Digital Transformation in Education:
A Mixed Methods Study of Teachers and Systems

Aidan Michael McCarthy
DipT, BEd, MEd

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AUTHOR'S DECLARATION

I declare that this thesis is my own account of my research and contains as its main content

work which has not previously been submitted for a degree at any tertiary institution.

Aidan Michael McCarthy

ETHICS APPROVAL

Ethics approval was gained both from Human Research Ethics Committee, Murdoch

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A note on formatting and style

This thesis comprises two published papers as well as a submitted manuscript that are

contained in chapter four. The formatting style follows the respective journal guidelines.

This thesis has continuous pagination. For published documents, the original journal page

numbers are also provided.

STATEMENT OF CONTRIBUTION

This thesis includes two original papers published in peer reviewed journals and one submitted paper. The ideas, development and writing up of all the papers in the thesis were the principal responsibility of myself, the student, working within the school of education under the supervision of Associate Professor Dorit Maor and Associate Professor Andrew McConney.

The inclusion of co-authors reflects the fact that the work came from active collaboration between researchers and acknowledges input into team-based research.

My contribution to the work and those of the co-authors involved the following:

Thesis Chapter and Section	Publication Title	Status	Nature and % of student contribution	Co-author name(s) Nature and % of Co-author's contribution
4.1	Mobile technology in hospital schools: What are teachers' professional learning needs?	Published in Journal of Technology and Teacher Education. https://www.learntechlib.org/primary/p/171461/	65%, data collection, creation of professional development program, data analysis and writing manuscript.	Dorit Maor, data collection, concept, input into manuscript, 20%. Andrew McConney, input into manuscript, 15%.
4.2	Transforming mobile learning and digital pedagogies: An investigation of a customized professional development program for teachers in a hospital school.	Published in Contemporary Issues in Technology and Teacher Education. http://www.learntechlib.org/p/184585/	65%, data collection, implementation of professional development program, data analysis and writing manuscript.	Dorit Maor, data collection, implementation of Professional development program, concept, input into manuscript, 20%. Andrew McConney, input into manuscript, 15%.

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The undersigned hereby certify that the above declaration correctly reflects the nature and extent of the student's and co-authors' contributions to this work.

Supervisor: *Dorit Maor*   Date: 17 March, 2020

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LIST OF PUBLICATIONS

Paper One.

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Paper Two.

McCarthy, A., Maor, D., & McConney, A. (2019). Transforming mobile learning and digital pedagogies: An investigation of a customized professional development program for teachers in a hospital school. *Contemporary Issues in Technology and Teacher Education, 19*(3). https://www.citejournal.org/volume-19/issue-3-19/general/transforming-mobile-learning-and-digital-pedagogies-an-investigation-of-a-customized-professional-development-program-for-teachers-in-a-hospital-school

Paper Three.

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Other Publications During Doctoral Candidacy

Cavanaugh, C., Maor, D., & McCarthy, A. (2018). Mobile learning. In K. Kennedy & R.E. Ferdig (Eds.), *Handbook of research on K-12 online and blended learning* (2nd ed., pp. 574-591). ETC Press.

Cavanaugh, C., Kelley, G., & McCarthy, A. (2018). Implementing New Technologies to Enhance Professional Learning. In A. Novack & C. Weber, Eds., *Best Practices in Professional Learning and Teacher Preparation: Methods and Strategies for Gifted Professional Development*. Prufrock Press.

Maor, D., Robinson, J.A., & McCarthy, A. (2016) *Mobile technologies in hospital schools: Innovative professional development to enhance the learning environment.* Young and Well Cooperative Research Centre/Murdoch University.

Cavanaugh, C., Maor, D., & McCarthy, A. (2014). Mobile learning. In R. Ferdig & K. Kennedy (Eds), *Handbook of Research on K-12 Online and Blended Learning* (pp. 391-441). Entertainment Technology Center Press. http://press.etc.cmu.edu/content/handbook-research-k-12online-and-blended-learning-0

ABSTRACT

The growth in digital transformation in many societies is outpacing its uptake in education. Leaders in education are seeking guidance about best practices to achieve their transformation goals, from mobile innovation for classroom teachers to system wide digital transformational change. The goal of this thesis is to offer insights, strategies and guidance for education leaders as they implement digital technologies for the purpose of transforming teaching, learning and administration. The mixed methods study utilised teacher interviews and surveys in a hospital school to gather data for descriptive statistics and inductive analysis, and qualitative thematic content analysis of existing industry and education digital transformation frameworks. The findings are presented in three articles, the first two from the hospital school setting. The focus of Paper One is teachers' professional learning needs to enable effective mobile technology integration in a hospital school setting. Paper Two examines the effectiveness of a customised professional development program for teachers to facilitate integration of mobile technologies with digital pedagogies. The findings of the hospital school-based research identified three types of teacher professional learning needs to enable the effective use of mobile technology: technological, pedagogical, and personal support. Participation in a customised professional development program resulted in notable improvement in hospital teachers' perceived preparedness to use mobile technology to transform pedagogical practices. Furthermore, technology needs were significantly impacted as teachers gained confidence and collaborated as a learning community. The third Paper used thematic content analysis to identify critical components that provide guidance for education leaders embarking on digital transformation. This Paper recognised four key digital transformation needs:

leadership, people, experience, and technology. The thesis affirms that identifying the needs of key stakeholders is a fundamental first step when embarking on transformative initiatives in education, and offers guidance on developing a coherent strategy that addresses drivers for scalable and sustainable change.

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CHAPTER 1: INTRODUCTION

This chapter outlines the background for this thesis and its structure. The research aims are summarised in section 1.3.

1.1   Background

Global digital innovation is rapid and continuously evolving so relevant literature and best practices can soon become outdated, further complicated by the nature of digital transformation, which has no defined endpoint. Many school systems, including the school in this study, have made the decision to undergo transformative change using technology, however, there is no simple 'how to guide' as drivers, resources and expectations of change are contextual.

My experience in working in education for over thirty years as a classroom teacher, Director of Information Technology, school administrator, Chief Information Officer, and as a consultant for multi-national technology companies informing large digital transformation projects in education systems worldwide, has made it clear to me that education leaders seek guidance in navigating the rapid and continuous evolution of global digital innovation. A personal commitment to support change in education using digital technology as an enabling tool for best practice learning, teaching and administration of schools presented an opportunity to work with the leaders of a hospital school in Australia. Located within the unique setting of a children's hospital, a new digital strategy was designed to improve learning experiences and outcomes for hospitalised students. This was enabled by utilising mobile technologies supported by relevant digital pedagogies. One of the goals of the initiative was to assist hospitalised students to maintain their learning in line with their regular school peers to facilitate their anticipated return to their regular school.

A key intention of the hospital-based study was to identify the hospital schools' contextual or systemic barriers to implementation of the initiative and to determine teachers' needs for successful integration of new technologies to improve student learning. To optimise transformational change, teachers participated in a pedagogical professional development program. It was important to establish how effectively the program supported teachers transforming their pedagogical practices using technology.

During the initial research situated at the hospital school, it became increasingly evident there was a lack of extant literature specifically related to digital transformation in education. This provided the impetus to examine successful transformation efforts in industries other than education to gather evidence of common components and traps for those implementing transformational change. The hospital school research provided a foundation for this broader study that attempts to define digital transformation for education and determine critical considerations in designing the best strategy for success.

1.2   Structure of the Thesis

A thesis by publication format was chosen for this doctoral dissertation. The research reported in the first two publications was carried out at a hospital school. The final paper represents a progression of the themes previously explored on a broader scale but drawing on the findings of the first two papers and my lived experience during the course of the study. In this way, a collection was produced providing teachers, school leaders, system leaders, and policy advisors with guidance and research outcomes to support them in the decisions they make as digital innovation and transformation impacts education.

1.3   Research Aims

As schools and education systems set about responding to stakeholder expectations and the focus on equipping students with 21st century skills (Mishra & Kereluik, 2011) or

future ready skills (World Economic Forum, 2020) to meet the challenges of an increasingly digital world, many leaders have made the decision to introduce new digital innovations or system wide digital transformation. It is important, and timely, to acknowledge that implementing organisational change as it relates to people and technology is a skill increasingly required by all education leaders. The overall aim of this thesis is to offer insights, strategies and guidance to education leaders as they engage in digital initiatives in the classroom, or embark on more transformative change enabled by technology. Specifically, the aims were to:

- identify the needs of teachers prior to engagement in a digital initiative using mobile technologies in a hospital school,

- offer insights into effectively addressing needs through professional development informed by educational frameworks, and

- provide guidance, informed by existing frameworks, for education leaders ready to engage in system wide digital transformation.

The research aims of the three publications that form this thesis are listed in Table 1.

