The digital technology components in the New Zealand Curriculum: Teachers' journey of adoption

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Abstract

Over the last century, digital technology (DT) has revolutionized our world. A digital revolution has taken hold; reshaping industries and schools, and making information, games and tools more accessible. Digital technology now has a steadfast place in our society and is changing the way we work and live. Subsequently, governments around the world are realising the benefit of digital technology and the need to incorporate it into educational curricula.

In 2020, new digital technology components (DTC) became a mandatory part of the New Zealand Curriculum technology subject area. DTC aim to create students who are not just passive users of technology, but instead students who are digital creators and understand how computers work. DTC aim to teach skills that could be considered essential in the twenty-first century, such as deeper understanding of technology, problem solving and the processes involved (TKI, n.d.b).

This research investigated teachers' adoption of DTC. Scrutinizing how DTC can be effectively integrated, the main affordances for implementation and what teachers' capabilities enable them to do. Adopting DTC was challenging for schools, as the new components encompass skills that are currently beyond many teachers' understanding of digital technologies. Therefore, the implementation of DTC can be problematic, needing to be scrutinized and unpacked by teachers as they work out how, when and where it will best fit and be integrated into existing classroom practices.

A qualitative approach to the research was adopted in this study as highly skilled teachers could struggle with DTC implementation. DTC recent establishment meant it introduced new concepts to teachers and schools and therefore a qualitative approach allowed participants to partake no matter what their current knowledge or experience of DTC. Participatory Action Research (PAR) was selected as the most appropriate research methodological approach. This approach enabled the teachers to have ownership and create lasting change, as teachers took on the role of co-researchers. The researcher also intended that participants would gain from the

research, as they developed their knowledge of DTC during their personal journeys of adoption and implementation.

The research found there were several problems in adopting DTC. Teachers articulated that professional learning development (PLD) and integration of DTC was unclear, misinterpreted and insufficient. Additionally, it was identified that teachers' confidence played an important role in DTC implementation. However, through suitable professional development sessions and successful integration teachers could build confidence and subsequently overcome several of the negative affordances associated with DTC adoption.

The agenda for completing this research lay within a belief that ICT is valuable to educational outcomes, that it should be utilised to benefit the next generation, enhancing their learning, abilities and subsequent employment opportunities. Assisting teachers in their adoption of this new curriculum and anticipating that schools and policy makers might take note of these findings is the main rationale for the research.

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Finally, I would say a big thank you to the teachers who participated in this study. Teaching is a busy and overwhelming job at the best of times. Digital technology implementation can seem like an extra load and an overwhelming task, but your willingness to participate and share your experiences was truly appreciated. Your enthusiasm to learn and embrace digital technology also demonstrates great attributes of you as a teacher and your willingness to learn - thankyou - any student is lucky to have you.

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Terms

Algorithm: “A precise, step-by-step plan for a computational procedure that begins with an input value and yields an output value in a finite number of steps” (Te Kete Ipurangi [TKI], n.d.a, para. 1)

Coding: “Coding, or computer programming, is giving a computer step-by-step commands to tell it what to do. This can include making websites, games and apps. Common coding languages include HTML and JavaScript” (TIK, n.d.b, para. 1).

Debugging: The process of identifying if there are any mistakes in algorithms, coding or programming (TKI, n.d.c).

Digital Technology (DT): “Are electronic tools, systems, devices and resources that generate, store or process data. Well known examples include social media, online games, multimedia and mobile phones” (Victoria State Government: Education and Training, 2019, para. 1).

Digital Technology Components (DTC): The new digital technology components of the New Zealand Curriculum technology subject. Specifically, two new progress outcomes (PO); Computational Thinking (CT) and Designing and Developing Digital Outcomes (DDDO) (TKI, n.d.d).

E-Learning: “learning supported or facilitated by ICT” (Ministry of Education [MOE], 2007, p. 36).

ICT: Information and Communication Technology that is; technologies that access information through telecommunications or digitally.

Programming/Computer Programming: “Coding, or computer programming, is giving a computer step-by-step commands to tell it what to do. This can include making websites, games and apps. Common coding languages include HTML and JavaScript” (TIK, n.d.e, para. 1).

Technology: “Refers to methods, systems, and devices which are the result of scientific knowledge being used for practical purposes” (Collins, 2019, para. 1).

