Digital Competence in Teacher Education

Oliver McGarr[1] and Adrian McDonagh[1]

Output 1 of the Erasmus+ funded Developing Student Teachers' Digital Competence (DICTE) project. (Erasmus+ KA203 – Strategic partnership – Higher Education 2017-1-NO01-KA203-034194)

To Cite: McGarr, O. & McDonagh, A. (2019) Digital Competence in Teacher Education, *Output 1 of the Erasmus+ funded Developing Student Teachers' Digital Competence (DICTE) project*. https://dicte.oslomet.no/

DICTE Team members:

Patrick Camilleri[2], Juan Carlos Colomer[3], Bård Ketil Engen[4], Tonje Hilde Giæver[4], Gréta Björk Gudmundsdottir[5], Ove Edvard Hatlevik[4], Hector Hernandez[3], José Ramón Insa[3], Adrian McDonagh[1], Oliver McGarr[1], Louise Mifsud[4], Josephine Milton[2], Anubha Rohatgi[5]

[1] University of Limerick, [2] University of Malta, [3] University of Valencia, [4] Oslo Metropolitan University, [5] University of Oslo

Contents

Background and Context

This review of literature, examining digital competence (DC) in teacher education, forms part of an Erasmus+ funded project, 'Digital Competence in Teacher Education' (DiCTE). The project is led by Oslo Metropolitan University with partners University of Limerick, University of Malta, University of Oslo and University of Valencia. The broader goals of the DiCTE project are to:

- Identify the student teachers' levels of digital competence when entering teacher education and compare across the partner institutions.
- Identify and benchmark approaches used in the participating teacher education institutions to develop student teachers' digital competence.
- Identify the student teachers' development of digital competence during their studies and compare across institutions.
- Create methods for integrating digital competence in teacher education and transfer of best practices

The literature review was conducted to help inform the ongoing development and revision of the research tools used to explore pre-service teachers' levels of digital competence and their views of digital technologies. The document is broken into four main parts:

Part 1 problematises the concept of Digital Competence and unpacks the development of the term.

Part 2 examines what is recognised as digital competence in teacher education internationally and describes the various conceptual models used to define its elements.

Part 3 examines research into digital competence in teacher education and how such competencies have been assessed in teacher education

Part 4 explores the main issues emerging from this review and their implications for teacher education

Before these sections are addressed a description of the search criteria used in the selection of sources as well as a brief introduction are provided.

Search criteria and method of selecting sources

To identify relevant sources for the literature review, a search of key research databases was conducted. The search involved identification of key terms and phrases. To that end, the terms "digital competence" and "digital literacy" were combined with the following terms, "student teacher", "teacher education", “measurement” and “assessment”. The following data bases Eric, Google Scholar, Web of Science and Scopus were searched. The output of each search was then compiled to a single database and duplicates removed and all sources from 2005 and later included in the initial list. This list was then examined and after sources were removed that were not considered suitable for the study (as they did not specifically address teacher education or digital competence/literacy) a total of 87 sources remained in the final list. These sources were subsequently read by the DICTE team members to determine their relevance for the review. As well as this systematic search approach, other relevant research studies and articles, familiar to the project team members, were also included in the final list of papers. Relevant policy documents were also reviewed and are included in the literature review.

Introduction

The pervasive use of digital technologies in all areas of life calls for the need for new skills and competencies. Referring to this need Ala-Mutka (2011) notes that*, 'there are different perspectives on what these new skills and competences should include, though they typically agree that digital competence is an integral part of them*' (p. 39). As it is generally assumed that digital competence should be acquired at school (Ilomki et al, 2016), it has consequently resulted in widespread attention in the international educational research arena (García-Martín and García-Sánchez, 2017) where there now exists a significant body of research in the area of digital competence in education and in teacher education more specifically. Brox (2017) notes, '*in the last decade, much effort has been put into defining the specific demands on new teachers' digital skills and to how they should be strengthened in their training*' (p. 130). This attention is not only limited to developed economies with a history of ICT use in education, but also extends to developing countries (Andema et al, 2013; Bukaliya & Kudakwashe-Mubika, 2011; Derbel, 2016). This review therefore aims to examine digital competency in teacher education and explore what the current research literature reveals about attempts to embed digital experiences and practices in teacher education. Before exploring this issue however, it is important to unpack the term 'digital competency' and the terms associated with it. While the phrase is often used in an uncritical way, there exists considerable debate as to what it does, and does not, entail, as it is a novel and evolving concept that is not well defined (Ilomaki et al, 2016). Tømte (2015), notes that the term is a, '*moving target in the sense that it evolves rapidly and in line with the appearances of new technologies'* (p. 140). For this reason, the first part of the literature review aims to untangle the many phrases used to describe the technology-related competencies and examine the various models used to conceptualise the components of it.

Part 1: Towards a definition of Digital competence

1.1 Unpacking the terminology

The ability to use technology effectively is considered a key competency under the European framework, yet while it is afforded a high level of importance, many different terms are used to describe these skills and competencies. This has resulted in 'a *complex landscape of definitions and concepts'* (Ala-Mutka, 2011, p. 15). Referring to these many different terms as a '*tangled ball of concepts'*, Aesaert et al (2013, p. 143) question whether these different terms have hampered interpretation and subsequent implementation within the education system. In their analysis of educational technology curricula at primary school level in England, Norway and Flanders, they concluded that;

> *The results indicate that national governments define digital literacy in their curricula in different and sometimes diverging ways. Different terms refer to the concept of digital literacy, such as digitally skilled, digitally competent, digitally literate, ICT competent and ICT capable. Not only are different terms used, each of their definitions contains different semantic meanings, ranging from the use of basic ICT skills to complex problem-solving abilities. This permissive use of concepts in national educational technology curricula supports Markauskaite's (2007) view that the notion of digital literacy is poorly understood in formal education and many terms are used to describe various sets of technology related capabilities.* (Aesaert et al., 2013, p. 143)

Similarly, in their review of the literature to investigate the use of the term digital competence between 2005 and 2013, Ilomaki et al (2016) found that the most used term was, first, digital literacy, second, new literacies, third, media literacy, fourth, multiliteracies and fifth, digital competence. They concluded that the term digital competence was a relatively new term in the research articles reviewed. This confusion in terminology may also contribute to what Janssen et al (2013) refer to as the 'lack of transparency' needed for educators, employers and citizens to respond to this challenge.

The range of terms used perhaps reflects the rapid evolution of the technology over the past number of decades. Bawden's (2001) early review in this area highlights the array of terms

used ranging from information literacy, computer literacy, library literacy, media literacy, network literacy, Internet literacy and digital literacy. In analysing the various terms used, Hatlevik et al (2015) observe that all these concepts consist of a 'domain part' (for example 'internet', 'medial' of 'digital') accompanied by a specific 'knowledge perspective' (for example, skills, competence, literacy). In many ways the 'domain part' of these terms has been determined by the dominant technology of that era or how it was used. For example, computer literacy reflects the stand-alone nature of early computing technologies before their information and communication capabilities expanded and brought the need for 'information' literacies (Bawden, 2001). Subsequent terms, such as internet literacy, information literacy and network literacy largely emerged from the further evolution of the technologies.

As the technologies evolved, reference to specific 'skills' appears to have been replaced with reference to 'literacy' and 'competency', largely reflecting broader dimensions beyond skills to include knowledge and attitudes (Ala-Mutka, 2011; Ferrari, 2013). The need to achieve a higher level of status and recognition in the wider education community could be an alternative explanation for this shift from 'skills' to 'literacy' and 'competency'. Buckingham (2015) argues that the term literacy carries a level of social status and is frequently used in conjunction with lower-status terms to elevate its importance. Hence it could be argued that the term 'computer literacy' elevates 'computer skills' from a vocationally-based understanding to a more universal ability needed by all - reflecting a pursuit for social acceptance of the skill as much as a change in focus.

1.2 Digital Literacy and Competence: From technical origins to encompassing broader dimensions

In exploring the evolution of the terms, it is apparent that what is encompassed as part of them is widening from an initial narrow base. Bawden (2001) notes that early 'computer literacy' had quite a pragmatic goal, focusing on basic computer skills and the ability to perform particular functions. Ala-Mutka (2011) reports a similar early focus which she argues contributed to narrow, '*tool-oriented approaches, where teaching is reduced to relatively trivial software instruction*' (p. 23). The first broadening of this understanding of literacy/competence emerged with the use of the term information literacy which moved

beyond the focus of specific devices (such as the computer) towards the information they handle. This information literacy held sway for a long period as the internet and networked technologies developed but now appears to have been replaced by digital literacy. As Bawden (2001) noted decades ago, '*While information literacy is generally taken to include an ability to deal with electronic sources, it has to some ears a somewhat dated ring; perhaps for this reason, variants of the concept of 'digital literacy' came in vogue during the 1990s'* (p. 246).

Yet while the term 'digital literacy' has largely replaced computer and information literacies, it would appear that its focus remains the same. Knobel and Lankshear (2015) highlight the importance of recognising a wide range of digital literacies beyond those tied to information, however, Buckingham (2015) notes that, '*… most discussions of digital literacy remain primarily preoccupied with information – and therefore tend to neglect some of the broader cultural uses of the internet (not least by young people)'* (p. 24). These broader cultural dimensions also point to the convergence of various forms of technology and how technology is merging with media so that it is no longer something the user must actively seek. Instead, the user is now constantly exposed to media, whether traditional media or social media, through various mobile devices. As a result of this, media literacy is playing a more critical element of digital literacy/competence. This, according to Koltay (2011), should include understanding the media economy and the difference between pluralism and media ownership. He also questions whether media literacy should also have a more explicit political and/or ideological agenda. If one was to see this as an important area within digital literacy/competency, similar questions should perhaps be asked.

As this section has highlighted, what encompasses digital competence has widened significantly over the years and it is likely that this will continue to widen as digital practices continue to converge with other traditional practices. What is also apparent from this section however is that changes in the language used to describe something does not necessarily reflect a change in what it constitutes. Instead these can be simply surface level changes in language as opposed to fundamental changes in thinking.

1.3 Digital literacy and digital competence: what's in a name?

Turning specifically to the issue of 'digital literacy' and 'digital competency', the extent to which they mean the same thing is an issue of debate. At one level, it may simply reflect linguistic preferences. Erstad (2015) notes that in Scandinavia the term competence is often used instead of literacy, '*since the latter term does not translate to the languages in these countries*' (p. 86). Almås and Krumsvik (2008) identified a similar difference noting that, '*competence as a concept has a broader, more holistic meaning in Scandinavian English than in traditional English*' (p. 280). The use of the term competence to signify a more holistic meaning however may reflect more significant differences in the terms. In explaining the use of 'digital competency' rather than 'digital literacy' Janssen et al (2013) argue that digital literacy is more often used in European policy and initiatives relating to e-inclusion whereas competence is employed more in an educational context. In addition, they also argue that competence encompasses a wider educational conceptualisation that includes knowledge skills and attitudes towards digital technologies. Aesaert et al (2013) define digital competences as the, '*integrated and functional use of digital knowledge, skills and attitudes*' (p. 132).