Table 1

Publication research aims

Publication title	Research aims
Paper One Mobile technology in hospital schools: What are hospital teachers' professional learning needs?	The aim of this study was to identify the professional learning needs of teachers to enable the effective use of transformative mobile technology in a hospital school setting. This study investigated teachers' mobile technology use and their current mindsets to answer the following research question regarding mobile technology integration: What are hospital teachers' professional learning needs?
Paper Two Transforming mobile learning and digital pedagogies: An investigation of a customised professional development program for teachers in a hospital school	The aim of this study was to evaluate the effectiveness of a customised professional development program to support transformational change integrating new mobile technologies into the teaching program of a hospital school. This article examined changes in hospital schoolteachers' views and asked the following research question: To what extent were hospital schoolteachers' technological, pedagogical, and personal needs for effective use of mobile technology in a hospital school met following participation in a customised professional development program?
Paper Three Digital Transformation in Education: Guidance for leaders embarking on system change	The aim of the third paper was to identify critical conversations and components to guide leaders embarking on system wide digital transformation in an educational setting. The article also sought to define digital transformation for education. A qualitative thematic content analysis of extant digital transformation frameworks produced by large organisations together with analysis of education systems with clear technology strategies was undertaken.

CHAPTER 2: LITERATURE REVIEW

This goal of this chapter is not to provide a comprehensive literature review, as this is provided in each of the published papers. This chapter provides a synthesis of key messages from the literature to frame the research as a whole by reviewing relevant literature on what is already known about:

- integration of mobile and digital technologies by schoolteachers.

- theoretical education frameworks that focus on stages of technology integration and their role in professional development.

- defining digital innovation and digital transformation.

- drivers of digital transformation.

- change management.

- theoretical frameworks.

When the opportunity to research the needs for successful integration of mobile and digital technologies for teaching in a hospital school setting arose there was a shortage of research literature in that specific area (Maor & Mitchem, 2015; Nicholas & Chahauver, 2017). Similarly, research related to technology relevant to digital transformation and guidance for successful implementation in an education context is currently scarce. However, there is growing recognition that digital technologies in education systems (Schleicher, 2019), cover more that learning with technology in the classroom, but also encompasses learning at home and in the wider community (Cavanaugh, et al., 2018; Léger, et al., 2019; Zhai, et al., 2019). This can enable transformative change in teaching and learning to improve outcomes for students, including "helping teachers and students develop the skills, competencies and mindsets essential for "as yet imagined" futures"

(Peters, et al., 2018, p. 3), supported by mobile learning (Cavanaugh, et al., 2018), and blended learning (Hofmann, 2018; Kennedy & Ferdig, 2018).

The literature extends to consider how social, economic and political changes have made an impact on digital transformation in education. Section 2.2 outlines the theoretical frameworks that inform this study.

2.1   Mobile Technology Innovation and Digital Transformation in Education

Expectations placed on educators to be prepared to use technology in teaching and on education leaders to transform teaching, learning, and administration using technology varies by jurisdiction, and influences can come from policy makers, parents, and the wider community (Bas & Sarıgöz, 2018; European Commission, 2018; Organisation for Economic Co-operation and Development, 2019; Schleicher, 2019; World Economic Forum, 2020). The literature confirms that digital technologies, including mobile devices to deliver mobile learning, can positively influence student engagement and learning by providing more opportunities for personalised and blended learning (Bartholomew & Reeve, 2018; Friend, et al., 2017; Haßler, et al., 2016; Hofmann, 2018; Huggins & Kellogg, 2020; Lee, et al., 2018; Peters, et al., 2018). Digital technologies can assist in overcoming contextual barriers for students' learning in rural or remote areas (Khan, et al., 2019) and students' learning in a hospital school (Äärelä, et al., 2018; Maor & Mitchem, 2015; Maor & Mitchem, 2020; Nicholas & Chahauver, 2017). Further to this, research suggests that new pedagogical practices to facilitate learning enabled by technology (Ally, et al., 2014; Hutchison & Woodward, 2018; Owen, 2015) are important to ensure the goals in implementing technology are realised (Kearney, et al., 2015; Vincent-Lancrin, et al., 2019).

In a technologically rich world where emerging technologies are ubiquitous outside the classroom, education systems face the challenge of leading and encouraging

transformative teaching (McKnight, et al., 2016; Tarling & Ng'ambi, 2016). Teachers can be

engaged through professional development, including individualised coaching and personal

reflection (Drennan & Moll, 2018; Kraft & Blazer, 2017; Yendol-Hoppey & Dana, 2010).

There is ample literature that confirms well-designed and inspiring professional

development has a positive influence on teacher practice leading to improved student

learning (Gutierez & Kim, 2017; Kools & Stoll, 2016). However, teachers also require that

their contextual needs be met, including the infrastructure to support the use of technology

for teaching (Chou & Block 2019; Moreira, et al., 2019). For example, hospital

schoolteachers in the study that informs this thesis felt added pressure to keep 'up to date'

with students' regular school programs (Maor & Mitchem, 2015; Maor & Mitchem, 2020).

Considering context is supported by Nicholas and Chahauver's (2017) examination of

computer use by hospitalised children and youth that revealed "a pediatric hospital context

without Internet-based communication and gaming opportunities may be seen by many

children and adolescents as limiting" (p. 287). Furthermore, hospital schoolteachers face the

unique challenge of effectively using mobile technology in a hospital environment with

infrastructure constraints (Maor & Mitchem, 2020; Nicholas & Chahauver, 2017).

Once context is considered, theoretical educational frameworks with a focus on

integrating technology with pedagogy, such as the technology, pedagogy, and content

knowledge (TPACK) framework (Koehler & Mishra, 2009), and 21st century learning skills

(Mishra & Kereluik, 2011) provide guidance for designing effective professional

development (Dimmock, 2016; Reichert & Mouza, 2018; Yurtseven Avci, et al., 2019). The

TPACK framework can facilitate the assessment of teachers' existing knowledge and assist

identification of areas of teacher practice requiring support (Voogt, et al., 2012; Koh, 2019).

The 21st century skills required to participate in a knowledge-based workforce (Australian

Institute for Teaching and School Leadership, 2020; European Commission, 2018; Grundke, et al., 2018; Organisation for Economic Co-operation and Development, 2018; Voogt, et al., 2012; World Economic Forum, 2020) can be used to scaffold professional development delivery to align with TPACK competencies. Koh (2019) suggests that this "pedagogical anchoring is important for supporting student-centered ICT pedagogical change" (p. 591).

Beyond the classroom, many countries are acknowledging the influence of global trends on education by introducing initiatives to drive change (Sullanmaa, et al., 2019; Traxler & Vosloo, 2014). For example, beginning in 2008 the Australian government responded to the increasing importance of digital technologies and globalisation on education (Buchanan, 2011) by implementing the Digital Education Revolution (DER) with the core aim to "contribute sustainable and meaningful change to teaching and learning in Australian schools that will prepare students for further education, training and to live and work in a digital world" (Australian National Audit Office, 2011). An audit of the program concluded that some school principals reported encouraging changes in students' access to technology and their engagement, and the program provided an impetus for modernising information and communications technology (ICT) infrastructure (Australian National Audit Office, 2011).

Outside of education, the speed of digital change and complexity has led to companies and corporations transitioning away from ICT as an enabler of innovation, to embrace the concept of *digital transformation* and "the potential to change the way we work, live, and even govern ourselves" (Gale & Aarons, 2018, p. 30). Digital transformation is a term now widely used to describe how public and private organisations respond to technology (Hinings, et al., 2018). Furthermore, Gale and Aarons (2018) assert "Government agencies around the world have also launched major initiatives to digitally transform the

way they function and interact with both citizens and other agencies" (p. 31), suggesting that major digital initiatives are being widely recognised as a means to improve function and the digital experiences of the constituencies they serve.

Defining digital transformation is important because it removes ambiguity in how we describe and differentiate digital innovation and digital transformation (Dörner & Edelman, 2015). Digital innovation can be expressed as the use of digital technology in the "concerted orchestration of new products, new processes, new services, new platforms, or even new business models in a given context" (Hinings et al., 2018, p. 52). Digital innovation can be seen in education initiatives that respond to trends such as one to one computer or mobile learning initiatives (Cochrane, et al., 2013; Geer et al., 2017; Jahnke, et al., 2017; Parrish & Sadera, 2020; Penuel, 2006; Young, 2016; Zheng, et al., 2016). Digital innovation in education, such as mobile, and virtual learning, can produce flow-on effects related to digital assessment and content, pedagogy, funding, accessibility, equity and/or classroom management.

Hinings et al. (2018) differentiate digital innovation from digital transformation, describing digital transformation as "the combined effects of several digital innovations bringing about novel actors (and actor constellations), structures, practices, values, and beliefs that change, threaten, replace or complement existing rules of the game within organizations, ecosystems, industries or fields" (p. 53). The European Commission (2019) characterises digital transformation as "a fusion of advanced technologies and the integration of physical and digital systems, the predominance of innovative business models and new processes, and the creation of smart products and services" (opening section, para. 2). The goal of defining digital transformation is to provide a platform on which to build a shared vision (Dörner & Edelman, 2015).

