journeys online, and the use of intelligent tutoring systems, where a 'chat bot' might replace the teachers. However, as a word of caution to educationalists, they note that "*we must not be seduced by the lure of exciting technologies, instead we should always start with the learning*" (p. 45) – a common theme noted across all literature discussed in this review. Indeed, a recent OECD (2019e) conference paper commented that while AI in education may disrupt and innovate ways of learning, concerns remain regarding data protection and cybersecurity of students (and staff) personal data, where data privacy is a "*flashpoint in digital transformation*" (p. 5). Data privacy and protection concerns must always be a factor in any decision about what technologies to implement in any environment, educational or otherwise, and AI, analytics and the prevalence of the "*internet of things*" (Ashton, 2009) have brought these concerns to the fore, in recent years.

Conclusion and Recommendations

This report has reviewed current thinking on technology in education. The report has reviewed the concept of technology in education, and noted developments in the literature from a techno-centric view of integration to an emergence of a focus on the pedagogies associated with use of technology. This demonstrates a maturation of the considerations required before decisions are made on use of technology for educational purposes. The main authors in this area (Mishra & Koehler, Selwyn, Teo & Tondeur) are keen proponents of strong pedagogical foundations before any new technology is introduced to an educational environment. Barriers to successful adoption of technology were then discussed and intrinsic and extrinsic factors that continue to influence use of technology by educators noted. Finally, the benefits and risks of various types of educational technologies were presented and concerns raised about future technological innovations, and their impact, on education environments analysed.

There are* four *key recommendations for EI members:

1. Technology should not be introduced to an educational environment if the pedagogical reasons for it are not clear. The *TPACK* and *PEAT* models of technology integration should be considered before making a decision to purchase and use any new technology in education.

2. An awareness of the technological self-efficacy skills of educators, staff and students is advised where often a *Dunning Kruger* effect persists. The value of *DigCompEdu* and other appropriate frameworks as a reliable method to identify digital competencies required for modern education cannot be underestimated.

3. Educators should be empowered to evaluate what educational technologies they can use in their school or teaching environments. This can be done by allowing them the time and space to share their experiences using technology with each other, and for national policies to listen to their voice.

4. Members should review the annual *Gartner* and New *Media Horizon reports* on a frequent basis, to ensure they are aware

of all technological development in education, and elsewhere. For example, AI, Blockchain and 5G technologies are on the horizon for educational environments, in the near future.

At the conclusion of this report it should be noted that education has been rooted in traditional pedagogical approaches for some time and a tipping point is imminent (Miners, 2013) and we look forward to developments in educational technology over the next three to five years.

References

Admiraal, W., Louws, M., Lockhorst, D., Paas, T., Buynsters, M., Cviko, A., . . . Kester, L. (2017). Teachers in school-based technology innovations: A typology of their beliefs on teaching and technology. *Computers & Education, 114*, 57-68. doi:https://doi.org/10.1016/j.compedu.2017.06.013

Aftab, P. (2015). Cyberbullying - we don't appreciate the pain we cause. *The Irish Times*.

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*(2), 179-211. doi:10.1016/0749-5978(91)90020-t

Alamäki, A. (2000). Current trends in technology education in Finland.

Albion, P. (1999). *Self-Efficacy Beliefs as an Indicator of Teachers' Preparedness for Teaching with Technology*. Paper presented at the Society for Information Technology & Teacher Education International Conference 1999. http://www.editlib.org/p/8156

Albion, P. (2000). *Preliminary investigation of some influences on student teachers' self-efficacy for teaching with computers*. Paper presented at the Society for Information Technology & Teacher Education International Conference 2000. http://www.editlib.org/p/15832

Albion, P. (2007). *Student Teachers' Confidence and Competence for Finding Information on the Internet*. Paper presented at the Society for Information Technology & Teacher Education International Conference 2007, San Antonio, Texas, USA. http://www.editlib.org/p/24731

Albion, P. (2011). *Come the Revolution: Pre-service Teachers' Access to, Attitudes toward, and Skills with ICT*. Paper presented at the Society for Information Technology & Teacher Education International Conference 2011, Nashville, Tennessee, USA. http://www.editlib.org/p/36237

Albion, P. (2012). *Designing for explicit TPACK development: Evolution of a preservice design and technology course*. Paper presented at the Society for Information Technology & Teacher Education International Conference 2012, Austin, Texas, USA. https://www.learntechlib.org/p/39992

Albion, P., Jamieson-Proctor, R., & Finger, G. (2010). *Auditing the TPACK confidence of Australian pre-service teachers: The TPACK confidence survey (TCS)*. Paper presented at the Proceedings of the 21st International Conference of the Society for Information Technology & Teacher Education (SITE 2010).

Alexander, B., Ashford -Rowe, K., Barajaas - Murphy, N., Dobbin, G., Knott, J., McCormack, M., ... Weber, N. (2019). *Educause Horizon Report 2019 Higher Education Edition*. Retrieved from Louisville: https://library.educause.edu/-/media/files/library/2019/4/2019horizonreport.pdf?la=en&hash=C8E8D444AF372E705FA1BF9D4FF0DD4CC6F0FDD1

Almerich, G., Orellana, N., Suárez-Rodríguez, J., & Díaz-García, I. (2016). Teachers' information and communication technology competences: A structural approach. *Computers & Education, 100*, 110-125. doi:10.1016/j.compedu.2016.05.002

Ananiadou, K., & Claro, M. (2009). *21st Century Skills and Competences for New Millennium Learners in OECD Countries*.

Ananiadou, K., & Rizza, C. (2010). *ICT in Initial Teacher training: first findings and conclusions of an OECD study*.

Anderson, S. E., & Putman, R. S. (2020). Special Education Teachers' Experience, Confidence, Beliefs, and Knowledge About Integrating Technology. *35*(1), 37-50.

Andrade, D. (2015). The Benefits of Education Technology. Retrieved from https://www.techlearning.com/tl-advisor-blog/9059

Ashton, K. (2009) That 'Internet of Things' Thing. Retrieved from https://www.rfidjournal.com/that-internet-of-things-thing

Association, A. T. (2017). We the Educators - Literature Review. Retrieved from https://wetheeducators.com/

Australian Government, D. o. E., Employment and Workplace Relations. (2011). Teaching Teachers for the Future. Retrieved from https://www.ttf.edu.au/

Ball, D. L., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching what makes it special? *Journal of Teacher Education, 59*(5), 389-407.

Banas, J., & York, C. (2014). Authentic learning exercises as a means to influence preservice teachers' technology integration self-efficacy and intentions to integrate technology. *Australasian Journal of Educational Technology, 30*(6), 728 - 746.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191-215. doi:10.1037/0033-295x.84.2.191

Bandura, A. (1994). Self Efficacy. In V. Ramachaudran (Ed.), *Encyclopedia of Human Behaviour* (Vol. 4, pp. 71-81). New York: Academic Press.

Bandura, A. (1997). Self-efficacy. *Harvard Mental Health Letter, 13*(9), 4.

Bajracharya, J. (2017). Cost-effectiveness analysis of "ICT in Education" in developingcountries. *International Journal of Scientific and Engineering Research, 8*, 1548-1562.

Bauer, J., & Kenton, J. (2005). Toward Technology Integration in the Schools: Why It Isn't Happening. *Journal of Technology and Teacher Education, 13*(4), 519-546.

BECTA. (2004). *A Review of the Research Literature on Barriers to the Uptake of ICT by Teachers*. British Educational Communications and Technology Agency Retrieved from http://www.becta.org.uk

Bennett, S., Maton, K., & Kervin, L. (2008). The 'digital natives' debate: A critical review of the evidence. *British Journal of Educational Technology, 39*(5), 775-786. doi:10.1111/j.1467-8535.2007.00793.x

Birch, A., & Irvine, V. (2009). Preservice teachers' acceptance of ICT integration in the classroom: applying the UTAUT model. *Educational Media International, 46*(4), 295-315. doi:10.1080/09523980903387506

Bocconi, S., Kampylis, P., & Punie, Y. (2013). Framing ICT-enabled Innovation for Learning: the case of one-to-one learning initiatives in Europe. *European Journal of Education, 48*(1), 113-130. doi:10.1111/ejed.12021

Bogusevschi, D., Muntean, C., & Muntean, G.-M. (2019). *Teaching and Learning Physics using 3D Virtual Learning Environment : A Case Study of Combined Virtual Reality and Virtual Laboratory in Secondary School*. Paper presented at the Society for IT in Teacher Education, Las Vegas, US.