Another reason for the apparent preference for the term digital competence in the literature may also relate to the diverse and ever-changing nature of 'digital literacies' which makes the term difficult to define (Bawden 2001 Koltay, 2011; Erstad, 2015). Given the evolving nature of technology and how it is used, Lankshear and Knobel (2015) argue that it is better to think in terms of diverse digital literacies. This view is supported by Ala-Mutka (2011) who writes;

> *Many literacy concepts which arose in pre-digital contexts were then developed and extended with the emergence of digital tools and media opportunities. This development will probably continue and trying to freeze concepts under one definition would not only be impossible but also lose its relevance quickly*. (Ala-Mutka, 2011, p. 29)

Ilomaki et al (2016) offer an alternative explanation for the apparent shift towards the use of digital competency arguing that it reflects a broader shift in education to the language of

competencies as opposed to content-based perspectives, '*there is a shift from a content-based (and knowledge-based) assessment approach to a competence-based approach, focusing on "new skills for new jobs*" (p. 658). They too however note the lack of clarity. Quoting Westera (2001) they note that, '*competence is a confusing term, and, from the research point of view, there is no appropriate and commonly accepted definition of it*.' (p. 658).

Similarly, Spante et al's (2018) review of the use of both digital literacy and digital competence in the higher education research literature revealed that, '*overall, there is a striking tendency of using the concepts without any reference to the terms' meanings' (p. 5).* In their analysis of the frequency of use of both terms they highlight that the term competence has grown since 2010 but that literacy still dominates. They also identified regional differences in the use of the terms. (see figure 1. Below)

Figure 3. Distribution of concept use over time (percentage of articles).

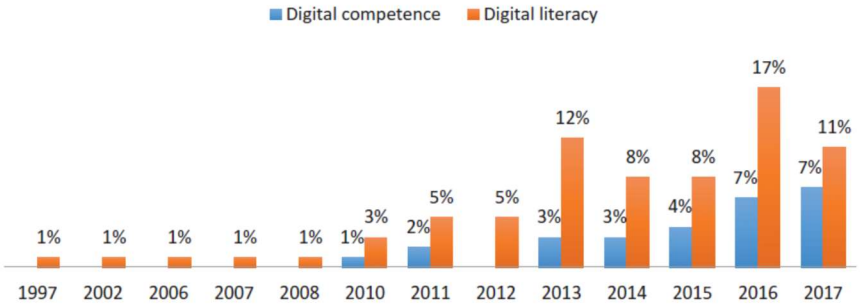

Figure 4. Distribution of concept use over countries and continents (percentages of articles).

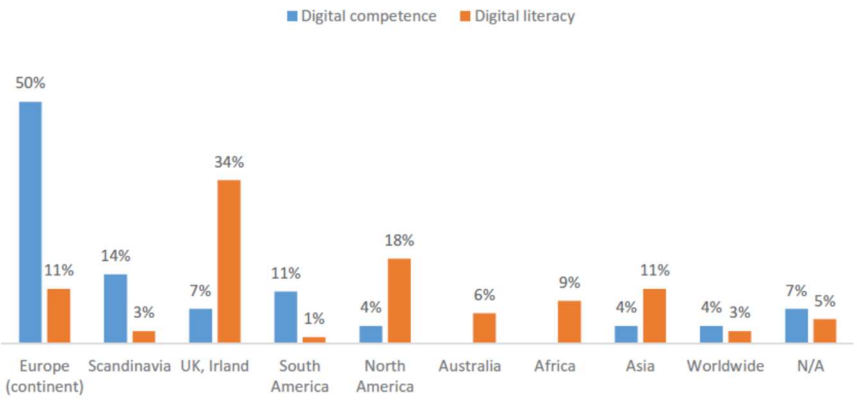

Figure 1. Use of digital competence and digital literacy terminology (Spante et al, 2018)

This differentiation of the terms is echoed in a European Commission report which argued that, digital literacy is needed to achieve digital competence suggesting that digital competence is more broad-ranging than digital literacy (European Commission, 2006). Similarly, and more recently, Petersson (2017) writes that, '*generally speaking, digital competence often refers to*

the skills and literacies needed for the average citizen to be able to learn and navigate in digitalized knowledge society' (p. 2).

Notwithstanding these differences, it is nonetheless important to recognise that many sources within the literature do not make distinctions between the terminology and that in some sources use of one term 'literacy' is taken in its broadest sense to include knowledge skills and attitudes (Ng, 2012; Greene et al, 2014) thus reflecting the broader term of 'digital competency' outlined earlier. In their review of the terms used in the literature by Ilomaki et al (2016), they noted that, '*the term most often used close to digital competence, and often as a synonym, is digital literacy and both the terms can be found in the same article'* (p. 664). Siddiq et al (2016) note a similar convergence between the terms of digital competence, ICT literacy and 21st century skills. Therefore, for the purposes of this review, the term 'digital competency' will be referred to throughout, however, references to digital literacy will be drawn upon where its meaning and interpretation adopts an equivalent broader conceptualisation to the term 'digital competence'.

1.4. Unpacking the dimensions of digital competence

Having explored the many terms used over the past three decades and the interchangeable use of current terms, this section aims to explore in more detail the concept of digital competency and what it encompasses.

Janssen et al (2013) note that as technologies develop they result in the need for new sets of competencies and this appears to be reflected at a policy level where there is increasing reference to the term digital competence in European policy (Engen et al, 2015). However, digital competence, similar to the other literacies outlined earlier, can take on different foci. Some conceptualisations can take an instrumentalist view reflecting more traditional technology-centred perspectives (Gentikow, 2015) focusing on developing the skills to retrieve, assess, store, produce, present and exchange information using technologies;

> *Digital competence involves the confident and critical use of Information Society Technology (IST) for work, leisure and communication. It is underpinned by basic skills in ICT: the use of computers to retrieve, assess, store, produce, present and exchange*

*information, and to communicate and participate in collaborative networks via the Internet. (*European Parliament and the Council, 2006)

Yet these early definitions appear to be strongly influenced by earlier information literacy skills since they suggest the user is actively involved in the access and use of the information. With the evolution and convergence of digital technologies with more traditional forms of media, and the disruptive aspects of social media on traditional forms of media, digital competency now encompasses a broader more complex set of knowledge, skills and attitudes. The attitudinal dimension is particularly important in this regard as it calls on a specific mindset to adapt to new requirements (Janssen et al, 2013) and important critical thinking skills in dealing with information (Ala-Mutka, 2011). As a result of these added dimensions, current definitions now appear to have a broader focus. As well as recognising the importance of these skills for social engagement in society in general (Ng, 2012; Instefjord, 2015), there is also a recognition of the more complex critical skills;

Digital Competence is the set of knowledge, skills, attitudes (thus including abilities, strategies, values and awareness) that are required when using ICT and digital media to perform tasks; solve problems; communicate; manage information; collaborate; create and share content; and build knowledge effectively, efficiently, appropriately, critically, creatively, autonomously, flexibly, ethically, reflectively for work, leisure, participation, learning, socializing, consuming, and empowerment. (Ferrari, 2012, p. 3)

Similarly, Rokenes and Krumsvik (2014) note that digital competence involves a wide range of skills including cognitive and emotional skills as well as sociological knowledge to use digital environments effectively. The emphasis on critical thinking skills forming a key part of this competency is also acknowledged by Instefjord (2015) who highlights the critical and reflective use of technology in building new knowledge.

Before concluding this section, it is worth reflecting on Lankshear and Knobel's (2015) contention that digital literacy should be problematised rather than taken as understood. In their critique of the concept, they argue against its information-focused nature and the 'truth-centric' ways in which it is constructed. This view holds that the 'truth' is available but only

careful skills of analysis of information will lead to its identification. Therefore, this view disregards broader epistemological considerations in relation to information and knowledge. The authors conclude that a much broader interpretation of digital competence is required;

> It means we should think of 'digital literacy' not as something unitary, and certainly not as some finite 'competency' or 'skill' – or even as a set of competencies or skills. Rather, it means we should think of 'digital literacy' as shorthand for the myriad social practices and conceptions of engaging in meaning making mediated by texts that are produced, received, distributed, exchanged etc., via digital codification. (Lankshear & Knobel, 2015, p. 13)

The issue of digital competence as a unitary skill or a multitude of competencies is therefore further complicated by the added complexity in relation to whether it is skill or a social practice.

1.5. Frameworks of Digital Competence

There is a significant amount of literature that has attempted to outline the different dimensions of digital competence. These have ranged from quite complex descriptions of the various dimensions encompassed by digital competence to broader organisational frameworks that attempt to consider the domains of knowledge and skills needed. In teasing out the various components of digital competence, Ala-Mutka (2011) identifies many different skills and knowledge as well as attitudes to be included in the term.

Calvani et al (2008) propose a framework based around three key areas, namely technological, ethical and cognitive aspects. A somewhat similar tri-partite models is offered by Ng (2012) (see figure 2). This 'digital literacy model' includes technical, cognitive (associated with the ability to think critically) and social-emotional (able to use the Internet responsibly including 'netiquette', protecting individual safety and privacy and recognising threats and dangers) dimensions. Referring the basic skills that a digitally literate person should demonstrate, Ng (2012) lists the ability to:

- carry out basic computer-based operations and access resources for everyday use
- search, identify and assess information effectively for the purposes of research and content learning
- select and develop competency in the use of the most appropriate technological tools or features to complete tasks, solve problems or create products that best demonstrate new understandings and
- behave appropriately in online communities and protect oneself from harm in digitally enhanced environments.

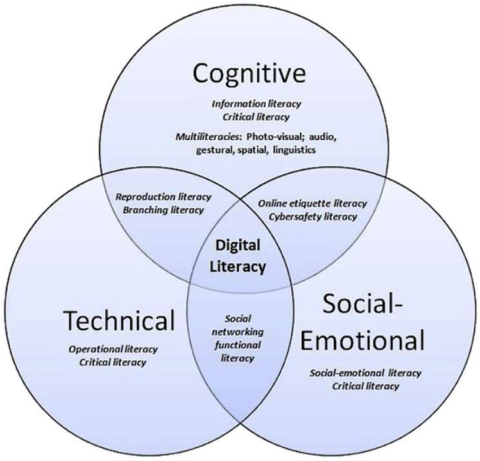

Figure 2. Digital literacy model (Ng, 2012)

Similarly, using a Delphi study to investigate experts' views on what it means to be digitally competent, Janssen et al. (2013) identified twelve different areas that encompass digital competence composing of knowledge, skills, and attitudes (see figure 3).

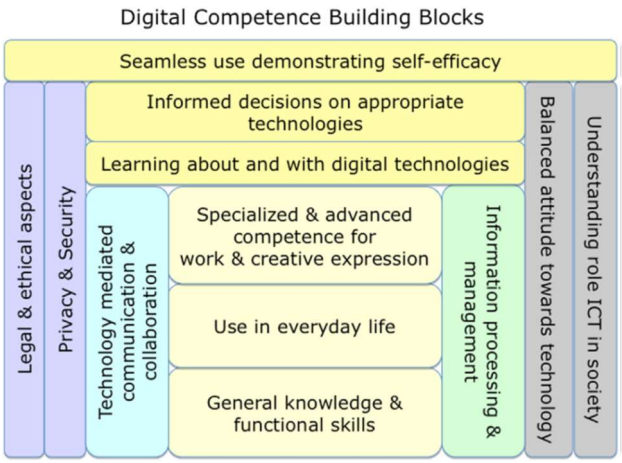

Figure 3. Areas of digital competence: experts' collective view (Janssen et al., 2013)

Other observers, rather than arranging the dimensions within an organisational framework, list a set of competencies required for digital competence. Erstad (2015), who uses the term

digital and media literacy interchangeably, lists ten aspects of media literacy as outlined in table 1 below.