The decision to implement digital innovation initiatives and digital transformation begins with understanding social, economic, political and/or technological conditions and trends (Riemke-Gurzki, 2017). Influencing organisations, such World Economic Forum, offer guidance, such as "Education models must adapt to equip children with the skills to create a more inclusive, cohesive and productive world" (World Economic Forum, 2020, p. 4). Understanding contextual drivers for change can inform strategies and decisions moving forward. Additional drivers for change in education delivery include "technology trends … [such as] advances in analytics, artificial intelligence, the cloud, mobile, consumerisation, social networks, and storage capacities" (Educause, 2019, p. 6). Furthermore, *Trends Shaping Education 2019*, suggests "in our quickly changing modern world, education cannot prepare for the future using only lessons of the past" (Organisation for Economic Co-operation and Development, 2019, press release section, para 1.), recommending reimagining education content and delivery together with long term strategic thinking to meet the unpredictability of major global trends (Organisation for Economic Co-operation and Development, 2019). While the Organisation for Economic Co-operation and Development and other organisations (see Appendix A) increasingly share reports and commentary relating to trends shaping the world and their impact on education, these often extend beyond technology and digital transformation, such as skills (World Economic Forum, 2020). However, increasingly technology trends are presented as key instigators for change. For example, in *Trends Shaping Education 2019* (Organisation for Economic Co-operation and Development, 2019):

> The unprecedented digital transformation of the global economy and society is likely to increase the complexity of the modern world, as well as the speed of change, largely because of increased connectivity and more educated individuals worldwide. These two elements – complexity and speed of change – mean that

connecting education to the trends shaping the world we live in has never been so urgent. (p. 13)

Digital innovation initiatives and digital transformation bring about change that has an impact on people. Fullan (2007) argues "transformation is not possible without accompanying messiness" (p. 31) and this remains relevant when considering educational change and its impact, including digital initiatives, keeping in mind that there is potential for great outcomes. People management and talent development (Mihalcea, 2017) is seen as critical for organisations managing change. Organisations require specialised human resource professionals to manage processes, such as "recruitment, preparation, induction, on-going professional development and collective improvement of practice" (Darling-Hammond, 2017, p. 291), to support the personal development journey of employees. Applying change management methodologies (Galli, 2018) can provide leaders with guidance to support employees during the change process. Successful organisations recognise and communicate that a "shift in mindsets" (Setili, 2018; Woltering, et al., 2019) of people is the biggest agent for change in an organisation, and technology is a support act that enables change (Dörner & Edelman, 2015; Kane, 2019). Furthermore, effective leaders use vision and creativity, communicate possibilities and progress, and are able to react to change by creating possibilities and something new (Feehan, et al., 2016; Tabrizi, et al., 2019). Scalable educational change has historically found sustainable (Hargreaves, 2007) success despite "shifting priorities, changes in funding, and challenges to policy coherence" (Coburn, 2003, p. 8). Research by MIT Sloan Management Review and Deloitte recommend the development of a comprehensive digital strategy to support the change process (Kane, et al., 2015).

2.2   Theoretical Frameworks

The theoretical concepts of constructivism and connectivism were used to investigate the needs of teachers for implementing mobile learning initiatives in a hospital school, and identification of critical components and considerations of digital transformation for education system leaders and policy advisors to achieve knowledge construction (Richardson, 2003; Cresswell, 2012; Creswell & Guetterman, 2019).

John Dewey's (1916/1997) pragmatic philosophy described the primary tenets of constructivist education which emphasised learning-by-doing and involvement in authentic activities. This constructivist approach guided the process of identifying the needs of hospital schoolteachers and the frameworks chosen to inform the design of coach-facilitated professional development. Constructivism points to the social dimensions of teacher interactions as essential processes. These include negotiating professional development with a coach, creating meaning through co-construction of knowledge, and developing collaborative learning communities with other teachers. From a constructivist viewpoint the role of a teacher coach is more than an information transmitter, and includes the role of facilitator to challenge ideas and negotiate meaning through multiple interactions with other teachers during professional development and personal coaching sessions (Bell et al., 2013; Palmer, 2005; Parrish & Sadera, 2020). A coach can help create a learner-centric and collaborative environment to support reflective and experimental learning, and enable the learner to be an information constructor. Constructivism in action sees teachers individually, in collaboration with peers, and/or with a personal coach, building meaning and understanding that informs relevant practice beyond the technology or applications used, to recognise the education opportunities of mobile learning and teaching with digital pedagogies.

Connectivism is a relatively new theory of learning reflecting living, working, and sharing in a digital age (Bell, 2011; Clarà & Barberà, 2014; Kop, 2011; Kop & Hill, 2008). This thesis aligns with Kop and Hill's (2008) view of connectivism as "the development of constructivism in response to the current scenario of the intense use of technology in education" (p. 210). Further, Goldie (2016) indicates, "Despite its limitations most authors recognize connectivism's potential to provide a useful perspective as to how learning might occur in the digitally saturated, connected world we live in" (p. 1067). Whether connectivism is a theoretical concept or is situated conceptually within constructivism, the theoretical framework for this thesis recognises both.

As teachers and students work within connected learning environments, connectivism helps explain how learning occurs within networked digital environments (Downes, 2010; Siemens, 2017). Connections for students and teachers in a hospital school environment see learning extend past the traditional classroom to include digital connection nodes, such as the hospital bed, the home during recuperation, or connecting with the regular school through video conferencing (Mattar, 2018). This concept is explained by Oddone, Hughes and Lupton (2019) who state, "A key principle of connectivism is that knowledge extends across multiple nodes within nebulous digital environments" (p. 104). How teachers and students engaged in the hospital school with mobile learning helped form a new learning process that involved actively creating connections between these nodes (Siemens, 2017). Siemens (2008), as cited in Mattar, (2018) builds four metaphors for the educator: master artist, network administrator, concierge, and curator. These metaphors support the role of a coach, for example, in responding to a teacher's personal needs, including identifying curriculum apps (curator) or linking teachers to support each other

(network administrator). Using these theoretical constructs helped researchers to better understand how learning eventuates as digital technologies are integrated into pedagogy.

Connectivism also formed the theoretical construct for Paper Three, which considers how school and system leaders, who support the needs of schools (staff, students, infrastructure), are accountable for the delivery of public policy and transformation agendas. A connectivist approach reveals how school and system leaders create information nodes (Siemens, 2017). This includes how digitally connected stakeholders (students, teachers, parents, administrative staff, system leaders) communicate and collaborate within a school, between schools, and with regional and central education offices (Cortellazzo, et al., 2019), bringing experiences, best practices and coherence to the transformation (Fullan & Quinn, 2016). Furthermore, connectivism plays an important role in the development and emergence of new pedagogies utilising digital technologies, such as remote and virtual learning. Goldie (2016) suggests "control is shifting from the tutor [teacher] to an increasingly more autonomous learner" (p. 1067), exemplified by unwell students who are often learning in isolation, using mobile devices as they seek to continue their education between regular school, home, an outpatient facility, and the hospital.

In conclusion, constructivism provides a framework for understanding, predicting, and changing human behavior, whereby, people actively construct or create their own subjective representations of objective reality. In education, a social constructivist perspective can provide instruction that facilitates deep learning and conceptual change (Atwater, 1996). The integration of mobile learning devices into teaching provides teachers the opportunity to create personal learning outcomes that engages them as learners. Identifying the critical components of digital transformation provides education leaders and policy makers potentially new knowledge and guidance for successful decision-making,

strategic planning, and implementation. Connectivism further supports this new knowledge

and learning outcomes by helping to explain how learning occurs within networked digital

environments and how digitally connected students, teachers, parents, administrative staff,

system leaders can evolve using emerging technologies.

CHAPTER 3: METHODS

This chapter provides an overview of the research methods employed to achieve the aims outlined in section 1.3. This is not a comprehensive review of methods as this has been provided in each paper. Overall, a mixed methods approach was utilised, combining "quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study" (Johnson & Onwuegbuzie, 2004, p. 18).

The research design components associated with Papers One and Two are described separately from those associated with Paper Three. The first two papers were linked in design whereas the third paper expands on identified components by using thematic content analysis to develop and suggest a synthesis of "lessons learned" in implementing system-level digital transformation. Additionally, education frameworks were utilised in the study to identify the needs, perceptions and knowledge required of teachers as they sought to effectively use mobile technologies and implement digital pedagogies (see Papers One and Two). These frameworks included TPACK (Mishra & Koehler, 2006) and 21st century skills (Kereluik, et al., 2013; Mishra & Kereluik, 2011). In Paper Three, digital transformation frameworks were reviewed to identify themes and subthemes to conceptualise a digital transformation framework for education.

3.1   Research Design Associated with Papers One and Two

The research presented in Papers One and Two applied the strengths of both quantitative and qualitative methodologies in a mixed methods approach to provide a more holistic understanding of participants' views to help answer the research questions. Although a mixed methods study can collect comprehensive data the complexity of analysis required careful planning and time to integrate the qualitative and quantitative data (Wisdom & Creswell, 2013). Furthermore, commitment by participants to the study was

critical due to the time required to obtain broad, rich data in a demanding setting. The initial research (described in Paper One) enabled hospital schoolteachers to express their perceived needs to transform their teaching using new mobile technologies. The findings informed the design of a professional development (PD) program implemented, studied and presented in Paper Two. This enabled the examination of changes in pre-PD and post-PD technology related pedagogical needs for hospital schoolteachers. Paper Two was therefore able to document and describe the extent to which teachers' technological, pedagogical, and personal needs for effective use of mobile technology in their teaching were met following participation in a customised professional development program.