Technology subject area: The technology subject area identified in the New Zealand Curriculum “is intervention by design: the use of practical and intellectual resources to develop products and systems (technological outcomes) that expand human possibilities by addressing needs and realising opportunities (MOE, 2007, p. 32).

Chapter One: Introduction

Preamble

Digital technology (DT) is now an integral part of the world we live in. It is ever changing, transforming the way we learn, work and live, and can be found in every aspect of our lives. Most jobs utilise a raft of DT for arduous tasks, many are automated through robotics and artificial intelligence and this development of technology might also negate the need for some professional roles increasing unemployment (Rotman, 2013). However, DT can assist in mundane and dangerous employment tasks and advancements have increased some areas of employment, with jobs that use computers tending to be higher earning roles (Bessen, 2015). The ever-increasing use of DT is having an effect and changing the face of many professional roles, such as accountancy, and subsequently training institutions need to ensure they are preparing their students for this.

Schools are recognising that students' need DT skills for their employment and to become informed citizens. Stošić (2015) identified that "educational [digital] technology has three domains of use: technology as a tutor (computer gives instructions and guides user), technology as a teaching tool and technology as a learning tool" (p.111). In this digital world, it is possible for people to take learning into their own hands and negate the need for a face to face teacher. Collins and Halverson (2018) suggested that DT integration is so important in schools, if policyholders and schools are unable to integrate DT effectively, people will start to look outside of schools for their learning. They suggested that "changes currently made by technology to learning are, in many ways, under acknowledged, marginalized, or feared by the custodians of schooling" (Collins & Halverson, 2018, p. xvi-xvii).

Prior to 2020 the New Zealand Curriculum did not have DT or e-learning as part of its key learning areas. However, it did identify that "e-learning has considerable potential to support the teaching approaches outlined" (MOE, 2007. p. 36). The

MOE (2007) also provide several examples of how ICT (Information and Communication Technology) can be used to assist traditional teaching methods and facilitate contemporary alternatives to conventional learning.

In 2020 two new digital components became a mandatory part of the New Zealand Curriculum's technology subject area. The new technology curriculum's digital technology components (DTC) encompass the creative use of DT. DTC aim to foster students who are not just passive users of technology, but instead who understand how computers work and are digital creators. DTC differs from using computers to perform tasks, such as in e-learning. Instead DTC are concerned with the process of learning about computers themselves (TKI, n.d.d). Adopting DTC might be challenging for schools, as they learn to implement and embed DTC into their practice. When examining DTC, it becomes apparent that they encompass skills that appear to be beyond many teachers' understanding of DT. Therefore, DTC implementation could be problematic, needing to be scrutinized and unpacked by teachers as they work out how, when and where, it best fits and can be integrated into classroom practice.

This research will examine three, provincial city primary school teachers and their journey of DTC implementation. Examining what DTC main affordances are for their adoption, and to see if a professional learning development (PLD) intervention can facilitate or enable implementation of DTC will be considered. The project hopes to offer new insights and a unique perspective of DTC implementation. Subsequently, findings from this study hope to aid teachers in their implementation and adoption of the new curriculum and help to ensure teachers are afforded the opportunity to successfully implement DTC into their classrooms.

Chapter Two: Literature Review

Introduction

This research project's review of literature will discuss important theoretical, conceptual, and empirical studies relevant to implementation of DTC. Firstly, this literature review will discuss the rise of DT over the last century, particularly in an educational setting. Next, effective classrooms DT integration and what this entails will be examined. This will be followed by how DT is embedded into and changing our schools, including twenty-first century learning environments and game-based learning. Subsequently, pedagogy related to DT will be examined, including several models of DT integration. Finally, an overview of the affordances and possibilities of DT for our education system will be explored.

The Technology Revolution

The very first computer was developed in the late nineteenth century, by mathematician Charles Babbage known as the "Analytical Engine" (Freiberger & Swaine, 2019, para. 1). The twentieth century was an extraordinary time of evolution for DT and often referred to as the "Digital Revolution" (Merritt, 2016, p.15) or the "Third Revolution" (Merritt, 2016, p. 15). The first general purpose computers were produced in the 1940s (Freiberger & Swaine, 2019). However, most schools only used computers for administration (Murdock, 2014) up until the 1980s and 1990s when schools started buying computers for students use (Purdue University, 2019). By 2008 93% of classrooms had computers for students and an average ratio of 5.3 students to computers (National Centre for Education Statistics, 2010).