Basic skills	Be able to open software, sort out and save information on the computer, and other simple skills in using the computer and software.
Download	Be able to download different information types from the Internet.
Search	Know about and how to get access to information.
Navigate	Be able to orient oneself in digital networks, learning strategies in using the Internet.
Classify	Be able to organize information according to a certain classification scheme or genre.
Integrate	Be able to compare and put together different types of information related to multimodal texts.
Evaluate	Be able to check and evaluate the information one seeks to get from searching the Internet. Be able to judge the quality, relevance, objectivity and usefulness of the information one has found. Critical evaluation of sources.
Communicate	Be able to communicate information and express oneself through different mediational means.
Cooperate	Be able to take part in net-based interactions of learning, and take advantage of digital technology to cooperate and take part in networks.
Create	Be able to produce and create different forms of information as multimodal texts, make web pages, and so forth. Be able to develop something new by using specific tools and software. Remixing different existing texts into something new.

Table 1. Different aspects and categories of media literacy (Erstad, 2015)

A similar set of skills and competencies is listed by Ferrari (2013). Drawing on the work of the Digicomp project, an EU funded project aimed at identifying the key components of Digital Competence and developing an overall digital competence framework, the project proposed 5 key areas of competence including:

1. Information: identify, locate, retrieve, store, organise and analyse digital information, judging its relevance and purpose.

2. **Communication:** communicate in digital environments, share resources through online tools, link with others and collaborate through digital tools, interact with and participate in communities and networks, cross-cultural awareness.

3. **Content-creation:** Create and edit new content (from word processing to images and video); integrate and re-elaborate previous knowledge and content; produce creative expressions, media outputs and programming; deal with and apply intellectual property rights and licences.

4. **Safety:** personal protection, data protection, digital identity protection, security measures, safe and sustainable use.

5. **Problem-solving:** identify digital needs and resources, make informed decisions as to which are the most appropriate digital tools according to the purpose or need, solve conceptual problems through digital means, creatively use technologies, solve technical problems, update one's own and others' competences.

The DigiComp 2.0 (Vuorikari et al, 2016), a revision of the original 2013 framework, offers a similar set of dimensions. As the table below highlights, while the dimensions have undergone refinement and updating, the framework maintains the overall structure of 5 competence areas - information, communication, content creation, safety and problem solving.

	Competence areas version 1.0	Competence areas version 2.0
Inter-related areas with overlapping points and cross-references	**1. Information**	**1. Information *and data literacy***
	2. Communication	**2. Communication *and collaboration***
	3. Content creation	**3. *Digital* content creation**
Cross-cutting across all areas	**4. Safety**	**4. Safety**
	5. Problem solving	**5. Problem solving**

Table 2. Comparision of the 5 compentence areas DigiComp 1.0 and 2.0 (Vuorikari et al, 2016)

These different dimensions of digital competence appear to be also reflected in actual practice. For example, in their analysis of educational technology primary school curricula in England, Norway and Flanders, Aesaert et al (2013) found similar themes in the three countries, despite

the use of different terminology. These central themes included: critical use of educational technology; safe and responsible use of educational technology; information retrieval, processing and production; communication by use of technology; and the use of technology for subject learning and practice.

However, in looking at these descriptions of digital literacy it is apparent that the models presented above do not include aspects more traditionally associated with media literacy (see Kellner and Share (2005; 2007) for a description of these media literacy traditions), even though at times the term media is referred to. Given the convergence of digital technologies and media, these aspects would appear to be increasing in their importance. Understanding how all texts and information are political, economically, and socially shaped is important (Buckingham, 2015). In addition, similar to media education, knowledge of how media and digital industry operates is an increasingly important competence given the prevalence of filter bubbles and the effects of digital echo chambers on one's understanding and perspectives on issues. Erstad (2015) notes that, '*media literacy relates to broader aspects of living in a media saturated society, and not only skills in operating applications or information handling, which is the main focus of many international frameworks'* (p. 87) and a similar concern could be raised about many of the digital competency frameworks in the literature to date. This gap in the provision would suggest that any evolving definition of digital competency should take into consideration these emerging issues. It is for this reason the 'Digital Competence landscape for the 21st century' by Ala-Mutka (2011) offers perhaps the most comprehensive model (See figure 4) in that it recognises the convergence of information, digital and media literacies as a result of evolving technologies.

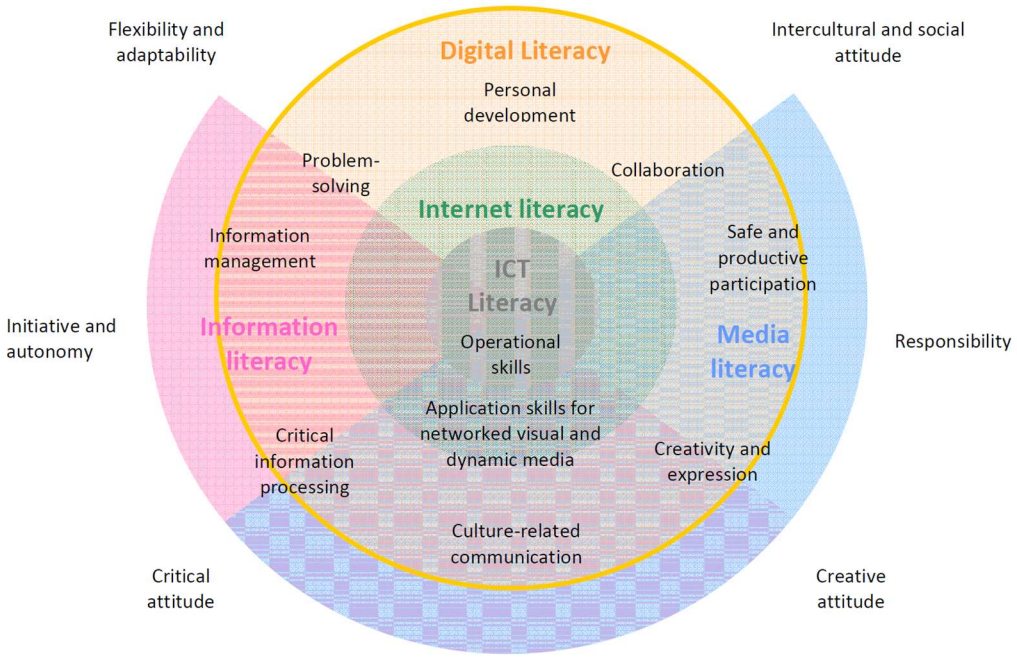

Figure 4. Digital Competence landscape for the 21st century (Ala-Mutka, 2011)

As the review of the above models has highlighted, there are many different components to digital competence and, while there is some consensus in relation to its various components, there remains many different interpretations in relation to what it encompasses. In general, most of the framework and lists of competencies focus on technical skills, knowledge of ICT related issues such as cyber ethics and attitudinal aspects. As the review has highlighted, many of these frameworks do not appear to have prioritised the importance of media literacy and the convergence of media with traditional digital practices. Surprisingly however, within the field of literacy education, this appears to be far more prominent and a central issue of concern (Mills, 2010). It appears therefore that two quite different communities are exploring the issue of digital literacy. Literacy educators, from the classical linguistic and literate competencies tradition, are examining the issue of digital competency and its implication for literacy education. In parallel, the educational technology community are similarly grappling with the issue of what it means to be digitally literate/competent from a broader educational perspective. While research in both fields have raised relevant issues, it does not appear that a significant 'cross pollination' of ideas has occurred between the two fields to date.

Having explored the dimensions of digital competence, the following section will now examine digital competence in teacher education.

PART 2: Digital Competence in Teacher Education

2.1. Digital competency in teacher education: a problem of clarity?

It goes without saying that teachers also need high levels of digital competence and there is general agreement that within teacher education it has added complexities (Petersson, 2017; Krumsvik, 2014; 2008). Krumsvik (2014) contends that digital competence is more complex in the teaching profession as opposed to other occupations or amongst average citizens, as there are two dimensions to their digital competence. The first relates to their ability to use technology in a seamless way to encourage students to mirror such personal use. The second is pedagogical in its focus as they must also simultaneously, '*continually make pedagogic-didactic judgements which focus on how ICT can expand the learning possibilities for pupils in subjects'* (Krumsvik, 2008, p. 283). Lund and Erikson (2016) also identify this 'double challenge' for teachers, claiming;

> *Professional digital competence (PDC) entails a double challenge for teachers: While they, like other professionals such as engineers, lawyers, or nurses, need to be proficient in using digital technologies (ICT) for certain professional tasks, their main challenge is to foster productive and relevant use of ICT among their pupils*. (p. 66)

For this reason and given the centrality of the teacher in encouraging the uptake of technology in schools, digital competence is now a key element of teacher education across the globe (Gudmundsdottir & Hatlevik, 2018; Yusop, 2015; Instefjord & Munthe, 2016). Ottestad and Gudmundsdottir's (2018) exploration of ICT Policy in Primary and Secondary Education across Europe list a number of national examples of initiatives in Germany, Austria, Switzerland, Flemish Belgium, Czech Republic, Denmark and Estonia all with varying levels of specificity in terms of digital competency for teachers.

However, despite its importance, effective teacher preparation in this area appears to be lacking. Tonduer et al (2017a) note, '*empirical evidence shows that preservice teachers often still do not feel adequately prepared to effectively incorporate technology into their classrooms*' (p. 463), this they argue is due to the gap between technical and pedagogical skills amongst

pre-service teachers. Others have reported similar conclusions in relation to the lack of adequate teacher preparation (Valtonen, et al, 2015; Røkenes & Krumsvik, 2014; Gudmundsdottir & Hatlevik, 2018). Moreover, in summarising relevant research in this area, Røkenes and Krumsvik (2014) conclude that, '*research on teacher education still depicts an overall lack of knowledge among student teachers and teacher educators on how to utilize ICT in a pedagogical and didactical manner*' (p.253).

Reasons for this poor level of preparation are varied. In his analysis of the current situation both in the UK and in other countries, Haydn (2014) argues that the problem relates to the longstanding gap between the rhetoric of the claims made and the reality in schools. This view is echoed by Tonduer et al (2017b) who refer to the strand of studies that have identified a 'reality shock' experienced by novice teachers when they begin teaching as a result of the gap between student teachers' experience of technologies as part of their teacher education experience and the reality of use within their practicum schools. Another explanation for these poor levels of professional digital competence amongst student teachers relates to its status in teacher education. Ottestad et al (2014) note that in many teacher-education programmes its level of treatment can be dependent on enthusiastic academic staff and hence, '*digital competence is often neglected or reduced into more shallow and instrumental activities, like learning to use the computer or searching the Internet*' (p. 244).

An alternative explanation for the poor levels of preparation of teachers may relate to the lack of clarity in terms of what digital competence in teacher education involves. Ottestad et al (2014) argue that there is a '*clear need to simplify and straighten out the concept of teachers' professional digital competence*' (p. 247). Similarly, in a review of literature in this area, Petersson (2018) comments that;

> … it seems as if no obvious consensus or shared knowledge has been developed on what digital competence in educational contexts 'is' and what the competence entails during the last 10 years of research investigated in this review. Rather, the meaning and scope of digital competence and its related concepts (e.g., digital pedagogy, ICT competence, digital literacy and pedagogical digital competence) seem seldom to be

> well-defined and are often used as synonyms when describing the competences needed for actors working in educational contexts. (Petersson, 2018, p. 1015)

There are many possible reasons for this lack of clarity and focus. At a basic level, the problem could lie in the rapid evolution of digital technologies where it is difficult to 'pin down' the range of digital skills that should be considered. Research in the area of technology has long suffered from this problem of 'consistent obsolescence' (Honan et al, 2013). While there is some weight to this argument, this explanation places too much emphasis on technical, as opposed to pedagogical and professional skills. A further possible explanation lies in the historical roots of educational technology courses in teacher education programmes where their content and focus were strongly determined by the skills, interests and resources at hand. Therefore, new iterations of such courses may have evolved from different understandings of educational technology.