3.1.1   *Participants and Research Site*

The research presented in Papers One and Two was conducted in a Western Australian hospital school in which teachers faced the challenge of providing learning experiences to unwell students of mixed ages in various locations, while maintaining partnerships with parents, regular schools, health professionals, and colleagues (Children's Hospitals Australasia, 2020; Government of Western Australia, 2020). The hospital school in this study operates at twenty government-owned sites across one Australian state, led by one principal based at the largest site.

The principal and the senior administration staff (leadership team) at the hospital school introduced a strategic plan to teachers and students (more than 5,500 per year) which included upgraded ICT infrastructure, such as improved Wi-Fi access, and provision of mobile devices and digital resources in an effort to enhance teaching and learning. In addition, a professional development program was implemented to support needed change and improvement with mobile technologies linked to relevant digital pedagogies.

At the time of the study the school employed 75 experienced schoolteachers with an average of 26 years teaching experience and nine years of hospital school experience. All teachers participated in the mobile learning initiative that included general technology related professional development. Teachers were made aware of this voluntary study by the school principal during a regular professional development day. During the initial research 29 hospital schoolteachers participated in this voluntary study to identify their needs prior to the design and implementation of a customised professional development program (Paper One). Many teachers chose not to participate in the study due to their part-time status or because they teach in remote or rural hospital school locations. Additionally, due to changes in circumstances, such as long service leave, 22 teachers participated in the second phase of the hospital school-based research (Paper Two). The hospital school's leadership team ensured that teachers were provided time and professional development opportunities to participate in the research.

The hospital school setting included spaces where teaching was conducted such as classrooms, students' hospital beds, and recuperating facilities, including students' homes. The hospital school mirrors the calendar of regular schools, operating four terms of ten weeks each over the course of the school year. Hospital schoolteachers work in small collaborative groups supporting specific groups of hospitalised students of different ages, curriculum areas and medical requirements.

3.1.2 Instruments

Instruments used in this research included pre-PD and post-PD surveys based on the TPACK framework (Archambault & Crippen, 2009) (see Appendix B). Qualitative data were gathered through researcher-created open-ended survey questions (see Appendix C), individual teacher interviews (see Appendix D), and focus group interviews (see Appendix E).

Pre-PD and post-PD TPACK surveys

The TPACK surveys were a modified version of Archambault and Crippen's instrument (2009) to accommodate the unique context of a hospital school. This instrument utilised the TPACK framework assessing the knowledge that teachers are typically expected to have. As this study was conducted in Australia, the knowledge and skills expected aligned with the Australian Institute for Teaching and School Leadership (AITSL, 2020). The survey included seven questions for each knowledge area (Archambault & Crippen, 2009) with an additional open-ended question (see Appendix C). Forty-nine items were administered via the online survey tool SurveyGizmo®. All participant teachers completed the survey prior to engagement in a customised professional development (pre-PD) program and again once completed (post-PD). Links to the survey were provided to participant teachers by the school administration. Teachers were allocated a week to complete the survey and time was provided within their daily schedules.

Pre-PD and post-PD teacher interviews

The researchers conducted individual interviews to all 29 teacher participants lasting 30 to 60 minutes to understand teachers' personal and professional needs for effective use of mobile technologies for teaching and learning. The interviews occurred during regular professional development days that were conducted offsite at the beginning and end of each school term. These interviews were recorded, transcribed and coded. Following participation in a customised professional development program, interviews compared pre-PD and post-PD teacher needs for support using mobile technology for teaching.

Pre-PD and post-PD focus group interviews

The purpose of focus group interviews was to gain a deeper understanding of the challenges and progress of the group as a collective, to provide insights into teacher needs.

The insights were gathered to inform the design of a customised professional development program. During school-based professional development the researchers conducted five pre-PD and five post-PD group interviews lasting between 30 and 60 minutes with groups of four to five teachers. The researchers developed a list of questions to guide participants; nevertheless, interviews were semi-structured, allowing flexibility in the scope and sequence of what was discussed.

3.1.3   Professional Development Design

The professional development program undertaken and completed by 22 teacher participants in this study was designed by the research team and customised to address participant needs initially identified. Contributions to the design of the program and school-based professional development incorporating technology were made by a digital technology coach, who was an experienced teacher previously engaged in mobile learning initiatives. The coach was an integral element of the professional development design by collaborating with the researchers, supporting group professional development, and delivering one-on-one professional development to teacher participants.

3.1.4   Procedure

A chronological overview of professional development and data collection procedures (see Figure 1) that also appeared in Paper Two (see Figure 2, Paper Two, p. 68) articulates the order of procedure and represents the structure for the research.

Figure 1.
Chronological overview of professional development (PD) and data collection procedures.

In addition to the school-based professional development program that incorporated technology, the customised professional development program was undertaken in two cycles each lasting four weeks. Cycle one focused on basics such as accessing a device, connecting to a wireless network, printing and storing files, learning to use communication applications and sharing files with students. Cycle two focused on teachers' pedagogical needs such as working with a technology coach to identify apps relating to curriculum areas, development of 21st century skills, and digital textbook resources. Teachers engaged in two cycles of four weeks with one-on-one workshops for a minimum of one hour per week. Each participant was allocated eight hours of personalised professional development with a coach.

The coach provided advice via emails, phone calls or face to face, in a location such as in the school staffroom, to all teacher-participants. As the coach was only available on-site for two days a week due to funding, all teacher participants were provided options for when they wished to begin their one-on-one professional development with the coach. The coach scheduled one hour per week face to face sessions. After previously agreeing on the

focus for sessions through emails and phone calls, teachers had the options of having the coach co-teach in their classroom, spend time in the staffroom discussing strategies and needs, or in a location they proposed. Following each session, the coach provided feedback and agreed on actions, including preparation for the next session. Actions included activities a teacher participant could engage in with students. Additionally, the coach assisted collaboration opportunities to enable teachers with shared technology needs to reflect on their professional development and shared classroom experiences using mobile technologies.

3.1.5 Analysis

Descriptive statistics were used to summarise data from teachers' TPACK survey responses. Quantitative survey responses were exported from SurveyGizmo® and analysed in Microsoft® Excel® 2016, to graphically represent survey responses within each TPACK dimension and across all teacher participants. Means were calculated based on the 5-point Likert scale used in TPACK, for which a "5" indicates strong agreement with the indicator. The researchers used inductive analysis and open coding to analyse responses to open-ended questions.

For analysis of the individual qualitative interview data, focus group data, and TPACK open-ended questions the researchers used a thematic coding approach initially based on TPACK categories. These codes were then refined to reflect terms that described the most consistent type of teacher needs, for example, peer collaboration. Transcripts were subjected to qualitative data analysis, assisted by qualitative data management and analysis software. In this way, key teacher needs were identified (technological, pedagogical, and personal support) as they relate to the use and integration of mobile technologies in the context of a hospital school. Analysis comprised an initial process of line-by-line coding.

Codes within and across the transcripts were identified, followed by categorisation of codes that reflected interrelationships of, and distinctions between, codes (Strauss & Corbin, 1990). Replaying of recorded interview data and accurate transcription enabled analysis and interpretation of responses by researchers. The process of coding and categorisation was supported by NVivo 11® and Microsoft® Excel® to determine patterns of responses, identify themes, and assign categories. This iterative process was continued until no new insights emerged from transcripts; hence, data saturation was perceived to be achieved (Creswell, 1998).

3.2   Research Design Associated with Paper Three

Paper Three focuses on a qualitative thematic analysis (Clarke & Braun, 2017) of data and a coding approach to identify key themes. This enabled a systematic analysis of the common components of the digital transformation frameworks of various non-education organisations and technology strategies of various education systems with the aim of providing guidance for leaders embarking on system wide digital transformation in an educational setting. Thematic analysis in a qualitative study provides a flexible and accessible method for identifying the most common themes expressed, however, an open-minded approach to determining patterns (Cupchik & Hilscher, 2008) is required due to the active role of the researcher in data analysis (Clarke & Braun, 2017). No human participants were involved in the data gathering for this aspect of the study.

The following outlines data gathering and analysis stages:

1. Review of literature and data collection.

2. Initial data analysis to determine themes and subthemes within the concept.

3. Data analysis based on pre-determined themes, using the method of frequency analysis.

3.2.1 Data Collection

The digital transformation frameworks of 50 organisations were initially reviewed

with 20 organisations selected for deeper analysis if digital transformation was expressed as

a key theme and/or a digital transformation framework was presented and available,

without a paid subscription or required membership, via the organisations websites (see

Paper Three, appendix C, p. 111). As the purpose of this study was to provide guidance to

education leaders, reviewing organisations with primary research and reports that

education leaders could easily access was an important consideration. Organisations

reviewed included management consulting and research organisations, technology

companies that provide hardware, software and digital consulting services to education, and

organisations engaged in education policy. In addition, 15 Ministry of Education (MoE)

strategic plans were reviewed to understand how education systems conceptualise digital

transformation, including whether a framework was mentioned. Seven MoEs that have

publicly shared their digital transformation journey were selected to represent a range of

developed and developing countries. Like the selection process of other organisations,

MoEs were chosen if strategic plans and directions were publicly accessible in English

translation (see Paper Three, Appendix C, p. 111). A total of 65 organisations were initially

reviewed for this part of the study.