Preliminary uses of DT tended to impersonate that of traditional techniques such as; using word processing to write letters instead of paper. However, in the early twenty first century digital technology, particularly the World Wide Web (WWW), was seen as more than just a passive tool for storing and transferring information from one place to another (Brown, 2000). One of the fundamental realisations of the

WWW, was that unlike traditional mediums that provide information or push information to us, WWW is an intricate source of information that is both push and pull. That is, we can draw information to us like traditional sources, but we can also push or upload our own multimodal information (Brown, 2000).

In the early 2000s the “Net Geners” (Tapscott, 2009, p. 2) (those born between 1977 and 1997) became the first generation who had grown up with DT to enter their adult years. Tapscott (2009) suggested that due to their lifelong immersion in DT, this generation think differently and expect different things from their predecessors; suggesting “their memorization skills have gone downhill, but omnipresent Internet access makes those less necessary. You don’t have to know all the facts anymore; you need to know how to search and evaluate what you find” (Tapscott, 2009, p. 3). Several authors suggested that changes in the brains of people who have grown up with computers, means the way we integrate and teach DT in schools also needs to change (Rosen, 2010; Prensky, 2001a; Prensky, 2001b; Tapscott, 2009). In the following section we explore how DT can be integrated into schools.

Digital Technology in Schools - What is Digital Technology Integration?

As the digital revolution took hold and the first generation grew up immersed in DT, large shifts in thinking happened. Industries and schools were reshaped by DT. Initial DT integration in education consisted of video cassettes, word processing and a general substitutive use of DT where little interaction took place and DT was used to replicate current teaching methods (Romrell, et al., 2014). However, soon schools began to use DT as an interactive tool and the pedagogy of DT started to evolve. Including professional bodies acknowledging that DT should be a fundamental, integrated part of classrooms, such as the “No Child Left Behind Act” (Ertmer, 2005).

Differing opinions on DT are rife. From leaders to teachers, and from students to parents, personal interests, opinions and preferences are abundant. What is the

correct technological balance to strike? Before we can consider what DT should or should not look like in our schools, it is important to understand what DT integration is, how it is currently being used in the classroom, and how it is embedded within the New Zealand Curriculum.

What is DT integration? There are different interpretations and terminology, and an array of research on DT and its integration (Hamilton, 2007; Hunter, 2015; Kimmons, 2018; Reigeluth & Joseph, 2002). DT tends to be dissimilar to other subject areas because it is so new and quickly evolving, whereas other subject areas have been part of society for many decades. Acceptable DT integration of today is not the same as fifteen years ago and will probably be vastly different in fifteen years' time.

Schools' DT integration could be viewed simply as the use of DT in a classroom. However, the idea of DT integration can be far more complex with a variety of suppositions. Hunter (2015) defined DT integration as a process where computers are *included* in teaching. Kimmons (2018) suggested DT integration is a "meaningful implementation of DT in educational settings to achieve learning goals" (para. 1). Whereas, Hamilton's (2007) ideas were somewhat more complex defining DT Integration as "when classroom teachers use DT to introduce, reinforce, extend, enrich, assess, and remediate student mastery of curricular targets" (p. 20). Reigeluth and Joseph (2002) also proposed that DT integration is using DT to support current teaching methods. However, they advocated for "technology transformation" (p. 9), where DT is used to transform education systems. These transformed education systems create schools that were not possible prior to DT and produce people who can work in teams, problem solve and offer diverse and meaningful contributions.

Although the above authors provide definitions of DT integration, they also articulated multifarious elements that should be considered. Hunter's (2015) simple definition was followed with categorisation that there are those doing DT integration well and others that are not; "It's not about the tools being used, but how teaching practice, when it is mindful of pedagogy and rich subject matter, can be enhanced and re-imagined when DT is used to engage students in learning" (p. 3).

Additionally, Hamilton (2007) maintained that simply using a computer to teach programming, playing games or using applications for drill practice is not integration. Instead integration is an “instructional choice” (Hamilton, 2007, p. 20) which requires teacher participation, collaboration, intentional planning and always links into other curriculum areas. Ertmer (2005) suggested that there are three conditions that need to be in place for DT integration including “ready access to technology, increased training for teachers, and a favourable policy environment (p. 25). The above definitions and explanations of DT integration appear to quantify that just using a computer is not integration and that for DT integration to be effective, it needs to be intricately interwoven with curriculum content and used to enhance students' skills and abilities.