A third explanation, and one that appears to carry significant weight, is the lack of consensus of what constitutes effective pedagogical use and the balance between technical aspects, pedagogical aspects and professional aspects. While technical skills remain a key element, more contemporary perspectives have placed less of an emphasis on this technical focus and now put a greater emphasis on more generic pedagogical skills (Tondeur, et al, 2017a). More recently the concept of 'professional digital competence', which captures educational competencies beyond simply teaching and learning expertise, have emerged. Instefjord and Munthe (2017) contend that professional digital competency requires the ability to integrate and use technology for educational purposes as well as having more generic skills suitable for all situations, both personal and professional. However, defining these broader 'professional skills' appears at its infancy and are often quite optimistic in terms of the breadth of skills expected of teachers. This is exemplified by Güneş and Bahçivan (2018) who note that, '*a digitally literate teacher is expected to have numerous competencies, such as using technology to improve teaching, being familiar with technology tools, having a positive attitude towards the use of technology in teaching practice, and having adequate technical, cognitive and socioemotional skills in digital literacy*' (p. 99). The following section therefore aims to unpack these various dimensions in an attempt to provide greater clarity in relation to what constitutes digital competence in teacher education.

2.2. Unpacking the dimensions of teachers' digital competence - Taxonomies of digital competence

Several authors have attempted to unpack the dimensions of teachers' digital competence and many have identified similar dimensions to teacher digital competence in this analysis. In their review of the literature into the various frameworks used to describe teachers' digital competence, Almerich et al (2016) note the influence of various models: most notably the European DigiCompEdu framework (See figure 5), a framework that developed from the DIGICOMP for citizens work (Redecker et al, 2017) and Mishra and Koehler's (2006) TPACK model (figure 6).

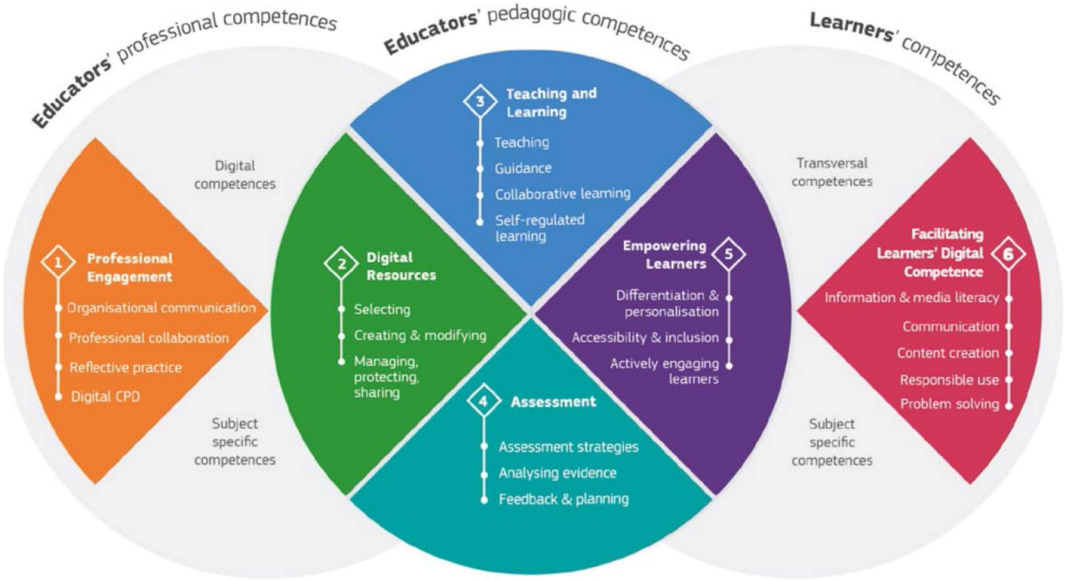

Figure 5. European DigiCompEdu framework for teachers (Vuorikari et al, 2017)

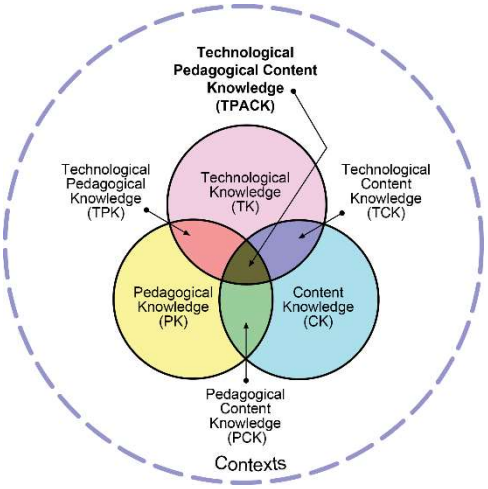

Figure 6. TPACK model (Mishra and Koehler, 2006) - (image from http://tpack.org)

Almerich et al, (2016) also identified two large subsets that frame most ICT competency frameworks for teachers, consisting of technological competences and pedagogical competences. In addition to these key aspects, other models include a dimension that encompasses broader aspects of what could be termed cyber ethics or aspects that explore wider societal issues related to technology. Johannesen et al (2014) suggests a framework which includes three aspects: teaching of ICT (concerned with technical/digital skills); teaching with ICT (the pedagogical uses of technology in teaching and learning); as well as teaching about ICT (exploring the broader societal issues). These aspects somewhat mirror the three dimensions put forward by Ottestad et al (2014): Generic digital competence, Didactic digital competence and Professional-oriented digital competence and Ottestad et al's (2014) three-pillar model of Professional Digital Competence which includes (a) generic digital competence, (b) subject/didactic digital competence, and (c) profession-oriented competence. In the two latter cases professional-orientated competence encompasses technology use by teachers that transcends subject specific pedagogy which can include, '*school-home communication, the psychosocial learning environment, classroom management and relational skills, and teachers' own research and continuous professional development in the field of ICT*' (Gudmundsdottir & Hatlevik, 2018, p. 4). A similar tripartite organisational framework was put forward by Instefjord and Munthe (2016) who likewise differentiated 'technological proficiency' from 'pedagogical compatibility' but included 'social awareness' (defined as teachers' understanding of and ability to negotiate social aspects of the school culture). Four

dimensions were described in a study by Hatlevik (2017). In an investigation of 332 teachers from a sample of 500 Norwegian schools, digital competence was operationalised as containing four sub-categories as defined by the Norwegian Directorate for Education and Training (2012), namely: (1) search and process, (2) produce, (3) digital responsibility, and (4) communication. Lund et al (2014) similarly notes the importance of technical knowledge but appear to place a stronger emphasis on understanding students' learning processes and specifically, '*to the more specific disciplinary practices and features characterizing each individual school subject*' (p. 293). This last aspect reflects the TPCK element of Mishra and Koehler's (2006) TPACK model reflecting the, '*complex, situated form of knowledge*' (p. 1017) which is needed to respond to the technology-enhanced learning opportunities unique to specific subject areas and disciplines.

Finally, Ilomaki et al (2016) offer another four-part model which includes (1) knowledge and practice in the use of technology; (2) skills to implement ICT in class; (3) skills to understand limitations, ethical considerations and challenges derived from the use of ICT; and (4) motivation to participation in the digital culture. This model is somewhat novel in that it includes a motivation to participate in a digital culture which is not referred to in other reviewed works.

National responses to the need for a systematic responses to digital competence for teachers have drawn on national frameworks which can be linked to broader professional standards for teachers. The Australian professional standards for teachers include ICT standards for teachers under the '*know the content and how to teach it*' and '*Create and maintain supportive and safe learning environments*' sections (Australian Institute for Training and School Leadership, 2011). In this way the competencies are embedded in a broader professional standards framework. The *Norwegian Digital Competence framework for Teachers*, (Kelentric et al, 2017) (see figure 7) developed by the Norwegian Centre for ICT in Education, is also set within a broader framework based on national regulations, guidelines for

Figure 7 Visualisation of the Professional Digital Competence Framework for Teachers (Norway) (Kelentric et al, 2017)

teacher education programmes, the national curriculum and the National Qualifications Framework.

Other national frameworks are either influenced by or adopt supranational frameworks. The Spanish digital competence framework for teachers (see figure 8) draws from the EU Digicomp 2.0 framework reflecting its 5 main competencies. Whereas the Irish *Digital Strategy for Schools* policy is underpinned by the 2011 *UNESCO ICT Competency Framework for Teachers* (UNSECO, 2011) but is also informed by the EU's DigCompEdu and DigCompOrg frameworks (DES, 2017)

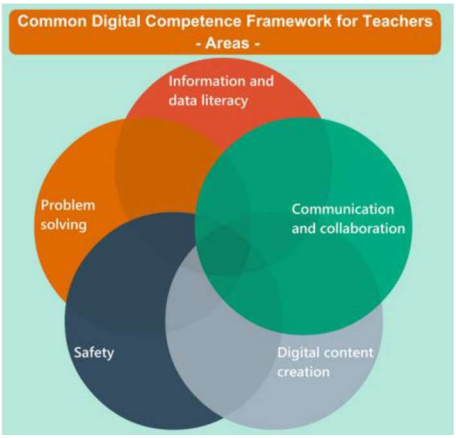

Figure 8. Spanish Common Digital Competence Framework for Teachers (NTEF, 2017)

THE UNESCO ICT COMPETENCY FRAMEWORK FOR TEACHERS

	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 9. UNESCO ICT Competency Framework for Teachers (UNSECO, 2011)

Within the US context, the ISTE standards for educators (ISTE, 2017) appear to be influential in relation to teacher education as recent research by Nelson et al (2019) highlights.

In conclusion, different models aiming to capture the breadth of teachers' digital competence exists. Some models have been proposed by researchers in the field, others emerge from national accreditation requirements and standards and some from supranational digital competency frameworks.