Bordalba, M. M., & Bochaca, J. G. (2019). Digital media for family-school communication? Parents' and teachers' beliefs. *Computers & Education, 132*, 44-62. doi:https://doi.org/10.1016/j.compedu.2019.01.006

Botterill, M., & Warren, W. (2010). *Learning to be literate: Introducing ePortfolios in first year teacher education*. Paper presented at the ePortfolios Australia Conference 2011.

Briggs, J., & Jensen, A. (2013). 'eLectrifying'ECE practicum: A pilot study on implementing ePortfolios for use in early childhood initial teacher education practicum assessment at Wintec.

Bronfenbrenner, U. (1979). *The ecology of human development : experiments by nature and design / Urie Bronfenbrenner*.

Buchanan, R. (2011). Paradox, Promise and Public Pedagogy: Implications of the Federal Government's Digital Education Revolution. *Australian Journal of Teacher Education, 36*(2), 67-78.

Burns, T. and F. Gottschalk (eds.) (2019), *Educating 21st Century Children: Emotional Well-being in the Digital Age*, Educational Research and Innovation, OECD Publishing, Paris, https://doi.org/10.1787/b7f33425-en.

Butler, D., Leahy, M., Shiel, G., & Cosgrove, J. (2015). *Towards the Development of a new Digital Strategy for Schools in Ireland*. Paper presented at the Society for Information Technology & Teacher Education International Conference 2015, Las Vegas, NV, United States. http://www.editlib.org/p/150177

Butler, D., Hallissy, M. & Hurley, J. (2018). The Digital Learning Framework: What Digital Learning can look like in Practice, An Irish Perspective. In E. Langran & J. Borup (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference* (pp. 1339-1346). Washington, D.C., United States: Association for the Advancement of Computing in Education (AACE). https://www.learntechlib.org/primary/p/182702/.

Butler, T. (2015a, 19.10.15). Ending the digital myth about electronic devices in classrooms. *The Irish Examiner*.

Butler, T. (2015b). ICT in Education: Fundamental Problems and Practical Recommendations. *UCC*, 1 - 35. Retrieved from http://afis.ucc.ie/tbutler/ICT%20in%20Education.html

Cagiltay, K., Cakir, H., Karasu, N., Islim, O. F., & Cicek, F. (2019). Use of Educational Technology in Special Education: Perceptions of Teachers. *6*(2), 189-205.

Campbell, C. (2012). Setting the scene: The Teaching Teachers for the Future Project. Paper presented at the Society for Information Technology & Teacher Education International Conference 2012, Austin, Texas, USA. http://www.editlib.org/p/40001

Campbell, C., Albion, P., Kearney, M., Maher, D., Pressick-Kilborn, K., & Zagami, J. (2012). *Teaching Teachers for the Future: Building the Educational Technology Capacity of Pre-service Teachers in Australian, Universities, Part 1*. Paper presented at the Society for Information Technology & Teacher Education International Conference 2012, Austin, Texas, USA. http://www.editlib.org/p/39919

Caro, R., & Harvey, D. (2016). *Developing Preservice Teachers Technology Integration skills using TPACK*. Paper presented at the Society for Information Technology & Teacher Education International Conference 2016, Savannah, GA, United States. https://www.learntechlib.org/p/172089

Cearley, D., Jones, N., Smith, D., & Burke, B. (2019). *Gartner Research : Top 10 Strategic Technology Trends for 2020*. Retrieved from online: https://www.gartner.com/en/doc/432920-top-10-strategic-technology-trends-for-2020

Celik, B., & Yildirim, Z. (2016). *Pre-Service Teachers' Self-Efficacy Beliefs in Relation to Educational Podcasting: Integration and Educational Usage Self-Efficacy*. Paper presented at the Society for Information Technology & Teacher Education International Conference 2016, Savannah, GA, United States. https://www.learntechlib.org/p/171956

Centre, Educational Research. (2015). The Programme for International Student Assessment. Retrieved from http://www.erc.ie/programme-of-work/pisa/

Chang, C. C., Tseng, K.-H., Liang, C., & Chen, T.-Y. (2013). Using e-portfolios to facilitate university students' knowledge management performance: E-portfolio vs. non-portfolio. *Computers & Education, 69*, 216-224.

Chen, M.-Y., Mou-Te Chang, F., Chen, C.-C., Huang, M.-J., & Chen, J.-W. (2012). Why do Individuals Use e-Portfolios? *Educational Technology & Society, 15*(4), 114-125.

Clow, D. (2013). *MOOCs and the funnel of participation*.

Collings, D., & McMackin, D. (2019). *Enabling the Workforce of the Future : The Role of Learning and Development*. Retrieved from Kildare:

Compeau, D. R., & Higgins, C. A. (1995). Computer Self-Efficacy: Development of a Measure and Initial Test. *MIS Quarterly, 19*(2), 189-211.

Conole, G., de Laat, M., Dillon, T., & Darby, J. (2008). 'Disruptive technologies', 'pedagogical innovation': What's new? Findings from an in-depth study of students' use and perception of technology. *Computers & Education, 50*(2), 511-524. doi:10.1016/j.compedu.2007.09.009

Cosgrove, J., Butler, D., Leahy, M., Shiel, G., Kavanagh, L., & Creaven, A.-M. (2013). *The 2013 ICT Census in Schools - Main Report*. Retrieved from Educational Research Centre: www.erc.ie

Cuban, L. (2001). *Oversold & Underused - Computers in the Classroom*: Harvard University Press.

Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly, 13*(3), 319-340.

Dawson, V. (2008). Use of information communication technology by early career science teachers in Western Australia. *International Journal of Science Education, 30*(2), 203-219.

De Smet, C., Bourgonjon, J., De Wever, B., Schellens, T., & Valcke, M. (2012). Researching instructional use and the technology acceptation of learning management systems by secondary school teachers. *Computers & Education, 58*(2), 688-696. doi:10.1016/j.compedu.2011.09.013

Department of Education and Skills, I. (2011). *Literacy and Numeracy for Learning and Life* Dublin Retrieved from https://www.education.ie/en/Publications/Policy-Reports/lit_num_strategy_full.pdf

Department of Education and Skills, I. (2016). *Action Plan for Education, 2016 - 2019*. Dublin: Department of Education and Skills Retrieved from http://education.ie/en/Publications/Corporate-Reports/Strategy-Statement/Department-of-Education-and-Skills-Strategy-Statement-2016-2019.pdf

Department of Education and Skills, I. (2017). *Action Plan for Education, 2017*. Dublin: Department of Education and Skills Retrieved from http://education.ie/en/Publications/Corporate-Reports/Strategy-Statement/Department-of-Education-and-Skills-Strategy-Statement-2016-2019.pdf

Devine, D., Fahie, D., & McGillicuddy, D. (2013). What is 'good' teaching? Teacher beliefs and practices about their teaching. *Irish Educational Studies, 32*(1), 83-108. doi:10.1080/03323315.2013.773228

Dewey, J. (1904). *THE RELATION OF THEORY TO PRACTICE IN EDUCATION*.

Dewey, J. (1916). *Democracy and education : an introduction to the philosophy of education / John Dewey*.

Dewey, J. (1938). *Experience and education / by John Dewey*.

Dewey, J. (1956). *School and society. The school and society ; and, The child and the curriculum / John Dewey ; introduction by Philip W. Jackson*.

Dewey, J., Boydston, J. A., & Ross, R. (1983). *The middle works, 1899-1924* (Vol. 13): SIU press.

Dishaw, M. T., & Strong, D. M. (1999). Extending the technology acceptance model with task-technology fit constructs. *Information & Management, 36*(1), 9-21.

Doering, A., Hughes, J., & Huffman, D. (2003). Preservice Teachers: Are We Thinking with Technology? *Journal of Research on Technology in Education, 35*(3), 342.

Donnelly, D., McGarr, O., & O'Reilly, J. (2011). A framework for teachers' integration of ICT into their classroom practice. *Computers & Education, 57*(2), 1469-1483. doi:10.1016/j.compedu.2011.02.014

Drabowicz, T. (2017). Social theory of internet use: Corroboration or rejection among the digital natives? Correspondence analysis of adolescents in two societies. *Computers & Education, 105*, 57-67. doi:10.1016/j.compedu.2016.10.004

Drent, M., & Meelissen, M. (2008). Which factors obstruct or stimulate teacher educators to use ICT innovatively? *Computers & Education, 51*(1), 187-199. doi:10.1016/j.compedu.2007.05.001

Drummond, A., & Sweeney, T. (2017). Can an objective measure of technological pedagogical content knowledge (TPACK) supplement existing TPACK measures? *British Journal of Educational Technology, 48*(4), 928-939. doi:10.1111/bjet.12473

Education, Department of (2004). ISTE Standards for Innovation in Education - Educators. Retrieved from https://info.iste.org/educator-standards-poster?_ga=2.255142656.926300937.1580675089-24993749.1580471625

Education, Department of. (2017). ISTE Standards for Innovation in Education - Educators (revised). Retrieved from https://info.iste.org/educator-standards-poster?_ga=2.255142656.926300937.1580675089-24993749.1580471625

Education, National Council for Special (n.d.). Assistive Technology. Retrieved from https://www.sess.ie/resources/assistive-technology-overview.

