

A Review of Research Exploring Pre-service Teacher Education for the Digital Era

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Abstract: Internet and digital technologies play increasingly important roles in schooling systems. With teaching and schools evolving due to the integration of technologies, pre-service teacher education will also change. Through a systematic and full literature review of papers published in the recent over 10 years, this study examines research exploring pre-service teacher education for the digital era. The articles analyze critically what has as well as has not been studied over a series of literature and broad contexts on digital integration in schools. Digital competencies should be generic, teaching and professional. The future research lies in how pre-service teachers learn to take part in the professional work in education system infused with digital technologies. A idea of professional digital literacy is proposed.

Keywords: Digital competence, Pre-service teacher education, Digital era.

1. Introduction

The introduction of digital technologies in school education systems worldwide, including supporting infrastructure, applications and hardware, has impacted the work of pre-service teachers. Initially, the introduction of universal digital technologies had limited usability and usefulness in achieving the educational goals of teachers and school systems (Cuban, 2001; Davis, 1989). However, as technology improved its practicality and usability, management information systems have begun to replace some paper-based or manual systems and practices within schools, improving efficiency in areas such as timesheets and record keeping (Shah, 2014), and adding different options through access to information and instructional programs (Albion, Tondeur & Peeraer, 2015). Further advances have led to digital technologies that have the potential to transform the work of educators. For example, pre-service teachers and administrators have greater access to learning analytics and can use digital tools to inform policy and teaching decisions. (Collins & Halverson, 2018). Specialized applications are designed to take into account student learning and the school's background. (Voogt, Knezek & Lai, 2018), school curricula are evolving for the digital era. (Starkey, 2016), and new means of communication tools make professional collaboration and interaction among pre-service teachers (Starkey & Eppel, 2017). It is predicted that digital technologies will be further embedded throughout the school education sector and impact the work of pre-service teachers (Hall Giesinger, 2017). Pre-service teachers, who enter the profession, need to be prepared for an increasingly digital school and education system.

When students graduate from the initial teacher education program, they should have confidence in their ability to become a junior teacher in the context of current and future schooling (Kaufman, 2015). Curricula that prepare for the teaching profession should be evidence-based on research (Darling-Hammond, 2012). As digital technology and infrastructure are introduced, integrated and permeated into school education systems, research exploring pre-service teacher readiness in the digital age is expected to change.

Previous literature reviews have reviewed various aspects

of pre-service teacher preparation, including pedagogical approaches to developing digital competence (Krumsvik, 2014), pre-service teacher education courses for preparing students for knowledge societies (Cochran-Smith et al., 2015), or models used in research (Tondeur & van Braak, 2013). The purpose of the study is to answer research questions. What has been studied in the study of pre-service teacher readiness in the digital era? The aim is to determine which research priorities are needed in the future.

2. Findings

2.1. Pre-service teachers' digital competence

The digital competence of pre-service teachers was a major theme throughout the research literature, with 26 articles using the word competence either directly or as a synonym more than 10 times in the text. Although competence is often mentioned in the literature, there is no extensive definition. Moreover, it is not expressly defined in individual articles. The discussion sections of individual articles, interview questions or survey have an in-depth understanding of the implications of digital competence. The widespread use of self-reporting methods and the lack of objective data, which may have less subjective prejudice, are a limitation of the ability to study figures. The three implied directions of pre-service teachers' digital ability are the general use of computer, the integration of digital technology into teaching practice and professional digital ability, which are determined by deductive analysis of the whole literature.

2.1.1. Generic digital competence

Examined in 13 articles, synonymous with 'technical knowledge' of the TPACK model (Koehler, 2006), generic digital competencies included skills that were not the allusion to teaching or pre-service teacher professional work. However, the form of technical knowledge varies from study to study. The researchers discussed the views of pre-service teachers on their ability to perform common computer functions, such as managing online documents (Dobson & Petrina, 2008; Hartley & Marchand, 2016), touching type (Hope & Hunt, 2010), using such presentation software as image capture, word-processing or powerpoint (Aslan & Chang, 2017; Gill & Dalgarno, 2017), searching the Internet

(Gudmundsdottir & Hatlevik, 2017; Mukama, 2009), using spreadsheets (Guo et al., 2008), or online communication (Yeung et al., 2012), or using simulations or software (Yeung et al., 2012). This set of skills can become a common knowledge for anyone who uses a computer to study, work or manage their daily lives in the 2010s, and can be used and applied to teaching practices. It makes sense to focus on these types of generic skills, assuming that the student and teacher may not have them. This suggests that those pre-service teachers entering the teaching field have limited experience in the use of digital technology. The point is that these research articles come from many countries, not just the developing world.