2.3 Hierarchal and developmental models of teachers' digital competency

In addition to models that attempt to identify the various dimensions of teachers' digital competence (taxonomy-type models), Gill et al (2015) note that there have been a number of ways researchers have sought to define levels or stages of pre-service teacher proficiency. Krumsvik's (2008; 2014) digital competence model (See figure 10.) suggests a developmental process where technical proficiency undergirds didactical competence and competence in effective learning strategies. In this model digital bildung is the highest level of competence achieved. This digital bildung is described as;

> *Digital bildung [digital danning in Norwegian] focuses on how pupils' participation, multi-membership of different communities and identity development in the digital era are influenced by the digitisation of society. This implies ethical and moral reflections on technology's role in human development. In school settings it implies the need for both teachers and pupils to develop competence in the critical use of sources as well as an ethical awareness of the social implications of being in the digitised society and school* (Krumsvik, 2008, p. 288)

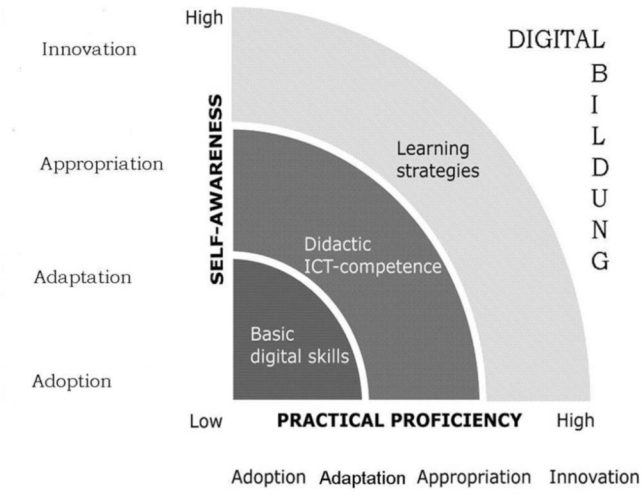

Figure 10. Teachers' digital competency model (Krumsvik, 2007)

This model is similar to the SAMR (Substitution, Augmentation, Modification and Redefinition) model proposed by Puentedura (2006) which suggests levels of technology use by teachers

ranging from 'substitutional' uses to 'redefinition' where the use of the technology opens up opportunities for new tasks made possible by the use of technology. While this model has gained increasing popularity amongst educators, Hamilton et al (2016) have argued that such a model 1) downplays important contextual factors such as resources and infrastructure and school leadership, 2) imposes a ridged hierarchical structure to teachers' technology use and 3) focuses on changing the instructional activity rather than the learning process.

Another framework that embeds a developmental or hierarchical structure is the UNESCO ICT competency framework for teachers (UNESCO, 2018). Building on the original 2011 model, this framework proposes three successive stages of development based on three approaches to teaching (See Figure 11). The 'Knowledge Acquisition' stage is described as where teachers, 'acquire knowledge about using technology and basic ICT competencies' (p. 8) whereas the 'Knowledge Deepening' phase is where teachers, 'acquire ICT competencies that enable them to facilitate learning environments that are student-centred, collaborative and cooperative in nature' (p. 9). At the 'Knowledge Creation' stage teachers, '*acquire competencies that encourage them to model good practice and set up learning environments that encourage students to create the kind of new knowledge required for more harmonious, fulfilling and prosperous societies*' (p. 9). Based around what it describes as the six aspects of a teacher's professional practice (understanding ICT and education policy, curriculum and assessment, pedagogy, application of digital skills, organisation and administration and Teacher professional learning), the framework outlines eighteen different 'modules' arising from the intersection of these six aspects with the three approaches to teaching in the model. The DigiCompEdu model proposes a similar framework with 'levels' of competence.

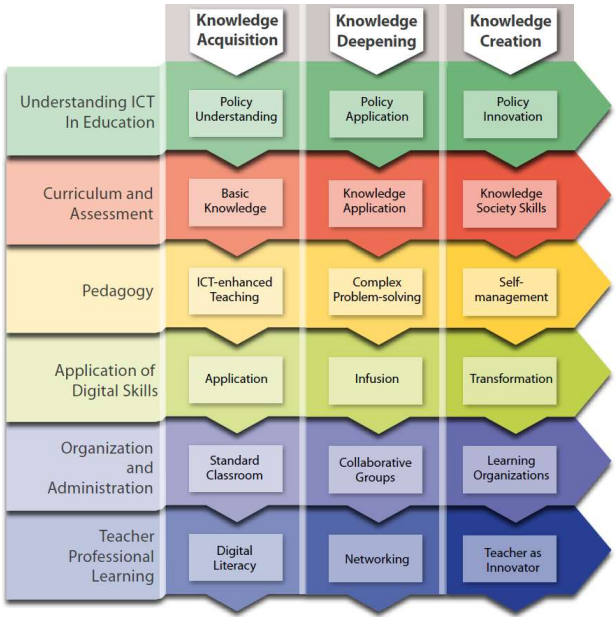

Figure 11. The UNESCO ICT competency framework for teachers (2018)

While not drawing from the same model, the Australian Information and Communication Technology (ICT) standards for teachers (AITSL, 2011) also presents a developmental model

where teachers' competence moves from graduate to proficient to highly accomplished before finally achieving leadership capabilities in supporting colleagues (see table 3). Similar stages are also presented in relation to the use of ICT in a safe responsible and ethical manner.

Graduate	Proficient	Highly Accomplished	Lead
Implement teaching strategies for using ICT to expand curriculum learning opportunities for students.	Use effective teaching strategies to integrate ICT into learning and teaching programs to make selected content relevant and meaningful.	Model high-level teaching knowledge and skills and work with colleagues to use current ICT to improve their teaching practice and make content relevant and meaningful.	Lead and support colleagues within the school to select and use ICT with effective teaching strategies to expand learning opportunities and content knowledge for all students.

Table 3. Australian professional standards for teachers – ICT component (AITSL, 2011)

As with Krumsvik's (2008) and Puentedura's (2006) models, it could be argued that these hierarchical, as opposed to taxonomy-type models, have in-built assumptions about technology use (often quite techno-centric in their focus) and while it is not within the scope of this review to engage in an in-depth critique of such models it nonetheless raises questions in relation to what is being developed. Brox (2017) asks the important question '*Does it matter what student teachers understand about technologies as long as they can use them and implement them in their own teaching?*' (p. 129). In this context it is important that such developmental models do not focus exclusively on technical or pedagogical proficiency which may lead to an uncritical and accepting approach to technology use by teachers (Taylor, 2004) or assume that there is an ideal technology use that teachers should aspire to.

Before concluding this section, it is worth noting the emergence of teacher educator technology standards that have been developed in the US to ensure teacher educators have a common set of technology competencies to prepare student teachers. The Teacher Educator Technology Competencies (TETCs) (Foulger et al, 2017) which describe in detail the technology competencies required (see table 4) points to the next and emerging challenge in this area.

Teacher Educator Technology Competencies (TETCs) – (Foulger et al, 2017)
1. Teacher educators will design instruction that utilizes content-specific technologies to enhance teaching and learning. 2. Teacher educators will incorporate pedagogical approaches that prepare teacher candidates to effectively use technology. 3. Teacher educators will support the development of the knowledge, skills, and attitudes of teacher candidates as related to teaching with technology in their content area. 4. Teacher educators will use online tools to enhance teaching and learning. 5. Teacher educators will use technology to differentiate instruction to meet diverse learning needs. 6. Teacher educators will use appropriate technology tools for assessment. 7. Teacher educators will use effective strategies for teaching online and/or blended/hybrid learning environments. 8. Teacher educators will use technology to connect globally with a variety of regions and cultures. 9. Teacher educators will address the legal, ethical, and socially-responsible use of technology in education. 10. Teacher educators will engage in ongoing professional development and networking activities to improve the integration of technology in teaching 11. Teacher educators will engage in leadership and advocacy for using technology. 12. Teacher educators will apply basic troubleshooting skills to resolve technology issues.

Table 4. Teacher Educator Technology Competencies (TETCs)

Having explored the various dimensions of teachers' digital competence the next section of the literature review aims to synthesise the various models reviewed and propose an alternative model that encapsulates the broad and varied dimensions reviewed in the previous sections.

2.4 Towards a synthesised model of Digital Competence in Teacher Education – the PEAT model

In providing a synthesis of the various components of teachers' digital competence, and attempting to encapsulate this within a single organisational framework, the first question that needed to be addressed was whether such a framework would be a taxonomy-type model (identifying the various dimensions of competence which may or may not be related) or a hierarchical-type model (which proposed a developmental framework with levels of competence). Hierarchical-type models can contain assumptions relating to more desirable ways of using technology. They suggest an 'ideal' way in which technology can be used in education and how the teacher should respond. Recognising the problematic nature of such views, the synthesised model presented here, could be described as a taxonomy-type model highlighting the most commonly referred to dimensions from the models reviewed earlier.

In putting forward a synthesis of the various dimensions offered by the models reviewed, it is apparent that technical/digital skills are common to all and, while the centrality of this aspect of digital competence has rightfully waned, it is nonetheless important that a model describing digital competence contain a technical dimension. A second dimension evident within the literature is the pedagogical dimension. This ranges from unique pedagogical practices afforded by technology in specific subject areas to broader 'professional' educational practices that transcend subject or classroom use. This would include possibly, home-school communication or generic applications of ICT across the school for management of pedagogical purposes. Overlapping with these 'professional' aspects are the broad range of cyber ethics issues that teachers need to be aware of, hence the inclusion of the ethical dimension. This dimension includes issues of privacy, copyright and source awareness, information security, child welfare etc. While not specifically related to teaching/pedagogy they are nonetheless important areas of teachers' professional knowledge.

Finally, the fourth dimension that has emerged from this review relates to one's openness to new digital technologies. While openness was only mentioned directly in one framework (Ilomaki, et al, 2016), and it did not appear to be evident in the other models reviewed, nor was there other terms used to express a similar dimension, however given the importance of perceived ICT competence as a predictor of teachers' technology use (Aslan & Zhu, 2017),

openness would appear to be an important dimension. Therefore, this four-part model (see figure 12) encompasses Technical skills, Pedagogical skills, Cyber-ethics and Attitudes (PEAT).

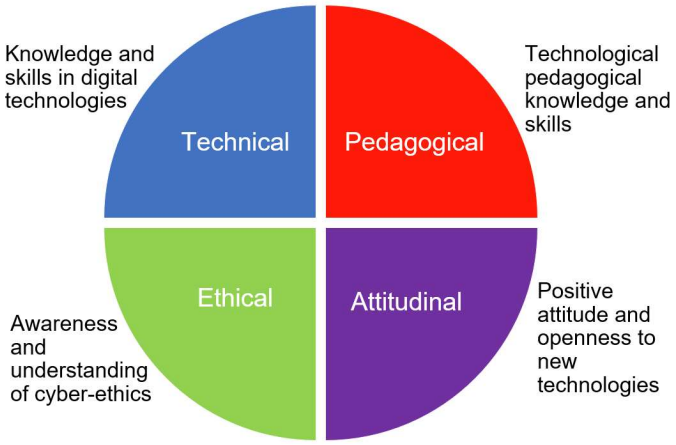

Figure 12. Synthesised model of teachers' Digital Competence – The PEAT model

This model therefore encapsulates the necessary technical competencies and pedagogical competencies that one would expect for teacher education but importantly also includes an ethical dimension. This ethical dimension would not only include personal ethical practices in ICT use but also a deeper understanding of the broader ethical questions brought about by digital technology use. Brox (2017) argues that to date there has been quite a tools-based understanding of technology with an assumption that the use of technologies in education is both necessary and beneficial. This has led to quite narrow utilitarian adoptions of technology that are deemed suitable for current education provision. To address this issue she argues, '*teacher education should encourage a deeper understanding of technology, in which both human and technological agency are explored and problematized*' (p. 129). She further adds;

> *An unfortunate side effect has emerged from this. It has left teacher education with little room to raise important discussions about technology and about the ways technologies and forms of technological agency might work upon the conduct of human actors. For instance, how and where should it be addressed that technologies (both digital and non-digital) possess their own material properties that shape and alter 'content' and that predispose what can be done with and against them?* (p. 131)

The next section of the literature review aims to examine research studies that have explored digital competence in teacher education and how they are assessed.