3.2.2 Analysis

Theme-related text segments, definitions of the term "digital transformation", and

digital transformation frameworks proposed by 65 organisations were analysed. The review

included reports and surveys by the European Commission, Organisation for Economic Co-

operation and Development, World Economic Forum, as well as papers published by non-

governmental organisations. An independent iterative and inductive analysis of the identified organisations websites, research, white papers, and blogs was conducted utilising Microsoft® Excel® to identify common themes. Preliminary codes were assigned following a qualitative thematic analysis, then patterns were determined, themes assigned and reviewed then refined. The analysis was aided by my professional lived experience (Clarke & Braun, 2017) and a subjective, open-minded approach (Cupchik & Hilscher, 2008).

3.3   Ethics and Limitations

Papers One and Two required human subjects ethics approval which was obtained from relevant authorities (i.e., Murdoch University Ethics Board and the Department of Education of Western Australia) prior to starting the study. Written consent for this research was also obtained from the hospital school principal and teacher participants. Due to the confidential nature of a hospital setting this was particularly important. Assurances were made that participants had the right to withdraw from the study at any time, and it was expected that some teachers who began the research process would not continue due to changes in circumstances. To further safeguard participants and students (who were not directly involved in the study), the school was de-identified.

The hospital school had previously identified and addressed some obstacles to teachers' preparedness to use mobile technologies in their teaching, such as assigning new mobile devices. However, due to hospital safety policies there were limitations such as where mobile technologies and Wi-Fi could be used by teacher participants. Additionally, funding priorities and time constraints meant that the professional development delivery had to be staged over time. Hospital schools are characteristically small compared to regular schools, which had an impact on the participant sample size; however, confidence in

gathering the relevant data to answer the research questions was determined due to the subject matter expertise of the researchers and the teaching experience of the participants.

Paper Three presented a review of the current limited volume of existing literature dedicated to the theme of digital transformation and education. Research related to technology relevant to digital transformation is constantly emerging, so existing literature is potentially out-dated. Furthermore, digital transformation is responding to the continuous and rapid emergence of new digital innovations and therefore can have no defined endpoint. Digital transformation frameworks that were analysed only represented organisations that could be accessed directly from websites. Including digital transformation frameworks from organisations that required registration or paid subscriptions may have provided greater depth, breadth and evidence-based research. Thus, this review can never at any time be exhaustive. This paper represents a starting point rather than a destination.

3.4   Conflict of Interest

There were no conflicts of interest determined in the hospital school study. During the course of preparing articles for publication, I transitioned from a full-time role as Chief Information Officer and Head of Digital Transformation at an education system to a multi-national technology organisation working with Ministries of Education and policy makers envisioning and creating technology strategies. This organisation is one of the 65 organisations reviewed for Paper Three and met the criteria for further analysis. I decided to include this organisation due to the maturity of the digital transformation framework available which also has an education focus.

CHAPTER 4: PUBLICATIONS

4.1   Paper One

Pages 29-57 were removed due to copyright restrictions. The article can be found

here: McCarthy, A., Maor, D., & McConney, A. (2017). Mobile technology in hospital

schools: What are teachers' professional learning needs? *Journal of Technology and*

Teacher Education, 25(1), 61-89. Society for Information Technology & Teacher

Education. https://www.learntechlib.org/p/171461/.

Research Aim

The aim of this article was to identify hospital teachers' professional learning needs to

enable effective use of mobile technologies and relevant digital pedagogies in a hospital

school. This paper formed the first part of a larger study providing an evidence base from

which to develop a professional development program that supports the hospital school's

reform effort, beginning with the integration of mobile technologies with teaching and

learning, and thereby providing a foundation for teachers' digital pedagogies. A mixed

methods investigation was implemented to understand more deeply the needs of teachers.

Perception data was gathered on teachers' technological, pedagogical, and content

knowledge through surveys, and individual face to face and group interviews. A key

intention of the study was to develop a mobile learning framework with guidelines and

strategies for hospital schools that may embark on similar initiatives. Teachers were

introduced to mobile technologies for three purposes: improving their technological skills;

integrating mobile technologies in their teaching; and improving children's learning. The

study investigated teachers' mobile technology needs and mindsets to answer the following

research question regarding mobile technology integration: What are hospital teachers'

professional learning needs?

### 4.2	Paper Two

Pages 59-89 were removed due to copyright restrictions. The article can be found here:

McCarthy, A., Maor, D., & McConney, A. (2019). Transforming mobile learning and digital pedagogies: An investigation of a customized professional development program for teachers in a hospital school. *Contemporary Issues in Technology and Teacher Education, 19*(3).

Research Aim

The aim of this article was to examine the outcomes of a customised professional development program, introduced to effect pedagogical change by enabling integrated use of mobile technologies in a hospital school. The professional development program was developed to address hospital teachers' learning needs related to mobile technologies and digital pedagogies. A mixed methods investigation (surveys, individual interviews, and small group interviews) was utilised to examine teachers' views following completion of the professional development program and compared data to pre-professional development data obtained in Paper One. An intention of the study was to assess the effectiveness of a targeted approach, including coaching, in addressing teacher technological pedagogical knowledge needs to answer the research question: To what extent were hospital schoolteachers' technological, pedagogical, and personal needs for effective use of mobile technology in a hospital school met following participation in a customised professional development program?

4.3   Paper Three

Pages 91-119 were removed due to copyright restrictions. The article is submitted

for publication.

McCarthy, A., Maor, D., & McConney, A. (2020). *Digital Transformation in Education:*

Guidance for leaders embarking on system change. Manuscript submitted for

publication*.*

Research Aim

The aim of this article was to define digital transformation for education systems, in the

context of current major economic, political, social and technological trends affecting

education. The second aim was to open critical conversations that can support successful

digital strategies in an educational context. A review of 65 organisations, including

management consulting and research organisations, technology companies, organisations

with an interest in education policy, and Ministries of Education, was conducted. A

qualitative thematic analysis of existing digital transformation frameworks (DTF) was

undertaken to identify and interpret patterns of themes and key DTF components. An

intention of this study was to produce conversation starters, stimulate reflection on how to

approach digital transformation in an education context, inform strategic thinking, and to

provide guidance for education leaders embarking on system change.

CHAPTER 5: FINDINGS

This chapter draws on the major findings of the three articles included in this thesis as they relate to mobile technology integration, teacher professional learning needs, and digital transformation when considered through an education lens. In the first part of this chapter the major findings from each paper will be presented, framed by research questions, literature that supports these findings, and the role of theoretical frameworks.

A synthesis of findings is presented in the last section of this chapter and demonstrates how established frameworks can provide authoritative, evidence-informed guidance for teachers to increase their confidence in the use of technologies, and for school leaders as they introduce their staff to new technology initiatives.

5.1   Paper One Findings

In Paper One, the research question investigated: "What are hospital teachers' professional learning needs?" Hospital teachers' technology and professional development needs required to keep abreast of rapid technological change in regular schools were well articulated and important to the participants. The study identified three types of hospital teacher professional learning needs for preparedness to teach with mobile technology: *technological, pedagogical, and personal support* (see Figure 2, Paper One, p. 41). Major barriers to teaching using mobile technologies in a hospital setting were revealed, including inconsistent IT infrastructure (access to devices, printing, networks) and limiting hospital policies regarding technology, such as restrictions on Wi-Fi use. This finding aligns with the literature that suggests a particular context can influence the expectation and ability to use technology in teaching in unique contexts (Clausen, 2007; Gill, 2019; Nordlöf, et al., 2019; Parrish & Sadera, 2020; Xie, et al., 2019). Theoretical educational frameworks were

instrumental in providing a method of data collection and analysis to provide a deeper understanding of teachers' concerns regarding their capacity and willingness to undertake technological and pedagogical change (Voogt, et al., 2012; Koh, 2019). The findings revealed that the greatest perceived category need for successful integration of mobile technology by teachers were personal use, confidence, and time as they relate to technology.

Focus on the category technology needs (see Table 1, Paper One, p. 41) was supported by the pre-PD TPACK quantitative survey results that indicated teachers had a high level of content knowledge (CK) and pedagogical knowledge (PK), which was expected among senior and experienced educators. However, technology knowledge (TK), technological content knowledge (TCK) and TPACK were the lowest self-rated dimensions of the survey. The qualitative data derived from both pre-PD individual and group interviews provided a deeper understanding of teachers' concerns regarding their capacity and willingness for technological and pedagogical change.

The design of a customised professional development program was informed by these findings and delivered in the second phase of the hospital school-based research and presented in Paper Two.

5.2   Paper Two Findings

In Paper Two, the research question sought to identify "To what extent were hospital schoolteachers' technological, pedagogical, and personal needs for effective use of mobile technology in a hospital school met following participation in a customised professional development program?" The findings revealed substantial change in participant teachers' self-perceived preparedness to use mobile technology in their teaching. Identifying and addressing teacher needs through customised professional development, supported with technology models and individualised coaching, increased

teachers' technological pedagogical knowledge (TPK) to enable the improved use of mobile

technology in a hospital school. This finding reflects the literature that confirms that

effective, well-designed professional development can engage teachers and have a positive

influence on their professional practice (Drennan & Moll, 2018; Gutierrez & Kim, 2017;

Kools & Stoll, 2016). Theoretical educational frameworks were valuable in providing a

scaffold for designing a customised professional development program for hospital

schoolteachers (Dimmock, 2016; Reichert & Mouza, 2018; Koh, 2019). The post-PD

interviews revealed that teachers' personal confidence in their use of technology had

grown, although they realised there was more to learn. Prior to the professional

development, this group of teachers was lacking a set of technology skills. In addition, the

qualitative data highlighted their anxiety about what they were unable do to support their

students through their teaching.