How Digital Technology is Embedded and Changing our Schools

Although there are vast differences in opinions on how education is affected by technology, there is no doubt that DT has a steadfast place in the twenty-first century classroom and beyond. Oppenheimer (2003) asked us to question if DT has created a measurable impact on education, whilst others believed that DT needs to (and will be) the tool that revolutionises education reform (Brady, 2012; Prensky, 2001a; Prensky, 2001b; Rosen, 2010; Tapscott, 2009). Tapscott (2009) believed that current teaching methods are completely outdated, arguing that the need for mass produced information, delivered in a standard way, is no longer relevant. People can now access any information at any time, the traditional need to teach professional, factual knowledge is outdated. Computers allow individualisation of teaching with access to any required resources at any time.

The case for technologies transforming our schooling systems is found when we look at how the world around us has evolved. Even though school systems and pedagogies do not seem to have evolved substantially, the world has moved from an industrial age to an information age, as shown in Figure 1. Schools stuck in industrial age systems produce workers ready for factories and roles that are no longer part of most current employment requirements (Reigeluth & Joseph, 2002).

Key Markers that Distinguish Industrial-age and Information-age Aystems.

Industrial Age	Information Age
Standardization	Customization
Compliance	Initiative
Conformity	Diversity
Compartmentalization	Holism
Parts-oriented	Process-oriented
Bureaucratic organization	Team-based organization
Centralized control	Autonomy with accountability
Adversarial relationships	Cooperative relationships
Autocratic decision-making	Shared decision-making
One-way communications	Networking
Planned obsolescence	Total quality
Boss as "king"	Customer as "king"

Figure 1. (Reigeluth & Joseph. 2002, p. 9).

Figure 1 lists the vast changes of skills needed between the industrial age and the information age. The Information age has produced fresh needs in education, to prepare learners who can "problem-solve, take initiative, use metacognitive skills, work well in teams, and so forth" (Reigeluth & Joseph, 2002, p. 9). Castek (2012, p. 212) suggested "(digital) technology has the power to; support learning inquiry, provide access to a wealth of information, facilitate ways to share content and ideas online and extend learning experiences that prepare students for their futures". DT is changing how we work and interact with one another. The only way we can prepare the next generation for their roles in the workplace is to ensure they are adequately educated in technology. DT has made irreversible changes to the world and maybe the only thing education can do now, is ensure teachers are supported in the use of DT in the classroom (Su, 2009).

Twenty-first century skills, Innovative Learning Environments (ILE) and Modern Learning Environments (MLE) are all commonly used terms in New Zealand's education system. All include an array of teaching approaches and physical environments. But, at the core of these approaches is collaboration, flexibility,

individualisation and a focus on personal skills. These skills tend to sit outside of core subject areas such as; problem solving, critical thinking, communication and teamwork (Kay, 2010; Colvo De Mora & Kennedy, 2020; MOE, 2007; TKI. n.d.h). DT helps to facilitate the use of learning tools that were not as important in previous education models. Johnson, Adams Becker, Estrada and Freeman (2014) suggested that project-based learning, interactive, hands on learning and collaboration is far more achievable with the use of DT. DT is changing the world, including our classrooms and enabling us to attain more complex authentic life-skills (Ertmer, 2005). DT does more than enable old teachings in new ways, it can bring changes in education, the way teachers teach and develop constructivist learning environments (Su, 2009).

Another example of DT revolutionising education is the use of gaming for educational purposes. Play based education is not new, and gaming simply takes this play into a digital context. “Gamification - the integration of gaming elements, mechanics, and frameworks into non-game situations and scenarios for training and motivational purposes” (Johnson, et al., 2014, p. 38), is an important aspect that cannot be overlooked for education and student's future careers. A recent report identified that 96% of students used DT devices to access learning games (Johnson, Maguire & Wood, 2017). Games such as Mindcraft and Roblox have crossed the boundaries from entertainment to education and can be used to teach a variety of subject matter (Short, 2012). Although some teachers see gaming as “time wasting or distracting” (Bolstad, 2017, para. 3), gaming tends to motivate students to participate (Voogt, & Knezek, 2008). Gaming's full potential appears to be evolving with suggestions that gaming can be its own pedagogy, in which knowledge can be created collaboratively with a variety of abilities (Han, 2015; Hodgson 2013). Whilst the recent development of artificial intelligence and virtual reality are also expected to impact on educational possibilities. The gaming industry has seen a large growth in income each year, expecting to earn over $150 million dollars in New Zealand in 2020 (Hall, 2020). Subsequently, employment opportunities in the gaming industry are growing, as more and more industries and schools utilise gaming to engage customers and students.