PART 3: Pre-service teachers' levels of digital competence

3.1. Digital competence amongst student teachers: what does the research reveal?

In general, research has shown that student teachers express positive attitudes towards technology use in education. Research by Sadaf, Newby and Ertmer (2012) into pre-service teachers' beliefs and intentions to use Web 2.0 technologies in their future practice in the US found that the student teachers believed that technology has the potential to improve student learning. Similarly, a study by Koc (2013) into student teachers' conceptions of technology in Turkey found that most viewed technology as an essential part of modern life, however, a small proportion viewed technology as threatening and expressed pessimistic views about its use in the classroom. Based on these findings Koc (2013) argues that teacher education needs to take into consideration these concepts, both positive and negative, to challenge overly optimistic as well as pessimistic views. This is needed to, '*prevent student teachers from thinking technology as a quick fix to our educational problems or as a threat to disrupt our educational activities*' (Koc, 2013, p. 7). Using a national survey distributed to 356 newly qualified teachers in Norway to explore their level of preparation to use technology, Gudmundsdottir and Hatlevik (2018) similarly found that that more than 80% of the teachers had positive beliefs about the usefulness of ICT. However, they also found that half of the respondents had negative beliefs and considered ICT as a distraction during their teaching practice. Similar mixed findings of student teachers' expressed attitudes to technology was found in a small-scale longitudinal study in Spain by McGarr and Gavaldon (2018). Their research found that, while student teachers expressed positive views, they simultaneously expressed reservation about 'too much' use. The authors concluded that the student teachers may be holding these different views to align with the different expectations of technology use between their university college and placement schools.

These studies would suggest that student teachers, while generally expressing positive views, are not entirely enthusiastic in their support of technology. This challenges commonly held views in relation to the so called 'net generation' and is supported by a study by So et al (2012).

Drawing on a sample of 225 student teachers in Korea and Singapore, they concluded that, '*teacher educators need to be cautious about making generational assumptions solely based on the structural and technological changes that this new generation has experienced*' (p. 1244) as the group of student teachers surveyed were far more heterogenous in terms of technological capabilities and attitudes than is commonly believed. These findings are reflected in the levels of digital competence in the general student population which suggests that many students are not as actively engaged in content creation with Web 2.0 tools as expected (Ng, 2012).

Where studies have examined pre-service teachers' use of technology there appears to be a gap between personal and professional/pedagogical use. While research indicates that levels of web 2.0 technologies are increasing (García-Martín & García-Sanchez, 2017), this does not necessarily translate to their professional and pedagogical practice. In a study by Chen, Lim and Tan (2010) into the ICT experiences and competencies of 1554 pre-service teachers in Singapore they found that there was a lack of homogeneity in relation to ICT. The study also found a gap between personal use and that for teaching and learning - dispelling the common myth of the 'digital native'. This personal-professional gap was also found in research by Engen et al (2014). In their study into first-year teacher-education students' digital competence in Norway, they found similar levels of diversity amongst the group in terms of digital competence. They also noted that, '*there appears to be a mismatch between perceived competence and their actual levels of efficiency in using technology'* (p. 6).
Similarly, a small-scale study by Gill et al (2015) which explored 11 Australian pre-service teachers' preparedness to use ICT during their pre-service teacher-education programme concluded that confidence in the use of technology in the students' social life doesn't necessarily translate to use in teaching and learning.

Turning to teacher education specifically, it is perhaps not surprising then that research into student teachers' use of technology in schools show mixed results indicating that it is often under-used with only a small number using it in diverse ways (Tonduer et al, 2016). In a longitudinal study in Belgium with 16 novice teachers, Tondeur et al (2017b) found that there was, '*no evidence indicating that beginning teachers were using technologies to facilitate collaboration, creativity or critical thinking*' (p. 16) and instead the wide range of technology

applications tended to be used for more structured learning approaches. The authors concluded that teacher education needs to focus more on how to teach with technology rather than, '*merely getting acquainted with existing technology applications*' (p. 17). This narrow technical or instrumental approach was also evident in the views expressed by student teachers in Turkey in relation to technology where they tended to focus on technology hardware rather than the human activities it facilitates (Koc, 2013). The ineffectiveness of teacher preparation, as identified by Tonduer et al (2017b), was also reflected in the findings of Gudmundsdottir and Hatlevik's (2018) study into newly qualified teachers in Norway where they reported that '*nearly half of the newly qualified teachers in the study found that the quality of their ICT training was fairly poor and that ITE had a fairly poor contribution to the development of their PDC (Professional Digital Competence)*' (p. 225). This low level of technology integration within teacher education has led some to question the capability of initial teacher education to meet the challenge;

> *Current teacher-training programmes, however, have received extensive criticism, which has suggested that 'the development of professional digital skills is consistently weakly implemented in teacher training'. Some people have cast doubts on whether those teaching such courses have the skills to develop campus-based instruction in subject didactics and pedagogy in a manner that will promote professional digital skills among student teachers* (Elstad & Christophersen, 2017, p. 5)

These findings suggest that the integration of professional digital competence in teacher education has not moved beyond pockets of good practice in minor areas of the teacher education curriculum to a more integrated application across pre-service programmes. In a study by Instefjord and Munthe (2017) in Norway investigating the integration of professional digital competence employing three national questionnaire surveys to student teachers, teacher educators and mentor teachers, the study concluded that, '*digital competence does not have a prominent position in the general programme descriptions or in subject specific descriptions, nor is it found to be specifically mentioned as an expected learning outcome from field placement periods*' (p. 44). It appears therefore that teacher education has, '*some way to go before student teachers' digital competence reaches the desired levels*' (Brox, 2017, p. 131).

The situation with practicing teachers however does not appear to be any different. Research by Falcó (2017) in Spain amongst 341 teachers in the Aragon region found an average level of performance for personal use but poor application in teaching and learning. This divide between personal and professional use was also found by Hatlevik (2017) in a study of Norwegian teachers (referred to previously) and by Swedish teachers by Lindberg et al (2017) who noted that;

> *A third major challenge relates to teachers' digital competence and their CPD. Even though some teachers have advanced ICT skills, many teachers talk in the interviews about the difficulty they often experience in keeping pace with the rapid development of technology, the demands of teaching and those of the students*. (Lindberg et al, 2017, p. 129)

Speaking about the binary way in which individuals are categorised in relation to their level of digital competence, Burnett (2011) argues that in reality many individuals are insiders to some technologies and outsiders to others often dependent on social and cultural factors and the studies reviewed here supports this view. As a result, there needs to be greater recognition of the nature of technology use of pre-service teachers in their personal lives as well as their professional contexts. The realities of the school context where the practicum placement takes place is also highly influential. Martinovic and Zhang (2012) conducted an exploratory case study examining pre-service teachers' expectations of and attitudes toward the learning and integrating of ICT into their teaching in a Canadian university. Importantly the study found that pre-service teachers' opportunities to develop digital competency can be hindered by inadequate access to technology both on teacher education programmes and within placement schools. Issues of power and assessment also came to the fore where '*pre-service teachers seemed willing to use ICT in their teaching as long as such use does not negatively interfere with already limited class preparation time*' (p.468).

3.2. The challenges of measuring teachers' digital competence

In their synthesis of the literature in relation to how digital competence has been measured in the past Tonduer et al (2017a) identify three main approaches. The first utilises questionnaires aimed at frequency of use and how it is used in school. The second draw on more complex conceptual frameworks frequently framed by national curriculum requirements hence digital competence is assessed in a curriculum context, for example creating, communicating, information processing, etc. The third utilises performance assessment tasks aimed at assessing the extent to which students can perform given ICT-related tasks. As all these face validation challenges, the authors developed an ICT competency framework (ICT-CF) to assess student teachers' digital competency based around three domains, namely: 1) instructional and pedagogical tasks, 2) professional development and 3) the school in a broader context.

The need for this task-based approach as suggested by Tonduer et al (2017a) is echoed by Engen et al (2014) who caution the over-reliance on self-reported questionnaires. Noting the common mismatch in one's perceived competence and one's actual levels of efficiency in using technology, they advise that when examining levels of competence in a group it is important to take into account both self-reports and other measurements. Similar concerns over self-reported questionnaires were raised by Albion et al. (2010) and Harris, Grandgenett and Hofer (2010). The use of assessment instruments that measure digital competence based on the completion of tasks however is not without its challenges. Siddiq et al's (2016) review of assessment instruments that aim to measure primary and secondary school students' ICT literacy which did not include self-reported measures found that, '*most of the existing tests measure only a limited spectrum of competences within the complex domain of ICT literacy*' (p. 77) and that privacy and protection are scarcely addressed. They concluded that, '*there seems to be a gap between how ICT literacy is theorized in research and dominant frameworks, and how the concept is operationalized in curriculum and assessment*.' (p. 77). Therefore, not only is there a challenge in defining what digital competency entails, there is the added complexity of developing appropriate assessment instruments to assess it – particularly assessment instruments that mirror the authentic tasks that preservice teachers engage in for both personal and professional purposes.

PART 4: Issues arising from the review of literature

This review has aimed to unpack what is meant by the term digital competence from the research literature and explore the ways in which it is conceptualised in teacher education. As a result, there are a number of issues that have emerged from this review, they include: 1) the Nordic focus of the existing literature in teacher education, 2) the focus on framing digital competence and the paucity of research on exploring use within teacher education, 3) assumptions underpinning different digital competence frameworks in teacher education and, 4) competence as a singular skill or a multitude of competencies. This section will briefly explore these issues.

The review has drawn on a wide range of sources, however a significant number of these are from the Nordic countries, most notably Norway. This could reflect a limitation of the search criteria used and the fact that the review almost exclusively drew on research work published in English. However, recent work by Spante et al (2018) has highlighted regional differences in the use of the terms digital competence and digital literacy where competence is the preferred term in continental Europe and Scandinavia whereas in other regions of the globe, including north America, Australia, UK and Asia, literacy is more common (see table 5). It may also reflect the different levels of attention given to the issue within teacher education and the extent to which there is a significant research community exploring the issue in different regions and jurisdictions. There does appear to be a significantly higher level of attention devoted to this issue within Nordic countries in comparison to other countries, if one is to measure it by the number of research publications in the area. This would appear to be the most likely reason for the high number of Nordic-based research.

Table 1. Summarized findings		
	Digital literacy	**Digital competence**
First appearance in findings (in general)	1997 (1997)	2010 (2006)
Main region	UK, US, Asia	Continental Europe, South America
Main disciplines	Health and arts	Teacher education and economics
Dominating aim	Practical/Didactical change Develop educational system	Develop student competence Develop faculty competence
Most common Data collection method	Mixed, survey, interview, case studies, position papers	Mixed, survey, case studies, video analysis
Dominating referencing strategy	Research	Research and policy

Table 5. Summary of key findings from Spante et al (2018)

This focus also highlights however how the variation in uses of terminology can make the issue of digital competence/digital literacy in teacher education a difficult issue to examine thoroughly due to the variety of terms used within the research literature.

A second aspect to emerge from this review relates to the attention given in the literature to designing frameworks that encapsulate the various dimensions of teachers' digital competence. As the review has highlighted, there are many different frameworks within the literature and numerous definitions and requirements set out in teacher accreditation requirements and standards. While this is an important body of work, and one that will continue to be required into the future as technologies evolve and change, there does not appear to be equivalent attention devoted to studies exploring the lived experiences of pre-service teachers and how they acquire digital competence as part of their initial teacher education (including their experiences of accessing and using technology during key School Placement experiences). Such studies need to further explore models of best practice in terms of teacher education pedagogy, develop more innovative and authentic ways of assessing teachers' digital competence and further explore the role of school placement in influencing pre-service teachers' digital competence. Over the past two decades, technology in the teacher education community has focused predominantly on the integration of technology in schools and therefore has focused on encouraging teachers to use technology as part of their practice. As teachers' digital competence widens and begins to encompass broader aspects than pedagogical and technical dimensions, it is inevitable that this will result in a similar shift

in research focus towards if and how pre-service teachers are developing digital competence. At present however, this is an area that appears under-researched.