Egan, A. (2019). *Pre-service teachers' technological self-efficacy : An Irish perspective*. In D. Gibson & M. Ochoa (Eds.), Research Highlights in Technology in Teacher Education 2019 (pp. 149 – 158) : Association for the Advancement of Computing in Education.

Egan, A. (2018). *Pre-service teachers and their experiences of technology : A mixed methods study*. (PhD), Trinity College Dublin, Dublin.

Egan, A., FitzGibbon, A., Girvan, C., & Oldham, E. (2012). Self-Reported Competency and Technology Acceptance: Investigating the Relationship for a Cohort of Irish Pre-Service Teachers. Paper presented at the Society for Information Technology & Teacher Education International Conference 2012, Austin, Texas, USA. http://www.editlib.org/p/40084

Egan, A., FitzGibbon, A., & Oldham, E. (2013). *Teacher Identified Uses of Technology in the Classroom - an Irish cohort*. Paper presented at the Society for Information Technology & Teacher Education International Conference 2013, New Orleans, Louisiana, United States. http://www.editlib.org/p/48930

Egan, A., FitzGibbon, A., & Oldham, E. (2014). Technology Acceptance and ePorfolios: An Intervention in a College of Education. *INTED2014 Proceedings*, 6328-6336.

Egan, A., FitzGibbon, A., Oldham, E., & Johnston, K. (2014). *So You're a Technology Expert - What can you do?* Paper presented at the 8th International Technology, Education and Development Conference, Valencia, Spain.

Ell, F., Haigh, M., Cochran-Smith, M., Grudnoff, L., Ludlow, L., & Hill, M. F. (2017). Mapping a complex system: what influences teacher learning during initial teacher education? *Asia-Pacific Journal of Teacher Education, 45*(4), 327-345. doi:10.1080/1359866X.2017.1309640

Ellis, R. A., Hughes, J., Weyers, M., & Riding, P. (2009). University teacher approaches to design and teaching and concepts of learning technologies. *Teaching & Teacher Education, 25*(1), 109-117.

Enochsson, A., & Rizza, C. (2009). *ICT in Initial Teacher Training: Research Review*. (No. 38). OECD Publishing.

Ertmer, P. A. (1999). Addressing first- and second-order barriers to change: Strategies for technology integration. *Educational Technology Research and Development, 47*(4), 47-61. doi:10.1007/bf02299597

Ertmer, P. A. (2005). Teacher Pedagogical Beliefs: The Final Frontier in Our Quest for Technology Integration? *Educational Technology Research & Development, 53*(4), 25-39.

Ertmer, P. A., & Ottenbreit-Leftwich, A. (2013). Removing obstacles to the pedagogical changes required by Jonassen's vision of authentic technology-enabled learning. *Computers & Education, 64*(0), 175-182. doi:10.1016/j.compedu.2012.10.008

Ertmer, P. A., Ottenbreit-Leftwich, A. T., Sadik, O., Sendurur, E., & Sendurur, P. (2012). Teacher beliefs and technology integration practices: A critical relationship. *Computers & Education, 59*(2), 423-435. doi:10.1016/j.compedu.2012.02.001

Fahrman, M. B., & Gumaelius, L. B. (2015). Technology education in primary school in Sweden: A study of teachers views on teaching strategies and subject content. *age, 26*, 1.

Fanni, F., Rega, I., & Cantoni, L. (2013). Using Self-Efficacy to measure primary school teachers' perception of ICT: results from two studies. *International Journal of Education and Development using ICT, 9*(1), 100-111.

Farjon, D., Smits, A., & Voogt, J. (2019). Technology integration of pre-service teachers explained by attitudes and beliefs, competency, access, and experience. *Computers & Education, 130*, 81-93. doi:https://doi.org/10.1016/j.compedu.2018.11.010

Feng, D., Ching Sing, C., Chin-Chung, T., & Min-Hsien, L. (2014). The Relationships among Chinese Practicing Teachers' Epistemic Beliefs, Pedagogical Beliefs and Their Beliefs about the Use of ICT. *Journal of Educational Technology & Society, 17*(2), 245-256.

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention and behavior : an introduction to theory and research*. Reading, Mass. ; London [etc.]: Reading, Mass. ; London [etc.] : Addison-Wesley, 1975.

Fitzgerald, A., & Adams, S. (2016). *Design and Formative Evaluation of an e-Learning Module for Training Teachers to Integrate Technology into Teaching*. Paper presented at the Society for Information Technology & Teacher Education International Conference 2016, Savannah, GA, United States. https://www.learntechlib.org/p/171750

Foulger, T. S., Graziano, K. J., Schmidt-Crawford, D., & Slykhuis, D. A. (2017). Teacher Educator Technology Competencies. *Journal of Technology and Teacher Education, 25*(4), 413-448.

Freire, P. (1996). Pedagogy of the oppressed (revised). *New York: Continuum*.

Fullan, M., & Langworthy, M. (2014). *A rich seam: How new pedagogies find deep learning*: Pearson Publishers

Funkhouser, B. J., & Mouza, C. (2013). Drawing on technology: An investigation of preservice teacher beliefs in the context of an introductory educational technology course. *Computers & Education, 62*, 271-285. doi:10.1016/j.compedu.2012.11.005

George, M. J., Jensen, M. R., Russell, M. A., Gassman-Pines, A., Copeland, W. E., Hoyle, R. H., & Odgers, C. L. (2020). Young Adolescents' Digital Technology Use, Perceived Impairments, and Well-Being in a Representative Sample. *The Journal of Pediatrics*.

Goktas, Y., Gedik, N., & Baydas, O. (2013). Enablers and barriers to the use of ICT in primary schools in Turkey: A comparative study of 2005–2011. *Computers & Education, 68*, 211-222. doi:10.1016/j.compedu.2013.05.002

Goodhue, D. L., & Thompson, R. L. (1995). Task-Technology Fit and Individual Performance. *MIS Quarterly, 19*(2), 213-236.

Gross, M., & Latham, D. (2012). What's skill got to do with it?: Information literacy skills and self-views of ability among first-year college students. *Journal of the American Society for Information Science and Technology, 63*(3), 574-583. doi:10.1002/asi.21681

Gu, L. (2011). From National Commitment and Initiatives to Implementation in the Classroom: Some Critical Issues on Integration of ICT into Education in the Swedish Context. *UFV Research Review: A Special Topics Journal, 4*(1).

Hammond, M., Reynolds, L., & Ingram, J. (2011). How and why do student teachers use ICT? *Journal of Computer Assisted Learning, 27*(3), 191-203. doi:10.1111/j.1365-2729.2010.00389.x

Hanbridge, A. S., McMillan, C., & Scholz, K. W. (2018). Engaging with ePortfolios: Teaching Social Work Competencies through a Program-Wide Curriculum. *9*(3).

Harris, A. (2019). Why 'low technology' schools are trending. *The Irish Times*. Retrieved from https://www.irishtimes.com/news/education/why-low-tech-schools-are-trending-1.3789996

Harrold, M. (2016). How to tame teenagers' technology use in the digital age. *The Irish Times*.

Hartmann, S. B., Braae, L. Q. N., Pedersen, S., & Khalid, M. (2017). The Potentials of Using Cloud Computing in Schools: A Systematic Literature Review. *Turkish Online Journal of Educational Technology-TOJET, 16*(1), 190-202.