The standout finding was that teachers' perceptions of their confidence in using

technology increased following short, targeted professional development sessions with

personal coaching. This provided teachers with a new set of skills that empowered them to

use mobile technologies in their teaching practice. The post-PD TPACK survey results

suggested, and this was supported by the interpretation of interview data, that teachers

were increasingly aware across time that the domain of TK is much larger than they first

thought, and therefore, it is not surprising that teachers' self-reporting found that TK did

not change from pre to post survey. It was apparent that teachers recognised that there was

significantly more TK to be acquired, and their existing high levels of CK and PK were

supplemented by an increase in their TCK, and their TPK. The professional development

resulted in a positive impact on their teaching practice reflected in their TCK and expanding

their self-perceived TPACK overall. Furthermore, teachers expressed the positive effect of

peer collaboration and development of a learning community, including the value of one-to-one technology coaching and seeking opportunities to coach others (Parrish & Sadera, 2020; Van Ostrand, et al., 2020).

5.3   Paper Three Findings

Paper Three sought to define digital transformation in education and synthesize digital transformation frameworks to provide guidance for education leaders ready to embark on transformational change. Digital transformation in industry was found to be well defined. Applying a definition for education was attempted in this paper, with the following recommended:

> Digital Transformation in education can be defined as a realignment of, or new investment in, education models utilizing digital technology to more effectively engage students, teachers, parents and leaders at every point in the students' schooling journey with new student information systems, personalized experiences and analytics. (Paper Three, p. 105)

Building on the theme of identifying needs, a qualitative thematic analysis of 65 organisations was undertaken, and 27 organisations were identified for further analysis (see Table 1, Paper Three, p. 98). This study identified and interpreted patterns of themes and subthemes to form components that can constitute a digital transformation framework (see Table 2, Paper Three, p. 100) in order to guide education leaders embarking on change.

The findings revealed four digital transformation themes: *leadership, people, experience,* and *technology*; these were then underpinned by fifteen subthemes (see Table 2, Paper Three, p. 100). The results identified the diversity and complexity of the themes, and the breadth of stakeholder engagement required to conceptualise digital transformation. No individual organisation reviewed provided a complete framework or message that could translate easily into education needs or could define digital transformation in education. Further to this, "digital transformation" was not a term used

within Ministries of Education. Review of organisations indicated the impetus for embarking on digital transformation were wide and varied including political, economic, social and technological; this finding is supported by Gobble (2018), Kane (2019), OECD (2019) and Riemke-Gurzki (2017).

Key findings for guiding digital transformation success included the need for a compelling leadership who can communicate a rich and urgent change story with a shared vision and a well-funded strategy that extends beyond technology. This is followed by consideration of the people who will be impacted within the organisation. Findings guide leaders to consider the needs, talents and context of their community to create an environment of trust, coherence and empowerment. Implementing change methodologies with human resource development that supports more than just the new tactical attributes and skills required, but also the personal journey of each member of the community is another critical consideration (Allas, et al., 2019).

5.4   Synthesis of Findings

This thesis affirmed that defining a clear strategy and identifying the needs of stakeholders (students, teachers, parents, school and system leaders) are key first steps when adopting new innovations or embarking on transformative initiatives in education, providing valuable insight into change management focal points.

Applying a constructivist philosophy to identify personal needs, addressed through customised professional development could produce positive outcomes beyond increasing confidence in the use of technologies, to include deeper collaboration with peers and building capacity for a sustainable professional learning community. This constructivist approach of identifying needs by learning in an active, engaged process created the necessary knowledge to design and implement customised professional development for

teachers. Professional development provided teachers with opportunities to construct knowledge individually, or with a coach, and to work in small collaborative groups to reflect on their technology implementation. A connectivist approach can encompass diversity of opinion and the process of connecting specialised nodes or information sources. Examples of these connections included hospital teachers, students' regular school, the coach, and researchers to help form a mobile learning strategy and professional development. Other nodes included external organisations such as Ronald McDonald House of Charity.

This thesis found that established frameworks could provide authoritative, evidence-informed guidance for school leaders and teachers to introduce technology initiatives such as mobile learning, and for system leaders introducing system wide digital transformation. This is supported by Dimmock (2016), who suggests schools need coherent, holistic frameworks for informed decisions. The findings show different frameworks have different purposes. For example, to support specific innovations such as integrating technology and digital pedagogies, success has been established using various educational frameworks (Maor, 2017), including TPACK (Koehler & Mishra's, 2009) and 21st century skills (Kereluik, et al., 2013; Koh, et al., 2015). These frameworks were employed to provide evidence in Paper One and guidance in Paper Two for designing effective professional development (Dimmock, 2016; Reichert & Mouza, 2018; Yurtseven Avci, et al., 2019). Similarly, existing digital transformation frameworks can provide guidance for education leaders who have made the decision to move beyond introducing siloed technology innovations to embark on transformative change. Such digital transformation frameworks express a diversity and complexity of critical components and definitions for digital innovation and transformation.

This thesis revealed pitfalls in implementing digital innovation or transformation initiatives, and practices that underpin success. The hospital school study established that

identifying needs, customising professional development, and engaging a coach can generate impetus for teachers to adopt new initiatives with the added benefit of developing a learning community. Empowering people, at the school or education system level, is a critical factor when envisioning successful change, and recognising that the main barriers to transformation can be lack of confidence, sometimes perceived as resistance (Creasy, 2018). Identifying change drivers as well as barriers to introducing technology initiatives assists leaders in developing a coherent strategy that is scalable and sustainable.

The findings are supported by the literature that emphasises: effective *leadership* is a critical component to drive successful change (Feehan, et al., 2019; Kruschwitz, 2016), the importance of a change management process that considers the *people* (Darling-Hammond, 2017; Galli, 2018; Kane, 2019), and delivering *experiences* that include personalisation of services (e.g., inclusion, accessibility, coaching), and spaces (e.g., classroom) (Carvalho & Yeoman, 2018; Hagel, et al., 2019). Additionally, *technology* should not be considered the main driver of change, but rather a digital platform that includes personalised information services, such as devices and education apps for teachers, available anywhere anytime. Underpinning this digital platform are *people* with the technical capabilities and certifications to ensure governance, privacy, security, and ethical advanced analytics are implemented and managed to safeguard students.

CHAPTER 6: DISCUSSION AND FURTHER RESEARCH

This chapter begins with a review of the insights and strategies that this study revealed, and the theoretical frameworks used. Future research that could contribute to the limited and evolving literature on the emerging issue of how to successfully approach digital innovation and transformation in education will be examined. Finally, implications and recommendations for school and education system leaders as they implement digital initiatives and wider education transformation agendas are outlined.

6.1   Insights and Strategies

This thesis considered digital technologies through the lens of teachers, education system leaders, policy advisors, and Ministers of Education, who seek guidance when implementing digital initiatives or embarking on digital transformation. Introducing transformational change can have challenging implications for practice from the perspective of a unique context, such as the hospital school in this study, to a large education system, such as the Ministries of Educations presented in Paper Three, who plan to deliver on their digital vision and strategies.

Kane's (2019) assertion that "The most successful digital transformations start with a shift in mindset at the employee, leadership, and organization levels" (p. 48) encapsulates how consideration of *people* prior to the transformation process is critical. As presented in Paper Three, all organisations reviewed expressed *leadership* as the most important digital transformation theme. Once leaders have made the decision to embark on a transformative journey, communicating a rich change story to stakeholders with emaphsis on why the organisation is changing is an essential strategy. This critical step is designed to maximise engagement and is a fundamental component for success. The leadership team of the hospital school in this study communicated a vision and a purpose to teachers and the

hospital community as they implemented a mobile learning strategy. This strategic approach is supported by Cortellazzo, Bruni and Zampieri (2019) who advise that when developing a "digital culture", leaders must promote a collaborative process and engage with stakeholders. Successful change strategies include the critical component of identifying the needs of employees to be confident in participating in the change process with the required knowledge, skills and attributes, and recognition of prior experience.

6.2   Theoretical Frameworks

The theoretical concepts of constructivism and connectivism were used in combination to investigate the needs of teachers implementing mobile learning initiatives in a hospital school, and the critical components and considerations of digital transformation in an educational setting to achieve knowledge construction (Richardson, 2003; Creswell, 2012; Creswell & Guetterman, 2019). The role of constructivism in education is well researched, and discussed in this thesis as it relates to teachers' developing individually and in small groups their technological and pedagogical knowledge based on their needs to teach in the unique learning environment of a hospital school. Connectivism is a relatively new concept important for understanding how we consider digital technology initiatives in education (Siemens, 2017).