The development of digital competence frameworks for teachers must be viewed within the wider context of the rise in professional competency frameworks and standards for teachers (Struyvenv & De Meyst, 2010; Manso & Sánchez-Tarazaga, 2018; Adoniou & Gallagher, 2017) as well as the increasingly performativity culture in education (Ball, 2003). Care must be taken to ensure that within this environment, where teachers' professional knowledge can become reduced to a technicist view of knowledge, that digital competence does not become narrowly defined and reduced to pedagogical and technical proficiency. Ilomaki et al (2016) note that digital competence is a strongly political term reflecting beliefs and wishes about future skills. The rationale for such skills are frequently set within a modern-vocationalist ideology that has, underpinning it, a strong emphasis on human capital and economic development. An instrumentalist approach of this nature can downplay the more fundamental challenges to education as a result of digital technologies (Krumsvik, 2008). Discussing the problems with this instrumentalist approach, Lund and Erikson (2016), note that;

> Conceptually, we have advocated a view of digital technologies that removes them from metaphors of tools and instruments, since such metaphors carry notions of instrumentalism. They also risk reducing digital technologies to a role where they economize or speed up existing practices and consequently open up a perspective where their use value is restricted to measurable learning outcomes. (Lund and Erikson, 2016, p. 66)

It is important therefore that teacher education continues to enable pre-service teachers to critically explore technology, both in terms of its influence within education and more broadly within society in general. Whilst technical skills are important, having the ability to critically consume and utilise digital content from a myriad of devices and understand the disruptive effects of technology is perhaps more important given the convergence of media and digital technologies. This 'critical competence' (Cortoni et al, 2015) however is not a defined set of skills that can be addressed within a discrete area of the curriculum. Instead it represents a way of engaging with all content and how one consumes media and interacts with it. Hence

the challenge it poses is much greater than the traditionally viewed challenge of technology integration as it has implications across the curriculum.

To that end, it is important that all frameworks presented are critically interrogated and the assumptions underpinning their construction are examined. These assumptions may relate to what teachers *should* be able to do (and what they shouldn't), what pedagogical practices are favoured and what are the dimensions of teachers' work. Exploring the area of digital competence and digital literacy in higher education, Spante et al (2018) call for critically orientated research in this area noting that while terms such as digital literacy and digital competence have gained legitimacy in recent years, they nonetheless need to be interrogated critically. Problematising these terms and frameworks, and challenging the assumptions that accompany their use, can help to reveal the often 'techno-centric' assumptions that are behind such models and the assumptions about their applicability and transferability in different contexts and jurisdictions. For example, in taxonomy-type frameworks, what aspects are omitted and how are other dimensions grouped? In hierarchical models, what is prioritised and what skills, knowledge or attitudes are valued over others?

A final issue to emerge from this review relates to whether competence is a single skill or whether it is a multitude of competencies that together encompass digital competence. Almost all of the frameworks reviewed present different dimensions of digital competence and, as the synthesised PEAT model presented highlights, there are generally four areas present in most models: Pedagogical, Technical, Ethical and Attitudinal. This would suggest that digital competence encompasses a range of competencies. If that is so, does one therefore need to display competence in all areas to be a digitally competent teacher or can one have varying levels across the different dimensions and still be considered a digitally competent teacher? Also, are some dimensions more important than others?

In addition to these questions, there are also some frameworks that present digital competence progressively, suggesting basic, intermediate and advanced levels of competence (either as a single competence or multi-dimensional). In this regard, is digital competence a skill that one can improve over time or is it a threshold to achieve? If one sees digital competence as a way of being, as opposed to a set of skills, then frameworks that suggest levels of competence may be unhelpful. On the other hand, if one can develop more complex

levels of digital competence, such frameworks can play a useful role in scaffolding teachers towards more advanced practices. These and other questions highlight the complexity of issues in relation to digital competence in teacher education and the many issues that need for exploration within the research community.

References

Aesaert, K., Vanderlinde, R., Tondeur, J., & van Braak, J. (2013). The Content of Educational Technology Curricula: A Cross-Curricular State of the Art. Educational Technology Research and Development, 61(1), 131-151.

Adoniou, M. & Gallagher, M. (2017) Professional standards for teachers—what are they good for?, Oxford Review of Education, 43:1, 109-126, DOI: 10.1080/03054985.2016.1243522

AITSL (Australian Institute for Training and School Leadership). (2011). National Professional Standards for Teachers. http://www.aitsl.edu.au/verve/_resources/AITSL_National_Professional_Standards_for_Teachers.pdf

Ala-Mutka, K. (2011) Mapping Digital Competence: Towards a Conceptual Understanding, Luxembourg: Publications Office of the European Union

Albion, P., Jamieson-Proctor, R., & Finger, G. (2010). Auditing the TPACK confidence of Australian pre-service Teachers: The TPACK Confidence Survey (TCS). In D. Gibson & B. Dodge (Eds.), Proceedings of Society for Information Technology & Teacher Education International Conference 2010 (pp. 3772-3779). Chesapeake, VA: AACE.

Almås, A. G., & Krumsvik, R. (2008). Teaching in Technology-Rich Classrooms: Is There a Gap between Teachers' Intentions and ICT Practices? Research in Comparative and International Education, 3(2), 103-121. doi:10.2304/rcie.2008.3.2.103

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:https://doi.org/10.1016/j.compedu.2016.05.002

Andema, S., Kendrick, M. & Norton, B., 2013, 'Digital literacy in Ugandan teacher education: Insights from a case study', Reading & Writing 4(1), 1-8 http://dx.doi.org/10.4102/rw.v4i1.27

Aslan, A., & Zhu, C. (2017). Investigating variables predicting Turkish pre-service teachers' integration of ICT into teaching practices. British Journal of Educational Technology, 48(2), 552-570.

Ball, S. J. (2003). The teacher's soul and the terrors of performativity. Journal of education policy, 18(2), 215-228.

Bawden, D. (2001). Information and digital literacies: a review of concepts. Journal of Documentation, 57(2), 218-259. doi:doi:10.1108/EUM0000000007083

Brox, H. (2017). What's in a wiki? Issues of agency in light of student teachers' encounters with wiki technology. Nordic Journal of Digital Literacy, 12(4), 129-142. doi:10.18261/issn.1891-943x-2017-04-03

Buckingham, D. (2015). Defining digital literacy: What do young people need to know about digital media? Nordic Journal of Digital Literacy, 4 (1) 21–34.

Bukaliya, R. & Kudakwashe-Mubika, A. (2011) Teacher Competence in ICT: Implications for Computer Education in Zimbabwean Secondary Schools, International Journal of Social Sciences and Education, 1(4), 414-425.

Burnett, C. (2011). Pre-Service Teachers' Digital Literacy Practices: Exploring Contingency in Identity and Digital Literacy in and out of Educational Contexts. Language and Education, 25(5), 433-449.

Calvani, A., Cartelli, A., Fini, A., & Ranieri, M. (2008). Models and Instruments for assessing Digital Competence at School. Journal of e-Learning and Knowledge Society, 4(3), 183-193.

Chen, W., Lim, C., & Tan, A. (2010). Pre-Service Teachers' ICT Experiences and Competencies: New Generation of Teachers in Digital Age. In: S. L. Wong et al. (Eds.) (2010). Proceedings of the 18th International Conference on Computers in Education. Putrajaya, Malaysia: Asia-Pacific Society for Computers in Education. 631-638.

Cortoni, I., LoPresti, V., & Cervelli, P. (2015). Digital Competence Assessment: A Proposal for Operationalizing the Critical Dimension. Journal of Media Literacy Education, 7(1), 46-57.

DES (2017) Digital Learning Framework for Post Primary Schools. Available at: https://www.education.ie/en/Schools-Colleges/Information/Information-Communications-Technology-ICT-in-Schools/digital-learning-framework-post-primary.pdf

Derbel, F. (2016). Technologically-Capable Teachers in a Low-Technology Context. In J. Novotna & A. Jancarik (Eds.), Proceedings of the 15th European Conference on E-Learning (pp. 151-158).

doi.org/10.1108/EUM0000000007083

Elstad, E., & Christophersen, K.-A. (2017). Perceptions of Digital Competency among Student Teachers: Contributing to the Development of Student Teachers' Instructional Self-Efficacy in Technology-Rich Classrooms. Education Sciences, 7.

Engen, B. K., Giæver, T. H., & Mifsud, L. (2015). Guidelines and Regulations for Teaching Digital Competence in Schools and Teacher Education: A Weak Link? Nordic Journal of Digital Literacy, 10(02), 69-83

Engen, B., Giaever, T., Guðmundsdóttir, G., Hatlevik, O., Mifsud, L., & Tømte, K. (2014). Digital Natives: Digitally Competent?

Erstad, O. (2015). Educating the Digital Generation. Nordic Journal of Digital Literacy, 5(01), 56-71.

European Parliament and the Council. (2006). Recommendation of the European Parliament and of the Council of 18 December 2006 on key competences for lifelong learning. Official Journal of the European Union, L394/310.

Falcó, J. M. (2017). Evaluación de la competencia digital docente en la comunidad autónoma de Aragón. Revista Electrónica de Investigación Educativa, 19(4), 73-83. https://doi.org/10.24320/redie.2017.19.4.1359

Ferrari, A. (2012). DIGCOMP: A Framework for Developing and Understanding Digital Competence in Europe. Luxembourg: Publications Office of the European Union.

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. Waynesville, NC USA: Society for Information Technology & Teacher Education. Retrieved from https://www.learntechlib.org/p/181966/.

García-Martín, J., & García-Sánchez, J.-N. (2017). Pre-service teachers' perceptions of the competence dimensions of digital literacy and of psychological and educational measures. Computers & Education, 107, 54-67. doi:https://doi.org/10.1016/j.compedu.2016.12.010

García-Pérez, R., Santos-Delgado, J.-M., & Buzón-García, O. (2016). Virtual empathy as digital competence in education 3.0. International Journal of Educational Technology in Higher Education, 13(1), 30. doi:10.1186/s41239-016-0029-7

Gentikow, B. (2015). The role of media in developing literacies and cultural techniques. Nordic Journal of Digital Literacy, 2(02), 78-96

Gill, L., Dalgarno, B., & Carlson, L. (2015). How Does Pre-Service Teacher Preparedness to Use ICTs for Learning and Teaching Develop Through Their Degree Program?. Australian Journal of Teacher Education, 40(1). http://dx.doi.org/10.14221/ajte.2015v40n1.3

Greene, J. A., Seung, B. Y., & Copeland, D. Z. (2014). Measuring critical components of digital literacy and their relationships with learning. Computers & Education, 76, 55-69. https://doi.org/10.1016/j.compedu.2014.03.008

Gudmundsdottir, G. B., & Hatlevik, O. E. (2018). Newly qualified teachers' professional digital competence: implications for teacher education. European Journal of Teacher Education, 41(2), 214-231. doi:10.1080/02619768.2017.1416085

Güneş, E., & Bahçivan, E. (2018). A mixed research-based model for pre-service science teachers' digital literacy: Responses to “which beliefs” and “how and why they interact” questions. Computers & Education, 118, 96-106.