Hatlevik, O. E., Throndsen, I., Loi, M., & Gudmundsdottir, G. B. (2018). Students' ICT self-efficacy and computer and information literacy: Determinants and relationships. *Computers & Education, 118*, 107-119. doi:https://doi.org/10.1016/j.compedu.2017.11.011

Heitink, M., Voogt, J., Verplanken, L., van Braak, J., & Fisser, P. (2016). Teachers' professional reasoning about their pedagogical use of technology. *Computers & Education, 101*, 70-83. doi:10.1016/j.compedu.2016.05.009

Hermans, R., Tondeur, J., van Braak, J., & Valcke, M. (2008). The impact of primary school teachers' educational beliefs on the classroom use of computers. *Computers & Education, 51*(4), 1499-1509. doi:10.1016/j.compedu.2008.02.001

Hew, K., & Brush, T. (2007). Integrating technology into K-12 teaching and learning: current knowledge gaps and recommendations for future research. *Educational Technology Research & Development, 55*(3), 223-252. doi:10.1007/s11423-006-9022-5

Hofstede, G., & Bond, M. H. (1984). Hofstede's culture dimensions: An independent validation using Rokeach's value survey. *Journal of cross-cultural psychology, 15*(4), 417-433.

Hodges, C., Moore, S., Lockee, B., Trust, T., & Bond, A. (2020). The difference between emergency remote teaching and online learning. *EDUCAUSE Review*. https://er.educause.edu/articles/2020/3/the-difference-between-emergency-remote-teachingand-online-learning

Holmes, W., Bialik, M., & Fadel, C. (2019). *Artificial intelligence in education: Promises and implications for teaching and learning*: Center for Curriculum Redesign Boston, MA.

Huang, F., Teo, T., Sánchez-Prieto, J. C., García-Peñalvo, F. J., & Olmos-Migueláñez, S. (2019). Cultural values and technology adoption: A model comparison with university teachers from China and Spain. *Computers & Education, 133*, 69-81. doi:https://doi.org/10.1016/j.compedu.2019.01.012

Huang, H., & Kan, Y. (2020). The impact of the OECD on education worldwide: (International Perspectives on Education and Society [Series Editor: Alexander W. Wiseman]) Volume 31, edited by Alexander W. Wiseman and Calley Stevens Taylor, Bingley, Emerald Group Publishing, 2017, 296 pp., ISBN: 978-1-78635-540-9. In: Taylor & Francis.

Instefjord, E. J., & Munthe, E. (2017). Educating digitally competent teachers: A study of integration of professional digital competence in teacher education. *Teaching and Teacher Education, 67*, 37-45. doi:http://dx.doi.org/10.1016/j.tate.2017.05.016

INTO. (2015). Digital Strategy fails to address key concerns of primary schools. *In Touch*.

Istance, D., & Kools, M. (2013). OECD work on technology and education: Innovative learning environments as an integrating framework. *European Journal of Education, 48*(1), 43-57.

ISTE. (2017). ISTE standards. Available at: http://www.iste.org/standards Russell, M., Bebell, D., Dwyer, L.O. And O'Connor, K. (2003) 'Examining Teacher Technology Use Implications for Pre-Service and Inservice Teacher Preparation', Journal of Teacher Education, 54(4 September/October 2003), pp. 297-310.

Jassir, M. (2018). The Rise of Educational Technologies in Latin America: An Analysis of Brazilian and Mexican Ecosystems.

Jiaosheng, Q. (2019). A Review of Mobile Learning Research at Home and Abroad in Recent 20 Years. *10*(5), 1097-1102.

Johnson, L., Adams Becker, S., Estrada, V., Freeman, A., Kampylis, P., Vuorikari, R., & Punie, Y. (2014). *Horizon Report Europe : 2014 Schools Edition*. Austin, Texas, USA:

Jones, C. (2019). Capital, Neoliberalism and Educational Technology. *Postdigital Science and Education*. doi:10.1007/s42438-019-00042-1

Jones, M., Hobbs, L., Kenny, J., Campbell, C., Chittleborough, G., Gilbert, A., . . . Redman, C. (2016). Successful university-school partnerships: An interpretive framework to inform partnership practice. *Teaching and Teacher Education, 60*, 108-120. doi:https://doi.org/10.1016/j.tate.2016.08.006

Kagan, D. M. (1992). Implication of Research on Teacher Belief. *Educational Psychologist, 27*(1), 65.

Kelentrić, M., Helland, K., & Arstorp, A. T. (2018). Professional digital competence framework for teachers. *Accessed on*, 15.

King, F., Young, M., Drivere-Richmond, K., Schrader, P. G., & Kelly. (2001). Defining distance learning and distance education. *Educational Technology Review, 9*.

Kirk, A. (2017, 25.04.17). Are children getting enough 'me' time? *The Irish Times*.

Klichowski, M., & Costa, C. S. (2015). How do Pre-Service Teachers rate ICT Opportunity for Education? A Study in Perspective of the SCOT Theory. *Kultura i Edukacja, 4*(110), 152 - 168.

Koc, M. (2013). Student teachers' conceptions of technology: A metaphor analysis. *Computers & Education, 68*, 1-8. doi:10.1016/j.compedu.2013.04.024

Koh, J. H. L., & Chai, C. S. (2014). Teacher clusters and their perceptions of technological pedagogical content knowledge (TPACK) development through ICT lesson design. *Computers & Education, 70*, 222-232. doi:10.1016/j.compedu.2013.08.017

Koh, J. H. L., & Chai, C. S. (2016). Seven design frames that teachers use when considering technological pedagogical content knowledge (TPACK). *Computers & Education, 102*, 244-257. doi:10.1016/j.compedu.2016.09.003

Kopcha, T. J. (2012). Teachers' perceptions of the barriers to technology integration and practices with technology under situated professional development. *Computers & Education, 59*(4), 1109-1121. doi:10.1016/j.compedu.2012.05.014

Kruger, J., & Dunning, D. (1999). Unskilled and unaware of it: How difficulties in recognizing one's own incompetence lead to inflated self-assessments. *Journal of Personality and Social Psychology, 77*(6), 1121-1134. doi:10.1037/0022-3514.77.6.1121

Kurt, S., & Ciftci, M. (2012). Barriers to Teachers' Use of Technology. *International Journal of Instructional Media, 39*(3), 225-238.

Lai, J. W. M., & Bower, M. (2019). How is the use of technology in education evaluated? A systematic review. *Computers & Education, 133*, 27-42. doi:https://doi.org/10.1016/j.compedu.2019.01.010

Lai, K.-W., & Hong, K.-S. (2015). Technology use and learning characteristics of students in higher education: Do generational differences exist? *British Journal of Educational Technology, 46*(4), 725-738. doi:10.1111/bjet.12161

Lane, J. (2011). *Preparing Teachers of the Future: A National Initiative to Integrate ICT in Teacher Education in Australia*. Paper presented at the World Conference on Educational Multimedia, Hypermedia and Telecommunications 2011, Lisbon, Portugal. http://www.editlib.org/p/37904

Lee, Y., & Lee, J. (2014). Enhancing pre-service teachers' self-efficacy beliefs for technology integration through lesson planning practice. *Computers & Education, 73*, 121-128. doi:10.1016/j.compedu.2014.01.001

Leger, M., & Freiman, V. (2016). *Examining Developing Digital Competence in Teachers and Students Over Time: A Mixed Method Case Study of a School That Has Undertaken a Technological Shift in Its Educational Environment*. Paper presented at the EdMedia: World Conference on Educational Media and Technology 2016, Vancouver, BC, Canada. https://www.learntechlib.org/p/172955

Lehtinen, A., Nieminen, P., & Viiri, J. (2016). Preservice Teachers' TPACK Beliefs and Attitudes Toward Simulations. *Contemporary Issues in Technology and Teacher Education, 16*(2), 151-171.

Linden, A., & Fenn, J. (2003). Understanding Gartner's hype cycles. *Strategic Analysis Report Nº R-20-1971. Gartner, Inc*.

Liu, Y., Li, H., & Carlsson, C. (2010). Factors driving the adoption of m-learning: An empirical study. *Computers & Education, 55*(3), 1211-1219. doi:10.1016/j.compedu.2010.05.018

Livingstone, S. (2010). Interactive, engaging but unequal : critical conclusions from internet studies. In Bloomsbury (Ed.), *Media and Society* (5th ed. / edited by James Curran. ed., pp. 122 - 142). London: Bloomsbury.

Livingstone, S. (2012). Critical reflections on the benefits of ICT in education. *Oxford Review of Education, 38*(1), 9-24. doi:10.1080/03054985.2011.577938

Livingstone, S., & Helsper, E. (2007). Gradations in digital inclusion: children, young people and the digital divide. *New Media & Society, 9*(4), 671-696. doi:10.1177/1461444807080335

Luckin, R., & Cukurova, M. (2019). Designing educational technologies in the age of AI: A learning sciences driven approach. *British Journal of Educational Technology, 50*(6), 2824-2838.