Generic digital competency comprises the ability to use creationary and cooperative technologies and they can be applied to the development of learning resources. The researchers discussed the pre-service teachers' perception of multimedia creativity such as video editing (Bratina, 2017; Jamieson-Proctor et al., 2010), online drawing or image development (Hunt, 2010), web development skills (Vigil, 2011) and creating music or video (Guo et al., 2008). In addition, a study included observations of the digital capabilities of using Web 2.0 tools, including wikis, blogs, podcasts, and e-portfolios (Vigil, 2011).

A third aspect of the general digital ability included in the literature is the ability of pre-service teachers to use computer hardware. Specific tools identified were the use of data displays (Aslan & Chang, 2017), mobile phones, webcams, speakers, music players, laptops or printers (Martinovi, 2012). In addition, the ability of pre-service teachers to use interactive whiteboards was a specific ability in two studies (Munthe, 2017; Martinovic & Zhang, 2012). If the hardware is new and teacher educators are not familiar with how to incorporate technology into their curriculum, it may make more sense to study pre-service teachers' ability to use digital tools. For example, if a whiteboard is replaced by a screen, the ability to use data display may be a key skill in the initial teacher education curriculum. And the research may provide the reference for the curriculum and the teaching method.

A paper explaining the specific definition clarifies the reasons for the focus on universal digital capabilities. The term digital competency should be limited to and construed, which means having the s knowledge, ability and skill to successfully use software, their related applications and computers in the practice of education and teaching. This extensive definition can include a wide range of applications in teacher work. However, the report investigated pre-service teachers' reported knowledge of databases, word processing, spreadsheets, presentations, Internet, email and Web 2.0. Therefore, general computer knowledge can be applied to teaching practice.

2.1.2. Digital teaching competence

The second kind of digital competence in reviewing literature is the ability to incorporate digital technologies into teaching practices. Three areas were identified, including integrating digital tools into existing teaching practices, thinking critically about decision-making, and teaching students who use technology for learning.

Digital tools are integrated into existing teaching practices, including the use of Facebook, blogs, podcasts or other communication tools in teaching activities (Kabakci Yurdakul & Coklar, 2014) or the development and use of digital assessments (Kabakci Yurdakul & Coklar, 2014). In these

research articles, digital competence is defined as the ability to displace or reinforce existing teaching and learning practices with digital tools.

The technology, teaching and content knowledge (PaCK) model forms a theoretical framework for the combination of ICT and teaching practices (Mishra & Koehler, 2006). The TPACK model underpins 20 studies on the integration of general digital competencies and digital technologies with teaching practices. For example, in the TPACK model, the intersection of technical, instructional, and content knowledge is identified as blended instruction (Shepherd & Inan, 2010). This encompasses a wide range of competencies in selecting, critiquing, and using ICT for teaching and learning (Tondeur & Baran, 2017; Valtonen, Kukkonen & Sointu, 2018) and has been conducted in the area of pre-service teacher development (Gill & Carlson, 2015) and integration as they began teaching and learning (Ping et al., 2011).

A review of the literature exploring the theoretical underpinnings and practical applications of TaCK revealed different understandings of the models and technical knowledge as well as limited exploration of the subject area of TaCK (Voogt et al., 2013). This is in the review study. For example, content knowledge is seldomly specified. Technological knowledge, which may mean how to use slides or interactive whiteboards, and pedagogical knowledge ranges from how to use technologies instead of learning resources or tools, to student engagement or new digital pedagogies. Research articles on the intersection of these three types of knowledge seem to focus on training teachers to teach in the context of digital technology embedded teaching, where both teachers and students use technology. (Tondeur et al., 2017).

An examination of the pre-service teacher's ability to think about teaching objectives and how digital technology can accommodate this demonstrating critical integration. Instefford (2015) defines this digital capability as the attitudes, skills and knowledge required to use technology reflectively and critically in the process of building new useful knowledge. This is in contrast to the integration of information and communication technologies that have displaced existing practices.

Another aspect of numeracy in teaching practice in the research literature is the ability to teach children who use technology to learn. For example, the ability to organize or manage the environment to use technology in an appropriate way (Elstad, 2017; Kabakci Yurdakul, 2014; Tondeur et al., 2017) or use ICT for learning in a critical, ethical and creative way (Tondeur et al., 2017). The teaching methods studied include the ability of students and teachers to become online communicators with children about their learning progress (Tondeur et al., 2017; Turvey, 2008), Develop students' cooperation skills (Gudmundsdottir, 2017), learner-centred learning (Chen, 2010) or learning how to flip learning through videos and online resources. The ability to study the use of technology to teach learners takes into account differences from the ability to teach using digital technology.