The case for embedding DT into our educational system has been explored above. In the following section DTC will be examined, including how this fits into the New Zealand Curriculum's teaching and learning.

New Zealand's Digital Technology Curriculum Components.

In the 2007 revised New Zealand primary curriculum (MOE, 2007) DT was not a mandatory part of the curriculum's subject areas and instead the curriculum refers to e-learning, that is digital tools potentially supporting the current mandatory learning areas (MOE, 2007). However, in 2020 two new digital components have been added to the existing technology subject area. When any new DT is developed, it is often there to support the old way of doing things, then over time we realise it can be used in other ways and for new purposes (Reigeluth & Joseph, 2002). Several reports from Europe and America have accentuated the evolving importance of students being extended to gain a deeper understanding of computers, that there is a need for an overhaul in the education system and that DT could play a key role in this (Ertmer, 2005; Gander et al., 2013; Koh, 2015; Prensky, 2001a; Reigeluth, & Joseph, 2002; Su, 2009; Tapscott, 2009). In this part of the literature review, literature relating to both; New Zealand and countries which closely align with New Zealand digital curriculums will be identified. Next, any publications that align with DTC implementation, and therefore this study, will be discussed. The reasoning for DTC in New Zealand will be considered, with an explanation of DTC computational thinking (CT) and designing and developing digital outcomes (DDDO). Finally, consideration of teacher and school readiness to implement DTC is examined.

The New Curriculum Components

There appears to be no literature exploring New Zealand's DTC implementation in its entirety, which could be due to it only becoming mandatory in 2020. At the point of this study, the closest aligning research identifiable in New Zealand (and still being undertaken) was by Duncan, et al. (2018) who, through questionnaires, reviewed thirteen teachers' implementation of DTC CT resources and identified

relative themes. However, in contrast to this study their focus was on CT and not both components of DTC. Whilst several studies have addressed the need for DTC to be incorporated into the New Zealand Curriculum (Bell, & Duncan, 2015; Fox-Turnbull, 2018; Kellow, 2018; The work to revise the technology learning area, n.d.). An additional study by Duncan (2018) reviewed computational thinking in primary schools including; resources, how to teach primary students and what positive and negative effects there could be. However, most other New Zealand literature, seems to explore either DT and how to implement it into schools or looks at DT in education in a broad sense, exploring the advantages and hindrances (Bell & Duncan, 2015; Duncan, 2018; Duncan, Bell & Atlas, 2018; Fox-Turnbull, 2018; Kellow, 2018; The work to revise the technology learning area, n.d.).

Other curriculums around the world have similarities to New Zealand's DTC and related literature. Perhaps the DT curriculums which most closely align with New Zealand are those in England and Australia. All countries have research continuously emerging, with these curriculums also recently being developed and applied (Australian Curriculum, Assessment and Reporting Authority, n.d.; Berry, 2016; Johnson, et al., 2014; Johnson, et al., 2017; Sheffield, & Moro, 2017). A review of one hundred and fifty New Zealand and Australian computing education papers conducted by Simon, et al. (2008) identified elements entwined within DTC. Additionally, there have been several literature studies conducted and research undertaken on the implementation of Australian and English DT curriculum (Berry, 2016; Falkner, Vivian, & Falkner, 2014; Larke, 2019; Newhouse, 2017).

New Zealand's DTC aim to improve and enhance DT, providing students with essential skills for the modern workforce, to become innovative creators of digital solutions and move beyond Stošić's (2015) domains as users and consumers of DT. DTC moves to teach a deeper understanding of technology, problem solving and the processes involved (TKI, n.d.f). To do this, students need to be critical and creative thinkers and use problem solving techniques (Ramey, 2013; TKI, n.d.f). In 2018 the New Zealand Curriculum added DTC with two new progress outcomes (POs) to the existing technology curriculum, these then became mandatory in 2020. The two new POs are computational thinking for digital technologies (CT) and

designing and developing digital outcomes (DDDO) (TKI, 2018a). Like the curriculum's achievement objectives, these POs change as they align with different levels of the curriculum. Within DTC, students need to be creative, critical and reflective producers and inventors of digital concepts (TKI, 2018a). Students learn that humans are responsible for technological advancement in computers, how to be a part of this process and ensure New Zealand's unique culture is considered (Shown in Figure 2).