Luik, P., Feklistova, L., Lepp, M., Tınisson, E., Suviste, R., Gaiduk, M., . . . Palts, T. (2019). Participants and completers in programming MOOCs. *24*(6), 3689-3706.

Maderick, J. A., Zhang, S., Hartley, K., & Marchand, G. (2016). Preservice Teachers and Self-Assessing Digital Competence. *Journal of Educational Computing Research, 54*(3), 326-351. doi:doi:10.1177/0735633115620432

Mahmood, K. (2016). Do People Overestimate their Information Literacy Skills? A Systematic Review of Empirical Evidence on the Dunning-Kruger Effect. *Communications in Information Literacy, 10*(2), 199-213.

Mama, M., & Hennessy, S. (2013). Developing a typology of teacher beliefs and practices concerning classroom use of ICT. *Computers & Education, 68*, 380-387. doi:10.1016/j.compedu.2013.05.022

Marshall, K., & Anderson, J. (2008). The Emperor's new clothes? A meta-study of education technology policies in Ireland, North and South (1996–2006). *Computers & Education, 50*(2), 463-474. doi:http://dx.doi.org/10.1016/j.compedu.2007.09.010

Marshall, S. (2016). Technological innovation of higher education in New Zealand: a wicked problem? *Studies in Higher Education, 41*(2), 288-301.

Marwan, A., & Sweeney, T. (2010). Teachers' perceptions of educational technology integration in an Indonesian polytechnic. *Asia Pacific Journal of Education, 30*(4), 463-476. doi:10.1080/02188791.2010.519554

Maslow, A. H. (1962). *Toward a psychology of being / by Abraham H. Maslow*.

McCoy, C. (2010). Perceived self-efficacy and technology proficiency in undergraduate college students. *Computers & Education, 55*(4), 1614-1617. doi:10.1016/j.compedu.2010.07.003

McDonagh, A., & McGarr, O. (2015). Technology leadership or technology somnambulism? Exploring the discourse of integration amongst information and communication technology coordinators. *Irish Educational Studies, 34*(1), 55-68. doi:10.1080/03323315.2015.1010292

McGarr, O., & Johnston, K. (2016). *'Never let the facts get in the way of a good story' - Exploring Prevalent Discourses in the Reporting of OECD students, computers and learning study in the national media in Ireland*. Paper presented at the INTED 2016, Valencia, Spain.

McGarr, O., & Johnston, K. (2019). Exploring the Evolution of Educational Technology Policy in Ireland: From Catching-Up to Pedagogical Maturity. *Educational Policy*, 0895904819843597. doi:10.1177/0895904819843597

McGarr, O., & McDonagh, A. (2019). *Digital Competence in Teacher Education*. Retrieved from https://dicte.oslomet.no/

Mead, D. (2019). *The Expert Teacher : Using Pedagogical Content Knowledge to Plan Superb Lessons*.

Meisalo, V., Lavonen, J., Sormunen, K., & Vesisenaho, M. (2010). ICT in Finnish Initial Teacher Education. Country report for the OECD/CERI New Millennium Learners Project ICT in Initial Teacher Training. *Reports of the Ministry of Education and Culture, Finland, 25*.

Mena, J., Hennissen, P., & Loughran, J. (2017). Developing pre-service teachers' professional knowledge of teaching: The influence of mentoring. *Teaching and Teacher Education, 66*, 47-59. doi:http://dx.doi.org/10.1016/j.tate.2017.03.024

Meschede, N., Fiebranz, A., Möller, K., & Steffensky, M. (2017). Teachers' professional vision, pedagogical content knowledge and beliefs: On its relation and differences between pre-service and in-service teachers. *Teaching and Teacher Education, 66*, 158-170. doi:http://dx.doi.org/10.1016/j.tate.2017.04.010

Milheim, W. D. (2013). Massive open online courses (MOOCs): Current applications and future potential. *Educational Technology*, 38-42.

Miners, Z. (2013). Bill Gates : Schools are at a 'technolgy tipping point' [Press release]. Retrieved from https://www.computerworld.com/article/2496071/bill-gates--schools-are-at-a--technology-tipping-point-.html

Ministry of Education, New Zealand. Digital Technologies and Hangarau Mathiko Learning. New Zealand: Ministry of Education Retrieved from https://www.education.govt.nz/our-work/changes-in-education/digital-technologies-and-hangarau-matihiko-learning/.

Ministry of Education, New Zealand. (2017). Technology in the New Zealand Curriculum 2017. Retrieved from https://nzcurriculum.tki.org.nz/The-New-Zealand-Curriculum/Technology

Ministry of Education, New Zealand. (n.d.-a). Digital Technologies and Matihiko Learning. Retrieved from http://www.education.govt.nz/our-work/changes-in-education/digital-technologies-and-hangarau-matihiko-learning/

Ministry of Education, New Zealand (n.d.-b). Digital Technology. Retrieved from http://www.education.govt.nz/school/digital-technology/

Ministry of Education, New Zealand (n.d.). Ministry of Education website. Retrieved from https://nzcurriculum.tki.org.nz/The-New-Zealand-Curriculum/Technology

Mishra, P. & Koehler, MJ (2019). Becoming design wise: Going from the "what" to the "why" of learning educational technology. In Y. Zhao (Ed.), What Teachers Should Know about Technology: Perspectives and Practices. Greenwich, CT: Information Age Publishing.

Mishra, P., & Koehler, M. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *The Teachers College Record, 108*(6), 1017-1054.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017-1054. doi:10.1111/j.1467-9620.2006.00684.x

Moreira-Fontán, E., García-Señorán, M., Conde-Rodríguez, Á., & González, A. (2019). Teachers' ICT-related self-efficacy, job resources, and positive emotions: Their structural relations with autonomous motivation and work engagement. *Computers & Education, 134*, 63-77. doi:https://doi.org/10.1016/j.compedu.2019.02.007

Morpeth, Ros; Creed, Charlotte; Cullen, Jane; Page, Elspeth and Raynor, Janet (2009). *Open and distance learning for basic education in South Asia: its potential for hard to reach children and children in conflict and disaster areas*. UNICEF, Nepal: Kathmandu.

Morris, D. (2010). Are teachers technophobes? Investigating professional competency in the use of ICT to support teaching and learning. *Procedia - Social and Behavioral Sciences, 2*(2), 4010-4015.

Mumtaz, S. (2000). Factors affecting teachers' use of information and communications technology: a review of the literature. *Journal of Information Techology for Teacher Education, 9*(3), 319-342. doi:10.1080/14759390000200096

Neer, M. (2014). What does Technology in the Classroom mean? Retrieved from https://dataworks-ed.com/blog/2014/07/what-does-technology-in-the-classroom-mean/

Nikleia, E. (2008). Evaluating computer technology integration in a centralized school system. *Computers & Education, 51*(2), 669-686. doi:10.1016/j.compedu.2007.07.004

Nistor, N., Göğüş, A., & Lerche, T. (2013). Educational technology acceptance across national and professional cultures: a European study. *Educational Technology Research and Development, 61*(4), 733-749.

Nistor, N., Lerche, T., Weinberger, A., Ceobanu, C., & Heymann, O. (2014). Towards the integration of culture into the Unified Theory of Acceptance and Use of Technology. *British Journal of Educational Technology, 45*(1), 36-55. doi:10.1111/j.1467-8535.2012.01383.x

O'Brien, C. (2016, 29.09.16). Smartphone use can hinder children's reading skills. *The Irish Times*.

O'Brien, C. (2017). More than one in 10 schoolchildren cyberbullied, research shows. *The Irish Times*.

Oakley, G., Pegrum, M., & Johnston, S. (2013). Introducing e-portfolios to pre-service teachers as tools for reflection and growth: lessons learnt. *Asia-Pacific Journal of Teacher Education* (ahead-of-print), 1-15.

Oddone, F. (2016). Self-Efficacy: a booster for pedagogical innovation. *Journal of e-Learning and Knowledge Society, 12*(3).

OECD (2018), *Education and AI: preparing for the future & AI, Attitudes and Values*. Paper prepared for the 8th Informal Working Group of the OECD Future of Education and Skills 2030 Project Meeting, Paris, 29-31 October 2018. https://www.oecd.org/education/2030-project/about/documents/Education-and-AI-preparing-for-the-future-AI-Attitudes-and-Values.pdf

OECD (2019a), Data in the Digital Age. https://www.oecd.org/going-digital/data-in-the-digital-age.pdf

OECD (2019b), Artificial Intelligence in Society, OECD Publishing, Paris, https://doi.org/10.1787/eedfee77-en

OECD (2019c), *Enhancing Access to and Sharing of Data. Reconciling Risks and Benefits for Data Re-use across Societies*, OECD Publishing, Paris. https://www.oecd.org/going-digital/enhancing-access-to-and-sharing-of-data-276aaca8-en.htm

OECD. (2019d). *OECD Skills Outlook 2019, Thriving in a Digital World*. OECD Publishing, Paris.