Connectivism represents how nurturing and maintaining connections is needed to facilitate continual learning. The positive impact of a professional development coach, or "content expert" (Goldie, 2016; Van Ostrand, et al., 2020), to help develop the knowledge and skills teachers need to feel confident in their use of mobile technologies, for example, demonstrates connectivism in action. Connectivism is further exemplified in the hospital-based study in this thesis when knowledge was prompted by learners connecting to, and participating in, a learning community (Kop & Hill, 2018). Semiens (2017) suggests

connectivism begins with the individual and the connections they form that are needed to facilitate up-to-date and ongoing learning, including skills required in the digital era. The theory of connectivism complements constructivism by addressing learning that is increasingly impacted by technology.
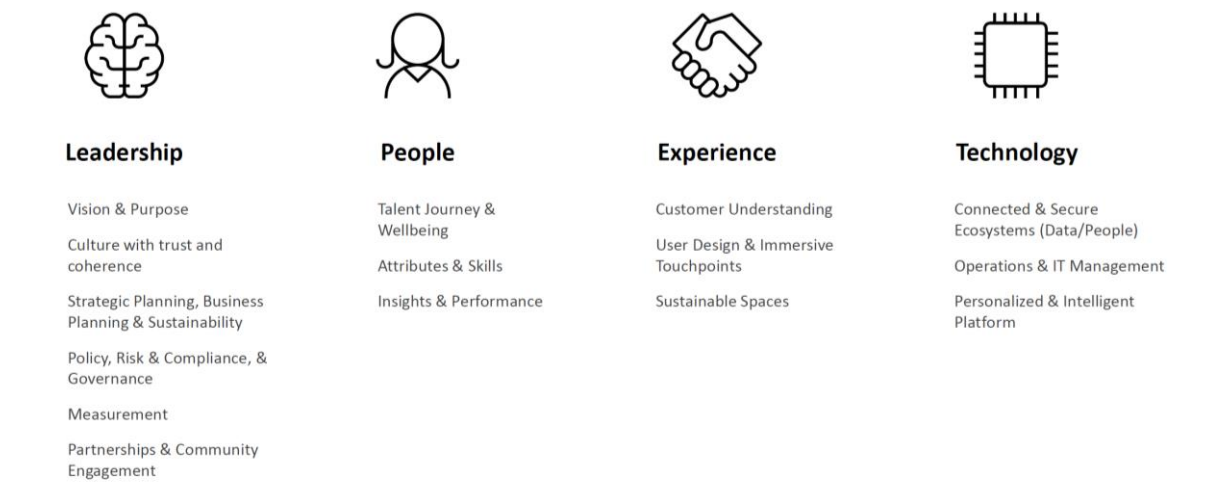
6.3   Future Research

Future researchers should recognise that existing research relevant to digital initiatives and transformative efforts is potentially outdated due to the constantly evolving nature of technology innovation. Goldie (2016) suggests "accurate, up-to-date knowledge (currency) of information is the aim of all connectivist learning activities" (p. 1065), therefore, education leaders and education policymakers require current and timely research. When considered in tandem with academic research, industry reports can provide the up-to-date knowledge required to support education leaders decision making. There is potential advantage in undertaking a synthesis of academic research and transparent independent industry research reports to strengthen approaches to digital transformation, particularly in the area of leadership and strategy development, people and human resources, technology and experience.

Research is needed to understand the specificities of each digital transformation theme identified in Paper Three, and illustrated in Figure 2, such as how can the themes be placed within a framework that is scalable for a school or a system of schools.

Figure 2

Digital Transformation themes and subthemes.

Leadership	People	Experience	Technology
Vision & Purpose	Talent Journey & Wellbeing	Customer Understanding	Connected & Secure Ecosystems (Data/People)
Culture with trust and coherence	Attributes & Skills	User Design & Immersive Touchpoints	Operations & IT Management
Strategic Planning, Business Planning & Sustainability	Insights & Performance	Sustainable Spaces	Personalized & Intelligent Platform
Policy, Risk & Compliance, & Governance			
Measurement			
Partnerships & Community Engagement			

For example, the attributes and skills of teachers (people) participating in the hospital-based study were positively impacted by customised professional development, access to personalised coaching, and supporting frameworks. The success of the professional development program and coaching in this study resulted in the hospital school leadership inviting teachers to be coaches themselves. This raised the question: What are the skills and attributes needed to be a digital coach? Furthermore, educational models not referenced in this study could be considered in future studies, such as the Technology Integration Matrix (TIM) which helps guide the complex task of evaluating technology integration in the classroom including the role of coaching (Florida Centre for Instructional Technology, 2020). Such a model could have further supported the hospital school mobile technology strategy in providing opportunities for teachers and coaches to develop their skills online, in collaboration, and with exemplars of best practice. Analysis of successful digital transformation and supporting frameworks also revealed a requirement for teachers to be provided a personal and career journey, that included a focus on their wellbeing that was underpinned with insights and performance. Further research may benefit educational

decision makers and leaders as they develop their human resource policies and prepare for organisational change.

Technology in education literature, such as mobile learning and theoretical frameworks, is well defined and can support the currently limited digital transformation in education research, from mobile innovation for classroom teachers to system wide digital transformation. As researchers investigate how these disruptive technologies are impacting education, there is a need to consider system wide approaches as well as the often specialised, or limited participant studies that are restricted to the classroom, or a subset of students such as hospital schools, or a particular application like virtual reality. In conclusion, this thesis raises the need for further research on how digital transformation in education intersects with the theories of constructivism and connectivism in response to the digital age.

6.4   Implications and Recommendations

As digital transformation in many societies is outpacing its uptake in education, guidance and examples of best practice to enable education leaders to achieve their transformation goals is essential. Furthermore, digital transformation is a process with no defined endpoint; thus it is imperative for education leaders to respond to the continuous and rapid emergence of new digital innovation. Education leaders and education policy makers require guidance based on current and emerging trends to inform their decision making.

It is recommended that system leaders and policy advisors, responsible for implementing digital transformation, consider the strategic and business planning required for successful preparation. The financial implications of digital transformation and change initiatives require prioritisation of precious resources, with the need to justify investments

(e.g., a mobile learning device for every child). Redefining government budget allocations for digital transformation in education is required and may include how private and public partnerships come together. Sustainable funding, such as tax benefits for those providing their child a mobile device for learning, or utilising publicly owned infrastructure (internet), technical services (IT support, security), and personnel (human resources), can be considered.

The identified digital transformation themes and subthemes in this thesis are suggestive and could be subdivided differently. However, it is recommended that a digital transformation education framework be established that places people first within the change process. When developing strategies to support people while implementing transformative initiatives in education the use of educational models with a focus on integrating digital tools with pedagogy, such as TPACK (Koehler & Mishra, 2009), 21st century skills (Kereluik et al., 2013; Mishra & Kereluik, 2011), or Technology Integration Matrix (Florida Centre for Instructional Technology, 2020) is recommended to achieve digital transformation success for teachers and students in the classroom. Furthermore, this thesis proposes that connectivism be considered together with constructivism, as a general philosophy of education in the digital age.

As schools and education systems increasingly engage in digital initiatives, defining digital transformation in education for each organisation is recommended to remove ambiguity about the vision and reason for implementing change. This can be applied regardless of the scale of change, whether it be mobile innovation for classroom teachers or system wide educational digital transformation. Imagining, then defining transformative change enabled by digital innovation and how it can be implemented presents an

opportunity to ground a digital transformation framework for education that encompasses the needs and themes identified in this thesis.

Finally, this thesis recognises education system leaders are under pressure by political leaders to respond to economic, social, political and cultural changes (OECD, 2019). The challenge for education systems is to develop and maintain the knowledge, skills and attributes required for a well-trained teaching workforce engaged in preparing students with knowledge and future-skills (European Commission, 2018; Grundke, Marcolin, Nguyen & Squicciarini, 2018) required to become active and productive members of their communities.

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LIST OF APPENDICES

Appendix A: Organizations and Education System Websites

Consulting Organizations	Websites
Accenture	https://www.accenture.com/
Cap Gemini	https://www.capgemini.com/resources/understanding-digital-mastery-today/
Deloitte	https://www2.deloitte.com/global/en/insights/topics/new-digital-transformation.html
EY (Ernest Young)	https://www.ey.com/en_gl/digital
Forrester	https://go.forrester.com/digital-transformation/
KPMG	https://assets.kpmg.com/content/dam/kpmg/ch/pdf/ch-digital-transformation-services-en.pdf
McKinsey & Company	https://www.mckinsey.com/
MIT Sloan Management Review	https://sloanreview.mit.edu/
The Boston Consulting Group	https://www.bcg.com/industries/education/k12-transformation-framework.aspx
Technology Organizations	**Education Websites**
Apple	https://www.apple.com/education/
Cisco	https://www.cisco.com/c/en/us/solutions/industries/education.html
Google	https://edu.google.com/
IBM	https://www.ibm.com/industries/education
Intel	https://www.intel.com/content/www/us/en/education/intel-education.html
Microsoft	https://www.microsoft.com/en-us/education/etf
Education Organizations	**Websites**
Consortium for School Networking (COSN)	https://www.cosn.org/
Educause	https://www.educause.edu/
Organisation for Economic Co-operation and Development (OECD)	http://www.oecd.org/
World Economic Forum (WEF)	https://www.weforum.org/
Aurora Institute, formerly known as International Association for K-12 Online Learning (iNaCOL)	https://www.inacol.org/
Education Systems	**Websites**
Finland (Finnish National Agency for Education)	https://www.oph.fi/en
Malaysia	https://www.moe.gov.my/
Myanmar	http://www.moe.gov.mm/en/
New Zealand	http://www.education.govt.nz/
Singapore	https://www.moe.gov.sg/education/education-system
United States of America	https://www2.ed.gov/about/reports/strat/plan2018-22/strategic-plan.pdf
United Arab Emirates	https://www.moe.gov.ae/En/AboutTheMinistry/Pages/MinistryStrategy.aspx

Appendix B: Pre-PD and Post-PD TPACK survey

**Professional Development and Mobile Technologies | Hospital School Study
Teaching and Technology Self-Assessment Survey**

Thank you for taking the time to complete this questionnaire. Please rate each statement to the best of your knowledge. Your thoughtfulness and candid responses are greatly appreciated. Your individual name or identification number will not be, at any time, associated with your responses. Your responses will be kept completely confidential and will not impact on your own work.
Please rate each statement to the best of your knowledge based on your teaching in the hospital school context.