Hamilton, E. R., Rosenberg, J. M., & Akcaoglu, M. (2016). The Substitution Augmentation Modification Redefinition (SAMR) Model: a Critical Review and Suggestions for its Use. TechTrends, 60(5), 433-441. doi:10.1007/s11528-016-0091-y

Harris, J., Grandgenett, N., & Hofer, M. (2010). Testing a TPACK-Based Technology Integration Assessment Rubric. Paper presented at the Society for Information Technology & Teacher Education International Conference 2010, San Diego, CA, USA. Retrieved from http://www.editlib.org/p/33978

Hatlevik, O. E. (2017). Examining the Relationship between Teachers’ Self-Efficacy, their Digital Competence, Strategies to Evaluate Information, and use of ICT at School. Scandinavian Journal of Educational Research, 61(5), 555-567. doi:10.1080/00313831.2016.1172501

Hatlevik, O. E., Ottestad, G., & Throndsen, I. (2015). Predictors of Digital Competence in 7th Grade: A Multilevel Analysis. Journal of Computer Assisted Learning, 31(3), 220-231.

Haydn, T. (2014) How do you get pre-service teachers to become ‘good at ICT’ in their subject teaching? The views of expert practitioners, Technology, Pedagogy and Education, 23:4, 455-469, DOI: 10.1080/1475939X.2014.892898

Honan, E., Exley, B., Kervin, L., Simpson, A., & Wells, M. (2013). Rethinking the literacy capabilities of pre-service primary teachers in testing times. Australian Journal of Teacher Education, 38(10), 48-63. http://dx.doi.org/10.14221/ajte.2013v38n10.

Ilomaki, L., Paavola, S., Lakkala, M., & Kantosalo, A. (2016). Digital competence-an emergent boundary concept for policy and educational research. Education and Information Technologies, 21(3), 655-679.

Instefjord, E. (2015). Appropriation of Digital Competence in Teacher Education. Nordic Journal of Digital Literacy, 9(04), 313-329.

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:10.1016/j.tate.2017.05.016

Instefjord, E., & Munthe, E. (2016). Preparing pre-service teachers to integrate technology: an analysis of the emphasis on digital competence in teacher education curricula. European Journal of Teacher Education, 39(1), 77-93. doi:10.1080/02619768.2015.1100602

ISTE (2017) International Society for Technology in Education. ISTE Standards for Educators. iste.org/standards

Janssen, J., Stoyanov, S., Ferrari, A., Punie, Y., Pannekeet, K., & Sloep, P. (2013). Experts' views on digital competence: Commonalities and differences. Computers & Education, 68, 473-481. doi:https://doi.org/10.1016/j.compedu.2013.06.008

Johannesen, M., Øgrim, L., & Giæver, T. H. (2014). Notion in Motion: Teachers' Digital Competence. Nordic Journal of Digital Literacy, 9(04), 300-312.

Kelentrić, M., Helland, K. & Arstorp, A. (2017) Professional digital competence framework for teachers. The Norwegian Centre for ICT in Education

Kellner, D. & Share, J. (2005). Toward critical media literacy: Core concepts, debates, organizations and policy. Discourse: Studies in the Cultural Politics of Education, 26 (3), 369–386.

Kellner, D. & Share, J. (2007). Critical media literacy is not an option. Learning Inquiry, 1(1), 59-69. doi:10.1007/s11519-007-0004-2

Lankshear, C. & Knobel, M. (2015). Digital Literacy and Digital Literacies: Policy, Pedagogy and Research Considerations for Education. Nordic Journal of Digital Literacy, 1(01), 12-24.

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

Koltay, T. (2011). The media and the literacies: media literacy, information literacy, digital literacy. Media, Culture & Society, 33(2), 211-221. doi:10.1177/0163443710393382

Krumsvik, R. J. (2008). Situated learning and teachers' digital competence. Education and Information Technologies, 13(4), 279-290.

Krumsvik, R. J. (2014). Teacher Educators' Digital Competence. Scandinavian Journal of Educational Research, 58(3), 269-280.

Lindberg, O., Olofsson, A. & Fransson, G. (2017) "Same but different? An examination of Swedish upper secondary school teachers' and students' views and use of ICT in education", The International Journal of Information and Learning Technology, Vol. 34 Issue: 2, pp.122-132, https:// doi.org/10.1108/IJILT-09-2016-0043

Lund, A. & Erikson, T. (2016) Teacher Education as Transformation: Some Lessons Learned from a Center for Excellence in Education, Acta Didactica Norge, 10 (2), 53- 72. https://www.journals.uio.no/index.php/adno/article/view/2483/2458

Lund, A., Furberg, A., Bakken, J., & Engelien, K. L. (2014). What does professional digital competence mean in teacher education?. Nordic Journal of Digital Literacy, 9(04), 280-298.

Manso, J., & Sánchez-Tarazaga, L. (2018) Competency frameworks for teachers: a contribution from the European education policy. Teacher Education Policy and Practice International Perspectives and Inspirations, 80.

Markauskaite, L. (2007). Exploring the Structure of Trainee Teachers' ICT Literacy: The Main Components of, and Relationships between, General Cognitive and Technical Capabilities. Educational Technology Research and Development, 55(6), 547-572.

Martin and Garcia-Sanchez, 2017 (García-Martín & García-Sánchez, 2017)

Martinovic, D., & Zhang, Z. (2012). Situating ICT in the teacher education program: Overcoming challenges, fulfilling expectations. Teaching and Teacher Education, 28(3), 461-469. doi:https://doi.org/10.1016/j.tate.2011.12.001

McGarr, O., & Gavaldon, G. (2018). Exploring Spanish pre-service teachers' talk in relation to ICT: balancing different expectations between the university and practicum school. Technology, Pedagogy and Education, 27(2), 199-209. doi:10.1080/1475939X.2018.1429950

Mills, K. A. (2010). A review of the "digital turn" in the new literacy studies. Review of Educational Research, 80(2), 246-271.

Mishra, P., & Koehler, M. J. (2006). Technological Pedagogical Content Knowledge: A new framework for teacher knowledge. Teachers College Record 108 (6), 1017-1054.

Nelson, M. J., Voithofer, R., & Cheng, S. L. (2019). Mediating factors that influence the technology integration practices of teacher educators. Computers & Education, 128, 330-344.

Norwegian Directorate for Education and Training (2012) Framework for Basic Skills. https://www.udir.no/contentassets/fd2d6bfbf2364e1c98b73e030119bd38/framework_for_basic_skills.pdf

Ng, W. (2012). Can we teach digital natives digital literacy? Computers & Education, 59(3), 1065-1078. doi:https://doi.org/10.1016/j.compedu.2012.04.016

Ottestad, G., & Gudmundsdottir, G. B. (2018). Information and Communication Technology Policy in Primary and Secondary Education in Europe. In J. Voogt, G. Knezek, R. Christensen, & K.-W. Lai (Eds.), Second Handbook of Information Technology in Primary and Secondary Education (pp. 1-21). Cham: Springer International Publishing.
Ottestad, G., Kelentrić, M., & Guðmundsdóttir, G. B. (2014). Professional Digital Competence in Teacher Education. Nordic Journal of Digital Literacy, 9(04), 243-249.

Pettersson, F. (2018). On the issues of digital competence in educational contexts–a review of literature. Education and Information Technologies, 23(3), 1005-1021.

Puentedura, R. (2006). Transformation, technology, and education [Blog post]. Retrieved from http://hippasus.com/resources/tte/.

Redecker, C., Carretero, S., Vuorikari, R. & Punie, Y. (2017). European Framework for Digital Competence of Educators. European Commission Joint Research Centre. Institute for Prospective Technological Studies. Spain: Seville.

Røkenes, F. M., & Krumsvik, R. (2014). Development of Student Teachers' Digital Competence in Teacher Education - A Literature Review, Nordic Journal of Digital Literacy, 4 (9). 250-280.

Sadaf, A., Newby, T. J., & Ertmer, P. A. (2012). Exploring pre-service teachers' beliefs about using Web 2.0 technologies in K-12 classroom. Computers & Education, 59(3), 937-945. doi:10.1016/j.compedu.2012.04.001

Siddiq, F., Hatlevik, O. E., Olsen, R. V., Throndsen, I., & Scherer, R. (2016). Taking a future perspective by learning from the past – A systematic review of assessment instruments that aim to measure primary and secondary school students' ICT literacy. Educational Research Review, 19, 58-84. doi:https://doi.org/10.1016/j.edurev.2016.05.002

So, H. J., Choi, H., Lim, W. Y., & Xiong, Y. (2012). Little experience with ICT: Are they really the Net Generation student-teachers? Computers & Education, 59(4), 1234-1245. doi:10.1016/j.compedu.2012.05.008

Spante, M., Sofkova Hashemi, S., Lundin, M., & Algers, A. (2018). Digital competence and digital literacy in higher education research: Systematic review of concept use. Cogent Education, 5(1), 1-21. https://doi.org/10.1080/2331186X.2018.1519143

Struyven, K., & De Meyst, M. (2010). Competence-based teacher education: Illusion or reality? An assessment of the implementation status in Flanders from teachers' and students' points of view. Teaching and Teacher Education, 26(8), 1495-1510.

Taylor, L. (2004). How student teachers develop their understanding of teaching using ICT. Journal of Education for Teaching, 30(1), 43-56. http://dx.doi.org/10.1080/0260747032000162307

Tømte, C. E. (2015). Educating Teachers for the New Millennium? Nordic Journal of Digital Literacy, 8(01-02), 74-88

Tondeur, J., Aesaert, K., Pynoo, B., Braak, J., Fraeyman, N., & Erstad, O. (2017a). 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., Pareja Roblin, N., van Braak, J., Voogt, J., & Prestridge, S. (2017b). Preparing beginning teachers for technology integration in education: ready for take-off? Technology, Pedagogy and Education, 26(2), 157-177. doi:10.1080/1475939X.2016.1193556

Tondeur, J., van Braak, J., Siddiq, F., & Scherer, R. (2016). Time for a new approach to prepare future teachers for educational technology use: Its meaning and measurement. Computers & Education, 94, 134-150. doi:https://doi.org/10.1016/j.compedu.2015.11.009

UNESCO (2011) UNESCO ICT COMPETENCY FRAMEWORK FOR TEACHERS. UNESCO, Paris. http://unesdoc.unesco.org/images/0021/002134/213475e.pdf

UNESCO (2018) UNESCO ICT COMPETENCY FRAMEWORK FOR TEACHERS. UNESCO, Paris. http://unesdoc.unesco.org/images/0026/002657/265721e.pdf

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

Vuorikari, R., Punie, Y., Gomez, S. C., & Van Den Brande, G. (2016). DigComp 2.0: The digital competence framework for citizens. Update phase 1: The conceptual reference model (No. JRC101254). Joint Research Centre (Seville).

Westera,W. (2001). Competences in education: A confusion of tongues. Journal of Curriculum Studies, 33(1), 75–88.

Yusop, F. D. (2015). A dataset of factors that influence preservice teachers' intentions to use Web 2.0 technologies in future teaching practices. British Journal of Educational Technology, 46(5), 1075-1080. doi:doi:10.1111/bjet.12330