OECD (2019e), *Data in Education, Data for Education*. Background paper and Issue for Discussion for the Global Education Industry Summit (GEIS), Talinn, December 2019.

OECD. (2020). *TALIS 2020 Results (Volume II): Teachers and Schools Leaders as Valued Professionals*, TALIS, OECD Publishing, Paris.

Okunola, O. M., Rowley, J., & Johnson, F. (2017). The multi-dimensional digital divide: Perspectives from an e-government portal in Nigeria. *Government Information Quarterly, 34*(2), 329-339.

Olofson, M. W., Swallow, M. J. C., & Neumann, M. D. (2016). TPACKing: A constructivist framing of TPACK to analyze teachers' construction of knowledge. *Computers & Education, 95*, 188-201. doi:http://dx.doi.org/10.1016/j.compedu.2015.12.010

Orben, A., & Przybylski, A. K. (2019). The association between adolescent well-being and digital technology use. *Nature Human Behaviour, 3*(2), 173.

Ottenbreit-Leftwich, A. T., Glazewski, K. D., Newby, T. J., & Ertmer, P. A. (2010). Teacher value beliefs associated with using technology: Addressing professional and student needs. *Computers & Education, 55*(3), 1321-1335. doi:10.1016/j.compedu.2010.06.002

Olszewski, B., & Crompton, H. (2020). Educational technology conditions to support the development of digital age skills. *Computers & Education, 150*, 103849. doi:https://doi.org/10.1016/j.compedu.2020.103849

Papert, S. (1987). Information Technology and Education: Computer Criticism vs. Technocentric Thinking. *Educational Researcher, 16*(1), 22-30. doi:doi:10.3102/0013189X016001022

Papert, S. (1996). *The Connected Family*: LongStreet Press.

Pardo, A., & Siemens, G. (2014). Ethical and privacy principles for learning analytics. *British Journal of Educational Technology, 45*(3), 438-450.

Perkmen, S., Antonenko, P., & Caracuel, A. (2016). Validating a Measure of Teacher Intentions to Integrate Technology in Education in Turkey, Spain and the USA. *Journal of Technology and Teacher Education, 24*(2), 215-241.

Peters, M. A., & Besley, T. (2019). 5G transformational advanced wireless futures. In: Taylor & Francis.

Petko, D. (2012). Teachers' pedagogical beliefs and their use of digital media in classrooms: Sharpening the focus of the 'will, skill, tool' model and integrating teachers' constructivist orientations. *Computers & Education, 58*(4), 1351-1359. doi:10.1016/j.compedu.2011.12.013

Petty, R. E., Briñol, P., & DeMarree, K. G. (2007). THE META-COGNITIVE MODEL (MCM) OF ATTITUDES: IMPLICATIONS FOR ATTITUDE MEASUREMENT, CHANGE, AND STRENGTH. *Social Cognition, 25*(5), 657-686.

Piaget, J. (1971). *Science of Education and the Psychology of the Child* (D. Coltman, Trans.). New York: Orion Press.

Pierce, D. (2018). TECHNOLOGIES TO WATCH FOR IN 2019. In (Vol. 45, pp. 18-22): T.H.E. Journal.

Pierson, M. E., & Cozart, A. (2004). Case Studies of Future Teachers. *Journal of Computing in Teacher Education, 21*(2), 59-63. doi:10.1080/10402454.2004.10784512

Plomp, T., Pelgrum, W., & Law, N. (2007). SITES2006–International comparative survey of pedagogical practices and ICT in education. *Education and Information Technologies, 12*(2), 83-92. doi:10.1007/s10639-007-9029-5

Pollak, S. (2015). Electronic devices making children 'tired and cranky'. *The Irish Times*.

Pope, C. (2015). Teens in Ireland more likely cyberbullied than other countries. *The Irish Times*.

Powers, J., & Musgrove, A. (2016). *Putting the "P" into TPACK: Using Digital Tools to Design 21st Century Lessons*. Paper presented at the Society for Information Technology & Teacher Education International Conference 2016, Savannah, GA, United States. https://www.learntechlib.org/p/172124

Prestridge, S. (2012). The beliefs behind the teacher that influences their ICT practices. *Computers & Education, 58*(1), 449-458. doi:10.1016/j.compedu.2011.08.028

Prestridge, S. (2019). Categorising teachers' use of social media for their professional learning: A self-generating professional learning paradigm. *Computers & Education, 129*, 143-158. doi:https://doi.org/10.1016/j.compedu.2018.11.003

Puentedura, R. (2010). SAMR and TPCK: Intro to advanced practice. Retrieved February, 12, 2013.

Raza, S.A., Khan, K.A., & Rafi, S.M.T (2020). Online Education & MOOCS : Teacehr Self- Disclosure in Online Education and a Mediating Role of Social Presence. *South Asian Journal of Management, 14*(1), 145-158.

Redecker, C. (2017). European Framework for the Digital Competence of Educators. Luxembourg Retrieved from https://ec.europa.eu/jrc/en/digcompedu

Redecker, C., & Punie, Y. (2017). *European Framework for the Digital Competence of Educators : DigCompEdu*. (10.2760/159770 (online)). EU: Publications Office of the European Union.

Redmond, P., & Albion, P. (2002). *In their own words: preservice teachers' perceptions of ICT integration*. Paper presented at the Society for Information Technology & Teacher Education International Conference 2002, Nashville, Tennessee, USA. http://www.editlib.org/p/17708

Redmond, P., & Lock, J. (2013). *TPACK: Exploring a Secondary Pre-service Teachers' Context*. Paper presented at the Society for Information Technology & Teacher Education International Conference 2013, New Orleans, Louisiana, United States. https://www.learntechlib.org/p/48940

Research, Norwegian Ministry of Education. (2017). *Skills Norway*. Retrieved from https://www.kompetansenorge.no/english

Reyes, V. C., Reading, C., Doyle, H., & Gregory, S. (2017). Integrating ICT into teacher education programs from a TPACK perspective: Exploring perceptions of university lecturers. *Computers & Education, 115*, 1-19. doi:https://doi.org/10.1016/j.compedu.2017.07.009

Ring, G., & Ramirez, B. (2012). Implementing ePortfolios for the Assessment of General Education Competencies. *International Journal of ePortfolio, 2*(1), 87-97.

Rizza, C. (2011). *ICT and Initial Teacher Education: National Policies*. OECD Working Papers.

Rohatgi, A., Scherer, R., & Hatlevik, O. E. (2016). The role of ICT self-efficacy for students' ICT use and their achievement in a computer and information literacy test. *Computers & Education, 102*, 103-116. doi:10.1016/j.compedu.2016.08.001

Røkenes, F. M., & Krumsvik, R. J. (2016). Prepared to teach ESL with ICT? A study of digital competence in Norwegian teacher education. *Computers & Education, 97*, 1-20. doi:10.1016/j.compedu.2016.02.014

Rovai, A. P., & Childress, M. D. (2002). Explaining and Predicting Resistance to Computer Anxiety Reduction among Teacher Education Students. *Journal of Research on Technology in Education, 35*(2), 226.

Roy, M., Giraldo-Garcia, R., Mathew, A. S., Matias, U., & Bommisetty, I. (2016). *Emerging Technologies for Face-to-face and online teachers: Use of Tablets*. Paper presented at the EdMedia: World Conference on Educational Media and Technology 2016, Vancouver, BC, Canada. https://www.learntechlib.org/p/173293

Russell, M., Bebell, D., O'Dwyer, L., & O'Connor, K. (2003). Examining Teacher Technology Use: Implications for Preservice and Inservice Teacher Preparation. *Journal of Teacher Education, 54*(4), 297-310. doi:10.1177/0022487103255985

Sawang, S., Sun, Y., & Salim, S. A. (2014). It's not only what I think but what they think! The moderating effect of social norms. *Computers & Education, 76*, 182-189. doi:10.1016/j.compedu.2014.03.017

Scherer, R., Siddiq, F., & Teo, T. (2015). Becoming more specific: Measuring and modeling teachers' perceived usefulness of ICT in the context of teaching and learning. *Computers & Education, 88*, 202-214. doi:10.1016/j.compedu.2015.05.005

Schleicher, A. (2012). Preparing Teachers and Developing School Leaders for the 21st Century: Lessons from around the World. *OECD Publishing*. doi:10.1787/9789264xxxxxx-en

Schunk, D. H., & Ertmer, P. A. (1999). Self-regulatory processes during computer skill acquisition: Goal and self-evaluative influences. *Journal of Educational Psychology, 91*(2), 251.