1. Strongly disagree **2**. Disagree **3**. Neither agree nor disagree **4**. Agree **5**. Strongly-agree

Technology Knowledge

1. I keep up with new technologies.

2. I have the technical skills I need in order to use the technology for my teaching.

3. I use Web resources and social networks (twitter and face-book) for teaching.

4. I use e-books for teaching purposes.

5. I use mobile technologies to benefit student learning, communication and collaboration.

6. I use various learning systems to deliver instruction (e.g., Edmodo, Blackboard, Moodle).

7. I troubleshoot technical requirements associated with mobile learning (e.g., selecting wireless networks, downloading from the App store).

Content Knowledge

1. I have sufficient knowledge about my content area (name it).

2. I find and adjust appropriate resources for the individual content I teach.

3. I create learning materials or appropriate resources for the individual content I teach.

4. I decide on the scope of concepts taught within my content area.

5. I have various strategies of developing my understanding of my content area.

6. I am teaching in the content area that I was trained in.

7. I have an awareness of the learning theories that inform my content area.

Pedagogical Knowledge

1. I adapt my teaching style to different learners.

2. I practice an inquiry based approach in my teaching.

3. I use a wide range of teaching approaches in an individual or group setting.

4. I use a variety of teaching strategies to relate various concepts to students.

5. I moderate collaboration among students in an offline-learning environment.

6. I adjust teaching strategies based on student performance and feedback.

7. I feel comfortable moving between online and offline teaching with my students.

Pedagogical Content Knowledge

1. I assist students in making connections between various concepts in unit material.

2. I select effective teaching approaches to guide student creativity and innovation in my content area.

3. I determine a particular strategy best suited to teach a specific concept or content.

4. I anticipate students' likely misconceptions within a particular topic.

5. I produce lesson plans and projects that support collaboration and communication.

6. I practice inquiry-based approaches in my content area.

7. I promote problem solving and critical thinking in the learning area.

Technological Content Knowledge

1. I use relevant and authentic content using mobile technology applications.

2. I use social media to teach a specific content.

3. I create digital resources that map to a specific unit of competency.

4. I use technology applications (Keynote, Power Point, Apps, etc.) to demonstrate specific concepts in my content area.

5. I use technology to create effective representations of content that depart from textbook knowledge.

6. I enable students to use mobile information and learning technologies.

7. I create digital learning materials or appropriate digital resources for the individual content I teach.

Technological Pedagogical Knowledge

1. I create a mobile learning environment that allows students to build collaboratively new knowledge and skills.

2. I reflect on how information and mobile technologies can influence my teaching approaches.

3. I am thinking critically about how to use mobile technology in my online/off line teaching.

4. I adapt mobile technologies to enhance teaching approaches appropriate for my students.

5. I implement different teaching strategies using information and mobile technologies to overcome students learning in isolation, when away from their home school.

6. I build collaboration among students in an online/mobile learning environment.

7. I meet the overall demands of teaching in an ever-changing technological learning environment.

Technology Pedagogy and Content Knowledge

1. I use mobile technologies to benefit students learning, communication and collaboration.

2. I use student online assessment to modify my teaching in my content area.

3. I integrate effectively the use of mobile technologies in individual or small group settings while teaching in my content area.

4. I utilise effectively the use of social media for teaching in my area.

5. I engage students in learning via the use of interactive iBooks and Apps to teach in my content area.

6. I use mobile learning technologies to assess students' skill and understanding of a particular topic.

7. I teach and collaborate online with individuals or small groups in my content area.

Appendix C: TPACK Open-Ended Survey Questions

Survey open question:

The following question was delivered in the pre-PD TPACK survey:

- Describe a specific episode where you as a teacher demonstrated or modeled the combination of content, technologies and a particular teaching approach in a lesson. Please include in your description the content that was being taught, the technology being used, and the teaching approach(es) that was implemented.

The following question was delivered in the post-PD TPACK survey:

- As you reflect on your personal and professional development, can you elaborate on your experiences in using mobile technologies this year.

Appendix D: Teacher (1:1) Interview Questions

Teaching with Mobile Technology in Hospital Schools

Interview Questions

- How long have you been teaching?
- How long have you worked in the hospital schools service?
- What is your content area?

Current situation
- What is the current use of mobile technology in your hospital school?
- Do you use it in your work? If so, how? (i.e., smartboard; laptops; iPad; iPhone)
- What is your perception of the use of technology in hospital schools and how important do you believe technology is in the learning of hospital schools students?

Professional development
- How are teachers guided and developed in the use of mobile and learning technologies?
- How does the professional learning and development provided to you deal with the integration of technology into your learning program?
- What are your expectations on professional learning and development opportunities?
- Do you feel you have the right access to people, resources, and time?
- When is the most appropriate time for you to engage in Professional development? Before school, after school, school holidays, just in time?

Teaching
- How does using technology impact on your pedagogical decisions?
- What changes have you noticed in your teaching with the growth in technologies? What brought about these changes?
- How do you manage the use of technology by the students so they achieve the goals of the lesson/topic?
- How important are 21st century skills such as problem solving, use of technology or creativity for curriculum development and use by students?
- Do you feel you have enough access to professional literature on the use of learning technologies?
- What are your current needs in order to better integrate technologies in your teaching?
- Have you heard of the following research models, and if so:
    o Can you see how the TPACK model assists in your PD and teaching?
    o Can you see how 21st century skills assists in your PD and teaching?

Additional questions
- What have you learnt from other teachers, and from students (in relation to mobile technologies usage)?
- Is there anything that you would like to add?

Appendix E: Focus Group Questions

Teaching with Mobile Technology in Hospital Schools

Substitution

Technology acts as a direct tool substitute with no functional changes.
(A common example is a type-writer being exchanged for a word-processor (albeit with a screen) and being used in exactly the same way. No cut and paste, no spell check, just direct substitution.) OR Students print out worksheet, finish it, pass it in.

- What are some examples of technology use that you consider or have used to be considered Substitution?

Augmentation

At this level you are using the same tool with some functional improvement.
(Improvements may include the spell check or instant dictionary definition, cut/paste and placement of images etc. Already at this secondary stage we are seeing a much higher level of productivity from the individual.) or Students take a quiz using a Google Form in stead of using pencil and paper.

- What are some examples of technology use that you consider or have used to be considered Augmentation?

Modification

This level actually slightly alters (but doesn't change) the task at hand. (*For example, beforehand your type-writer was being used to produce a text report. But now we have additional technology tools available, we could create the report in a spreadsheet. This would allow you to automatically calculate sums and create graphs for immediate visualisation of the information. We may choose to email the spreadsheet to colleagues instead of printing it. Our report (previously a fixed paper document) has now seen significant task redesign. This results in substantial productivity increase.) or Students are asked to write an essay around the theme "And This I Believe...". An audio recording of the essay is made along with an original musical soundtrack. The recording will be played in front of an authentic audience such as parents.*

- What are some examples of technology use that you consider or have used to be considered Modification?

Redefinition

At this level, we look beyond ways of just modifying the process (which still has the fundamental task at its heart). Is this the best way to perform the task? The Redefinition

level will use available technology to completely redesign tasks.
(We are no longer producing a simple report. Information that would original have been compiled by an individual could now involve many contributors; collaborating in real time on the same document. An example might be to use a public document on Google Docs allowing for instant global collaboration on the project. The project could include photographs, graphics, even video, added from many different devices. Spreadsheet calculations will cascade through a document and be available for all decision makers in a moment. Immediately the task has seen the removal of multiple steps, and many more users are viewing and editing the document, increasing communication, accuracy, and productivity.) or A classroom is asked to create a documentary video answering an essential question related to important concepts. Teams of students take on different subtopics and collaborate to create one final product. Teams are expected to contact outside sources for information.

- What are some examples of technology use that you consider or have used to be considered Redefinition?
- Would you agree with this statement?
  Task redefinition can remove constraints that may have existed before but were not addressed. At redefinition the task and its outcomes are clearer, the technology becomes invisible and the learning at hand takes priority.