The literature on integrating ICT in teaching practice includes three different kinds of competencies. Firstly, it is the ability to use specific technologies as a teacher. Secondly, it is the ability to select and critique technologies for specific pedagogical purposes. Thirdly, it is the ability to plan and teach students who learn through digital tools.

2.1.3. Professional digital competence

Professional digital ability is the third kind of digital ability studied in this paper. The notion emerged in the Norwegian context. Munthe and Instefjord (2015) gave an overview of a professional digital competency model. It includes three aspects: social awareness, pedagogical compatibility and technological proficiency. Social consciousness refers to pre-service teachers' understanding and negotiating ability on the social aspects of school culture. Pre-service teachers need to be able to negotiate and solve problems in order to successfully integrate digital technologies into their learning and teaching, which is the foundation of it. This model builds on previous researches and emphasizes the digital ability to integrate technical skills and competencies into teaching practices with digital tools and softwares. The same author in a later paper expanded this definition to being able to use and integrate technology for teaching purposes through a series of general skills suitable for all conditions, both professional and personal, as well as particular teaching-profession skills. Therefore, it goes beyond the scope of teaching and becomes a broader role for pre-service teachers. In their conclusions, they pointed out that professional digital competence needed to be clearly defined.

Gudmundsdottir and Hatlevik (2017) used the term again. In this study, professional digital competencies included a range of aspects of the work of pre-service teachers that might involve the use of digital tools, including assessment, data management and communication. The research also asked the pre-service teachers how they monitored the learning environment when the learners using ICT. The concept of professional digital capabilities has been further expanded and is at the forefront of the ICT capability framework by Tondeur et al. (2017). The framework is designed around three areas of the teacher profession: (1) teaching and teaching tasks, (2) professional development and (3) broader schools (p. 465). The concept of professional digital competence can be further expanded to include all aspects of being a teacher in the school educational context and educational system, where digital technology is embedded.

2.2. Pre-service teacher personal characteristics

The articles reviewed examined not only digital competencies, but also beliefs, confidence, or effectiveness of pre-service teachers on the use of ICT. This is framed in the literature reviewed in six ways, including: exploring the confidence of pre-service teachers in using ICT to inform the design of education projects (Jamieson-proctor et al. , 2010), pre-service teacher confidence or efficacy compared with intention to use (Yeung et al. , 2012) or use ICT in teaching (Baydas & Yilmaz, 2018; Valtonen et al. , 2015) , how efficacy, attitudes, beliefs or confidence affect technologies (Aslan & Chang, 2017) , and how self-efficacy in other aspects of teaching affects use (Elstad & Christophersen, 2017) , attitudes and beliefs about the use of ICT in inclusive education and practice (Beacham & McIntosh, 2014) , and how self-efficacy correlates with perceived quality of ITE in terms of digital competencies (Gudmundsdottir & Hatlevik, 2017). Learning different aspects of teaching in an emerging digital system is in this range. When digital technology is considered and embedded "normal practice" in the work of pre-service teachers, digital confidence or efficacy becomes less important in researches, or is subsumed into general researches on educators' motivation and effectiveness.

Research that explores the specific characteristics of pre-service teacher is consistent with research on beliefs, confidence, and efficacy, such as digital natives, learning experiences before becoming a teacher, and motivations for using ICT.

Two studies focused on whether pre-service teachers had a tendency to use ICT. According to Mukama (2009) , there are three trends in the use of ICT in the daily learning practices of pre-service teachers. These include reluctant, active and passive users. Tondeur et al. (2017) developed a pre-service teacher profile based on the motivation of pre-service teachers to integrate ICT into classroom practice, pointing out that some pre-service teachers have an incentive to integrate ICT and some do not. While the two studies focused on similar ideas, one focused on the universal use of ICT for learning and the other on the integration of ICT and teaching.

Four articles suggested research that supported or explored the concept of digital natives. The intersection of ICT competency and age was examined by Guo et al. (2008) and concluded that age did not affect ICT competency. This contrasted with a study exploring contemporary pre-service teachers' perceptions of engaging multimedia learning (Bratina, 2017). A third study examined how the 'cyber generation' transferred their general digital competencies to educational settings (Kumar & Vigil, 2011). The fourth research explored pre-service teachers' perceptions of using laptops in schools and subsequently learning to become teachers themselves (Walker, 2017). Thus, in the literature reviewed, it included two different ways on considering digital natives. One explored the concept of digital natives and the other used this concept to explore how current pre-service teachers viewed or incorporated their own digital knowledge and abilities into their teaching.