Selwyn, N. (2003). *Understanding students (non)use of information and communications technology in university* (Vol. Working Paper Series - Paper 40). Cardiff University.

Selwyn, N. (2010). Primary schools and ICT - what can we teach the pupils? *Education Journal*(122), 24-25.

Selwyn, N. (2011a). *Education and technology : key issues and debates / Neil Selwyn*.

Selwyn, N. (2011b). *Schools and schooling in the digital age : a critical analysis / Neil Selwyn*.

Selwyn, N. (2013). *Education in a digital world : global perspectives on technology and education / Neil Selwyn*. London: Routledge.

Selwyn, N. (2016). *Is Technology Good for Education*: Polity Press.

Selwyn, N. (2019). Teachers and Technology : Time to get Serious. *Journal of the Chartered College of Teaching, Special Issue January 2019*(Special Issue on Educational Technology). doi:https://impact.chartered.college/issue/special-issue-january-2019-education-technology/

Selwyn, N., & Bulfin, S. (2015). Exploring school regulation of students' technology use – rules that are made to be broken? *Educational Review, 68*(3), 1-17. doi:10.1080/00131911.2015.1090401

Selwyn, N., & Facer, K. (2013). Introduction: The need for a politics of education and technology. In *The politics of education and technology* (pp. 1-17): Springer.

Selwyn, N., & Facer, K. (2014). The sociology of education and digital technology: past, present and future. *Oxford Review of Education, 40*(4), 482-496. doi:10.1080/03054985.2014.933005

Selwyn, N., Potter, J., & Crammer, S. (2010). *Primary schools and ICT : learning from pupil perspectives / Neil Selwyn, John Potter, and Sue Cranmer*. London: Continuum.

Senkbeil, M., & Ihme, J. M. (2017). Motivational factors predicting ICT literacy: First evidence on the structure of an ICT motivation inventory. *Computers & Education, 108*, 145-158. doi:10.1016/j.compedu.2017.02.003

Shapiro, H. B., Lee, C. H., Wyman Roth, N. E., Li, K., Çetinkaya-Rundel, M., & Canelas, D. A. (2017). Understanding the massive open online course (MOOC) student experience: An examination of attitudes, motivations, and barriers. *Computers & Education, 110*, 35-50. doi:https://doi.org/10.1016/j.compedu.2017.03.003

Sheil, G., & O'Flaherty, A. (2006). *NCTE 2005 Census on ICT Infrastructure in Schools : Statistical Report*. Retrieved from St. Patrick's College, Drumcondra, Dublin 9:

Shellhorn, S. (2019). Comparing Administrator and Teacher Perceptions of Technology Integration Using the Technological Pedagogical Content Knowledge Framework and 2017 ISTE Standards for Educators.

Shinas, V. H., Yilmaz-Ozden, S., Mouza, C., Karchmer-Klein, R., & Glutting, J. J. (2013). Examining Domains of Technological Pedagogical Content Knowledge Using Factor Analysis. *Journal of Research on Technology in Education, 45*(4), 339-360.

Shulman, L. S. (1986). Those Who Understand: Knowledge Growth in Teaching. *Educational Researcher, 15*(2), 4-14.

Skills, D. o. E. (2015). *Digital Strategy for Schools 2015 - 2020 : Enhancing Teaching, Learning and Assessment*. Dublin Retrieved from https://www.education.ie/en/Publications/Policy-Reports/Digital-Strategy-for-Schools-2015-2020.pdf

Skinner, B. F. (1968). *The Technology of Teaching*. New York: Meredith Corporation.

Slay, H., Siebörger, I., & Hodgkinson-Williams, C. (2008). Interactive whiteboards: Real beauty or just "lipstick"? *Computers & Education, 51*(3), 1321-1341. doi:10.1016/j.compedu.2007.12.006

Smith, E. E. (2016). "A real double-edged sword:" Undergraduate perceptions of social media in their learning. *Computers & Education, 103*, 44-58. doi:10.1016/j.compedu.2016.09.009

Spaulding, M. (2016). *Does a Web 2.0 based technology integration course develop TPACK ready preservice teachers?* Paper presented at the Society for Information Technology & Teacher Education International Conference 2016, Savannah, GA, United States. https://www.learntechlib.org/p/172128

Stoecki, S. (2016). *How do you see the changing role of the teacher?* ISTE website, retrieved from https://www.iste.org/explore/ISTE-Standards-in-Action/How-do-you-see-the-changing-role-of-the-teacher%3F

Taleb, N. N. (2007). The black swan: The impact of the highly improbable (Vol. 2): Random house.

Teo, T. (2009a). Is there an attitude problem? Reconsidering the role of attitude in the TAM. *British Journal of Educational Technology, 40*(6), 1139-1141. doi:10.1111/j.1467-8535.2008.00913.x

Teo, T. (2009b). Modelling technology acceptance in education: A study of pre-service teachers. *Computers & Education, 52*(2), 302-312. doi:10.1016/j.compedu.2008.08.006

Teo, T. (2010). A path analysis of pre-service teachers' attitudes to computer use: applying and extending the technology acceptance model in an educational context. *Interactive Learning Environments, 18*(1), 65-79. doi:10.1080/10494820802231327

Teo, T. (2011). Factors influencing teachers' intention to use technology: Model development and test. *Computers & Education, 57*(4), 2432-2440. doi:10.1016/j.compedu.2011.06.008

Teo, T. (2012). Examining the intention to use technology among pre-service teachers: an integration of the Technology Acceptance Model and Theory of Planned Behavior. *Interactive Learning Environments, 20*(1), 3-18. doi:10.1080/10494821003714632

Teo, T. (2013). Digital Nativity: A Definitional Framework. *World Journal on Educational Technology, 5*(3), 389-394.

Teo, T. (2015). Comparing pre-service and in-service teachers' acceptance of technology: Assessment of measurement invariance and latent mean differences. *Computers & Education, 83*, 22-31. doi:10.1016/j.compedu.2014.11.015

Teo, T., Chai, C. S., Hung, D., & Lee, C. B. (2008). Beliefs about teaching and uses of technology among pre-service teachers. *Asia-Pacific Journal of Teacher Education, 36*(2), 163-174. doi:10.1080/13598660801971641

Teo, T., Ching Sing, C., David, H., & Chwee Beng, L. (2008). Beliefs about teaching and uses of technology among pre-service teachers. *Asia-Pacific Journal of Teacher Education, 36*(2), 163-174.

Teo, T., Lee, C. B., & Chai, C. S. (2007). Understanding pre-service teachers' computer attitudes: applying and extending the technology acceptance model. *Journal of Computer Assisted Learning, 24*(2), 128-143.

Teo, T., & Noyes, J. (2011). An assessment of the influence of perceived enjoyment and attitude on the intention to use technology among pre-service teachers: A structural equation modeling approach. *Computers & Education, 57*(2), 1645-1653. doi:10.1016/j.compedu.2011.03.002

Teo, T., & Noyes, J. (2012). Explaining the intention to use technology among pre-service teachers: a multi-group analysis of the Unified Theory of Acceptance and Use of Technology. *Interactive Learning Environments, 22*(1), 1-16. doi:10.1080/10494820.2011.641674

Thomas, K. M., O'Bannon, B. W., & Britt, V. G. (2014). Standing in the Schoolhouse Door: Teacher Perceptions of Mobile Phones in the Classroom. *Journal of Research on Technology in Education, 46*(4), 373-395. doi:10.1080/15391523.2014.925686

Thompson, P. (2013). The digital natives as learners: Technology use patterns and approaches to learning. *Computers & Education, 65*(0), 12-33. doi:10.1016/j.compedu.2012.12.022

Tondeur, J., Aesaert, K., Pynoo, B., van Braak, J., Fraeyman, N., & Erstad, O. (2017). Developing a validated instrument to measure preservice teachers' ICT competencies: Meeting the demands of the 21st century. *British Journal of Educational Technology, 48*(2), 462-472. doi:10.1111/bjet.12380

Tondeur, J., van Braak, J., Ertmer, P. A., & Ottenbreit-Leftwich, A. (2016). Understanding the relationship between teachers' pedagogical beliefs and technology use in education: a systematic review of qualitative evidence. *Educational Technology Research and Development*, 1-21. doi:10.1007/s11423-016-9481-2

Tondeur, J., van Braak, J., Sang, G., Voogt, J., Fisser, P., & Ottenbreit-Leftwich, A. (2012). Preparing pre-service teachers to integrate technology in education: A synthesis of qualitative evidence. *Computers & Education, 59*(1), 134-144. doi:10.1016/j.compedu.2011.10.009

Tondeur, J., van Braak, J., Siddiq, F., & Baran, E. (2016). *Enhancing Pre-Service Teachers' TPACK - How Teacher Education Matters*. Paper presented at the Educational Technology World Conference, Bali, Indonesia. Presentation retrieved from https://www.researchgate.net/publication/305986597_Enhancing_Preservice_Teachers%27_Technological_Pedagogical_Content_Knowledge_How_Teacher_Education_Matters

Trevethan, H. (2017). Educative mentors? The role of classroom teachers in initial teacher education. A New Zealand study. *Journal of Education for Teaching, 43*(2), 219-231. doi:10.1080/02607476.2017.1286784

Trucano, M. (2005). Knowledge Maps: ICTs in Education. Washington, DC: *info*Dev / World Bank. Retrieved from http://www.infodev.org/articles/icts-education-costs

Turel, V. (2014). Teachers' Computer Self-Efficacy and Their Use of Educational Technology. *Turkish Online Journal of Distance Education, 15*(4), 130-149.

Tzeng, J. Y., & Chen, S. H. (2012). College students' intentions to use e-portfolios: From the perspectives of career-commitment status and weblog-publication behaviours. *British Journal of Educational Technology, 43*(1), 163-176.

Uerz, D., Volman, M., & Kral, M. (2018). Teacher educators' competences in fostering student teachers' proficiency in teaching and learning with technology: An overview of relevant research literature. *Teaching and Teacher Education, 70*, 12-23. doi:https://doi.org/10.1016/j.tate.2017.11.005

Umar, I. N., & Hussin, F. K. (2014). ICT Coordinators' Perceptions on ICT Practices, Barriers and its Future in Malaysian Secondary Schools: Correlation Analysis. *Procedia - Social and Behavioral Sciences, 116*, 2469-2473. doi:10.1016/j.sbspro.2014.01.593

UNESCO. (2007). ICT in Education in the Asia-Pacific Region : Progress and Plans. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000154992

UNESCO. (2011). UNESCO ICT Competency Framework for Teachers. In: UNESCO.

UNESCO. (2012). ICT in Education in Latin America and The Caribbean : A Regional Analysis of ICT Integration & eReadiness. Retrieved from http://uis.unesco.org/sites/default/files/documents/ict-in-education-in-latin-america-and-the-caribbean-a-regional-analysis-of-ict-integration-and-e-readiness-en_0.pdf

Unwin, T. (2019). The Future Use of Technology in Education and Learning in the Commonwealth. *108*(4), 447-458.

Vahtivuori-Hänninen, S., Halinen, I., Niemi, H., Lavonen, J., & Lipponen, L. (2014). A new Finnish national core curriculum for basic education (2014) and technology as an integrated tool for learning. In *Finnish innovations and technologies in schools* (pp. 21-32): Brill Sense.

Valencia, K., Rusu, C., QuiÒones, D., & Jamet, E. (2019). The Impact of Technology on People with Autism Spectrum Disorder: A Systematic Literature Review. *19*(20), 4485-4485.

Valtonen, T., Kukkonen, J., Kontkanen, S., Sormunen, K., Dillon, P., & Sointu, E. (2015). The impact of authentic learning experiences with ICT on pre-service teachers' intentions to use ICT for teaching and learning. *Computers & Education, 81*, 49-58. doi:10.1016/j.compedu.2014.09.008

Valtonen, T., Leppänen, U., Hyypiä, M., Sointu, E., Smits, A., & Tondeur, J. (2020). Fresh perspectives on TPACK: pre-service teachers' own appraisal of their challenging and confident TPACK areas. *Education and Information Technologies*. doi:10.1007/s10639-019-10092-4

van Braak, J. (2001). Factors influencing the use of computer mediated communication by teachers in secondary schools. *Computers & Education, 36*(1), 41-57. doi:10.1016/s0360-1315(00)00051-8

van den Beemt, A., & Diepstraten, I. (2016). Teacher perspectives on ICT: A learning ecology approach. *Computers & Education, 92-93*, 161-170. doi:10.1016/j.compedu.2015.10.017

Varma, S., & Marler, J. H. (2013). The dual nature of prior computer experience: More is not necessarily better for technology acceptance. *Computers in Human Behavior, 29*(4), 1475-1482. doi:10.1016/j.chb.2013.01.029

Vega-Hernandez, M.-C., Patino-Alonso, M.-C., & Galindo-Villardon, M.-P. (2018). Multivariate characterization of university students using the ICT for learning. *Computers & Education, 121*(3), 124-130.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly, 27*(3), 425-478.

Verdegem, P., & De Marez, L. (2011). Rethinking determinants of ICT acceptance: Towards an integrated and comprehensive overview. *Technovation, 31*(8), 411-423. doi:10.1016/j.technovation.2011.02.004

Viherä, M.-L., & Nurmela, J. (2001). Communication capability as an intrinsic determinant for information age. *Futures, 33*(3-4), 245-265. doi:10.1016/s0016-3287(00)00070-7

Voogt, J., Mishra, P., Thompson, A., Crawford, D., Wang, W., Niederhauser, D., . . . Agyei, D. (2013). *Measuring TPACK: Part 2*. Paper presented at the Society for Information Technology & Teacher Education International Conference 2013, New Orleans, Louisiana, United States. https://www.learntechlib.org/p/48475

Vrasidas, C. (2015). The rhetoric of reform and teachers' use of ICT. *British Journal of Educational Technology, 46*(2), 370-380. doi:10.1111/bjet.12149

Vygotsky, L. S. (1978). *Mind in Society : The Development of Higher Psychosocial Processes*. Massachusetts: Harvard University Press.

Walsh, N. (2019). Will Blockchain technology disrupt education? Retrieved from https://www.learnovatecentre.org/will-blockchain-disrupt-education/

Wang, S.-K., Hsu, H.-Y., Campbell, T., Coster, D. C., & Longhurst, M. (2014). An investigation of middle school science teachers and students use of technology inside and outside of classrooms: considering whether digital natives are more technology savvy than their teachers. *Educational Technology Research and Development, 62*(6), 637-662. doi:10.1007/s11423-014-9355-4

Watson, J. M. (2012). The Quest for Expertise: A Review of Documenting Learning with ePortfolios: A Guide for College Instructors. *International Journal, 2*(1), 125-128.

Waycott, J., Bennett, S., Kennedy, G., Dalgarno, B., & Gray, K. (2010). Digital divides? Student and staff perceptions of information and communication technologies. *Computers & Education, 54*(4), 1202-1211. doi:10.1016/j.compedu.2009.11.006

Weber, R. K., Millwood, R., Kumpulainen, K., Freeman, E., O Murchu, D., FitzGibbon, A., ... Sorensen, E. (2004). *Addressing Barriers of Information Technology from a Multi-National View: A New Message for Teacher Education*. Paper presented at the Society for Information Technology & Teacher Education International Conference 2004, Atlanta, GA, USA. http://www.editlib.org/p/13700

Weller, M. (2020) *The online pivot and absence of a magic button*. Retrieved from http://blog.edtechie.net/higher-ed/online-pivot-the-absence-of-a-magic-button/ 10 June 2020

Wood, E., Mueller, J., Willoughby, T., Specht, J., & Deyoung, T. (2005). Teachers' Perceptions: barriers and supports to using technology in the classroom. *Education, Communication & Information, 5*(2), 183-206. doi:10.1080/14636310500186214

Wu, J.-H., Chen, Y.-C., & Lin, L.-M. (2007). Empirical evaluation of the revised end user computing acceptance model. *Computers in Human Behavior, 23*(1), 162-174.

Yen, D. C., Wu, C.-S., Cheng, F.-F., & Huang, Y.-W. (2010). Determinants of users' intention to adopt wireless technology: An empirical study by integrating TTF with TAM. *Computers in Human Behavior, 26*(5), 906-915.

Young, A.-M., O'Neill, A., & Mooney Simmie, G. (2015). Partnership in learning between university and school: evidence from a researcher-in-residence. *Irish Educational Studies, 34*(1), 25-42. doi:10.1080/03323315.2014.1001203

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