2.3. Teacher educators

The literature reviewed examined teacher educators' general digital competencies in the use of technologies, their ability to integrate technologies to teach pre-service teachers how to teach in a digital environment, and the pedagogy used to teach preservice teachers.

2.3.1. Digital competence

Research on teacher educators appears to mirror research on pre-service teachers. This research explores the integration of generic digital competencies and technology in teaching practice. The general digital competencies of teacher educators have been studied in different ways as vital prerequisites for digital integration. This included exploring teacher educators' perceptions of digital competencies (Instefjord, 2015), assessing teacher educators' general competencies or confidence in integrating technology into instructional practices (Brun & Hinojosa, 2014; Peeraer, 2011), and examining a program to develop teacher educators' ICT competencies so that they can integrate digital technology into instructional practices and model approaches to pre-service teachers (Bower & Mowbray, 2013). Two other studies have explored how teacher educators integrate digital technology into their teaching practices (Reyes & Gregory, 2017), and one study explored how to develop collaboration between pre-service teachers and mentor teachers (Liu, Tsai & Huang, 2015).

In a study conducted by Instefjord and Munthe (2017), the ability of teacher educators to prepare students to integrate technologies into their practices was the focus.

Digital competency is measured using six self-reported

indicators; the ability to educate students on the use of digital tools and ethical issues related to the use of social media, being a role model, knowing how to use digital tools to facilitate learning, using interactive whiteboards and digital tools for assessment. These indicators emphasise preparing teachers to integrate digital technologies into their teaching practices and to educate their students for a digital era and future.

The digital competencies of teacher educators are examined in review articles and Krumsvik uses the research and background to develop a digital competency model for teacher educators (2012). He defines teacher educator competence as an individual teacher educator's proficiency in the use of ICT in teacher education and one's awareness of the impact of learning strategies and digital education of pre-service teachers. Bildung is a process of philosophical and personal maturation. As such, it is perceived as a critical and informed use of technology to teach pre-service teachers to integrate technologies. A broader view of the professional digital competence of teacher educators, including aspects beyond teaching, was not found in the selected literature.

2.3.2. Pedagogical approaches

In a review of the literature examining the development of pre-service teachers' digital competencies at the secondary level, eight pedagogical approaches were identified in teacher education programs. These included: practice gap, bridging theory, assessment, student-active learning, authentic learning, modelling, blend-ing, metacognition and collaboration (Rokenes & Krumsvik, 2014). The teaching methods explored in the research papers reflect a belief in effective teaching methods.

In some of the studies exploring the use of ICTs by teacher educators, the ability of teacher educators to demonstrate the use of digital technologies to pre-service teachers has been particularly addressed. (Instefjord & Munthe, 2017). Admiral et al. (2016) in their study concluded that teacher educators needed to be role models, but did not explain why role models are a good teaching method. However, throughout the literature, three reasons for role-modeling are provided. Gill and Dalgarno (2017) pointed out that it provided pre-service teachers with a learner's perspective. Tondeur and Prestridge (2016) believed that the mode of technology use of teacher educators was an important driving force for beginning teachers to use technologies in their own teaching, while recognizing that field experience is a key factor influencing practices. Rokenes and Krumsvik (2011) concluded that modeling was a moderate way to introduce pre-service teachers to digital tools, but hands-on learning is needed to make good use of ICT in teaching practices. Thus, while some researchers believe that role modelling may be a useful teaching method when pre-service teachers are unfamiliar with using digital technology for learning. Its value may be limited if it is not a stage near practices, in which students are guided purposefully from using digital tools to being able to apply the tools in teaching practices in the classroom. (Hammerness & McDonald, 2009).

2.3.3. Pre-service teacher education programme

The third area of research reviewed in the literature focuses on pre-service teacher education programmes, curriculum design, student learning in specific courses, and the links between learning and design.

The development of different kinds of digital competencies is central to this focus. Instefjord and Munthe explore the positioning of digital competencies in the curriculum

documents (Instefjord & Munthe, 2015). This contrasts with studies that examine pre-service teacher learning through pre-service teacher education programs. Examples include how trainee teachers develop TaCK in their pre-service teacher education programmes (Hofer & Grandgenett, 2012; Shinas, Mouza & Glutting, 2015) and the development of pre-service teacher technologies to support learning design thinking (Bower et al., 2013). These studies have focused on how the curriculum enables teachers to use digital technologies for teaching and learning.

The intersection of curriculum design and pre-service teacher learning has the potential to uncover high leverage practices in pre-service teacher education. Studies exploring this intersection include: how pre-service teacher education programs develop pre-service teachers' digital competencies (Rokenes, 2014; Urbani et al., 2017), how aspects of the program influence pre-service teachers' intentions to use ICT (Aslan, 2017; Baydas, 2016) how teacher education institutions develop the capacity to integrate digital technologies into teaching and learning (Tondeur, Roblin & Voogt, 2013). The link between pre-service teachers' technology use and their pre-service teacher education programs (Tondeur et al., 2016). Indirect research into the intersection of student learning and curriculum design was identified in two further research agendas, one examining how curriculum leaders influence the development of students' TPaCK competencies (Xiong & Lim, 2015), while the second focused on how pre-service teachers perceive the quality of ITE courses in relation to their digital competency development (Hatlevik, 2017; Koh & Lim, 2013). The highly leveraged practices in these examples focus on pre-service teachers developing general digital capabilities and integrating technology into instruction. Pre-service teacher education project research reflects research that explores the abilities of pre-service teachers and teacher educators, with an emphasis on digital competence.

Research which examines pre-service teacher preparation for a digital era have paid attention to three areas. The first aspect is pre-service teachers' personal characteristics or dispositions, beliefs, confidence and competence. The second aspect has been the teacher educators' pedagogical approaches and digital competence and the third aspect is the design, the pre-service teacher education programs, student learning within particular programs and the links between learning and design. The aim of digital competence is central over the three aspects and includes three broad explanations; general digital competence, competencies to integrate technologies into teaching and learning practice and an promising field of professional digital competence.

2.4. Summary

Digital competence was a main research focus over the reviewed literature. However, three explanations of digital competency were identified. They are professional digital competence, competence to integrate technologies into teaching and learning practices and general digital competence. Digital competencies in the studies stands for different points in what was examined and how the research was framed. The different points seem to align across three totally different sections of the permeation over the work of the pre-service teacher, the integration into existing practices and systems, the introduction of digital tools to schooling environment and digital integration.

Researching general digital competencies can provide

insight into a situation where digital technology is introduced. The schools, teacher educators and pre-service teachers, have limited various experience of using digital technologies and the pre-service teacher education programs which aim to teach students how can use computers. The teacher educators and beginning teachers' use of educational technologies is predominantly through general software for communication and presentation purposes. This research examines whether teacher educators or pre-service teachers believe they are able to use some technologies instead of the teaching uses of technologies. Developing expertise in general competence can appear when technologies are embedded in the broader societal and educational context that pre-service teachers and teacher educators experienced. If those who enter the teaching field have not learnt presentation and communication technologies, these general competencies have to be explicitly learnt and taught in the programs. Researches into general competence can have deep understanding of the broader environment of digital skills, educators who have such skills will change for a long time and the researches need to explicitly find why the specific skills are so important for learning to become a teacher or teaching pre-service teachers to teach.

The notion of the digital immigrant and digital native has been a rhetoric in the area of education, suggesting that teachers and schools were somehow failing the younger in the programs they were providing especially as digital tools are brought about school systems. While there is no evidence to support differences in the use of learning technologies, the notion occurs to have affected the research agendas directly across studies that explore teacher age. There is one assumption that youngers are more digitally capable and indirectly through paying attention to general digital competencies of pre-service teachers and teacher educators instead of the application of the skills when using digital technologies for teaching.

3. Conclusion

Pre-service teacher education is the process by which teachers are prepared for the school environment they will enter. When digital technology is introduced, integrated and injected into the education system, the school environment changes, as does the pre-service teacher education curriculum and the research that provides the basis for the curriculum and practice. Beside, as digital tools are introduced, the agenda underpinning pre-service teacher education research is changing.

This study explains digital competence in three different ways: general digital competence, digital teaching competence and professional digital competence. The general digital capabilities are consistent with the context in which digital tools were introduced into the system. Researchers are studying the skills that teacher educators and pre-service teachers believe they have. Digital teaching and learning competencies focus on the context of integration and enable pre-service teachers to use technology for teaching and learning. Teachers critically assess use and teach children or young people who are using digital devices for learning. A third form of competence is appearing in the literature. This paper presents the concept of professional digital competence. The concept is also defined as the ability of teachers to work in digital education systems, including teaching, managing digital learning environments and working professionally as teachers. Further research into professional digital

competence in pre-service teacher education should be a future research agenda.

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