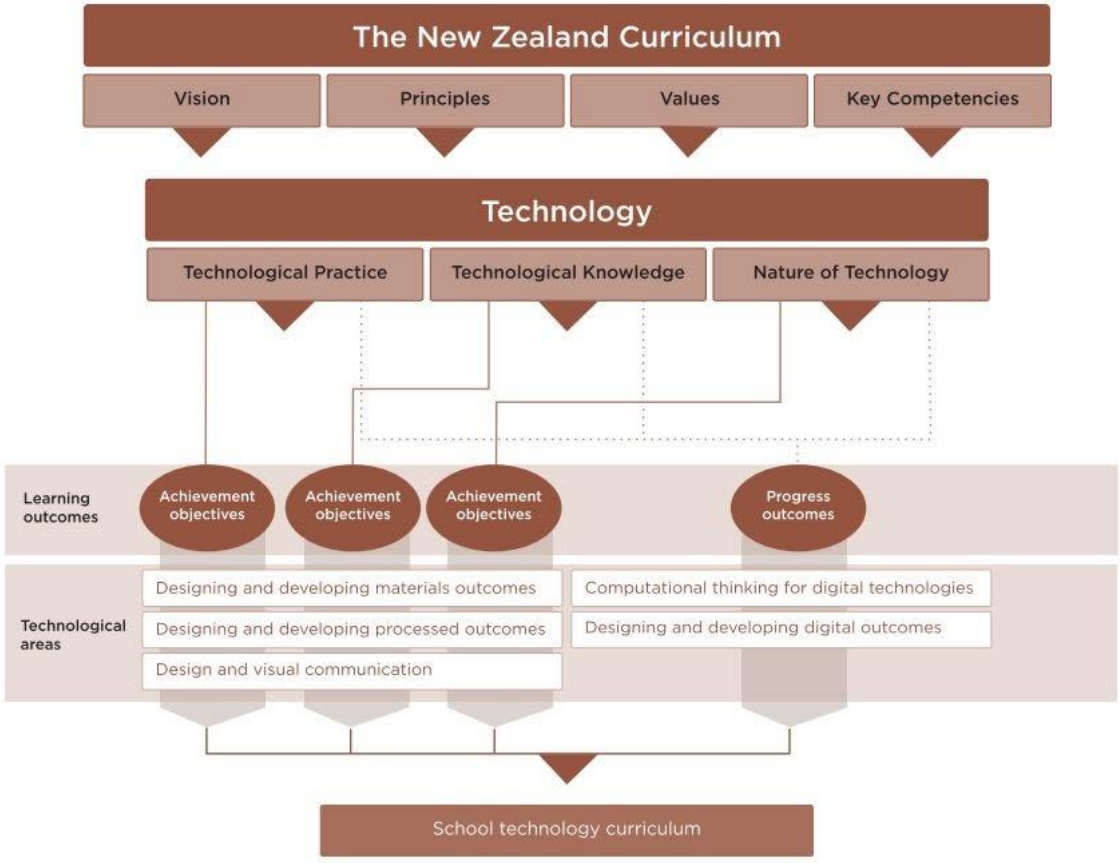

Figure 2. The new structure of the New Zealand Curriculum's technology learning area, where two additional Progress outcomes have been added to the existing three achievement objectives (Ministry of Education, 2017b, p. 7).

Computational Thinking

CT is a "specific thought process involving formulating problems and solutions" (Mindlab, 2019a, 10:32) and encompasses several aspects:

- “Express problems ...and formulate solutions.
- Algorithmic thinking... to understand computer science principles.
- Understand computer capabilities... so students can make judgements and informed decisions in the digital world.
- Learn programming concepts... to utilise computers to their full advantage and become digital creators.
- Understand how digital data can be stored... and its impact” (TKI, 2018b, para. 14-16)

The curriculum outlines eight CT POs which align to different levels of the New Zealand Curriculum (see Figure 3), which students work through between year one and thirteen (MOE, 2017b, p. 11-13). Teachers identify their curriculum level and the corresponding PO. Figure 3 shows the POs do not equally align with the curriculum levels or year levels, showing at primary school level, teachers only need to encompass CT POs one to three. Each PO can also be seen in detail in Appendix B.

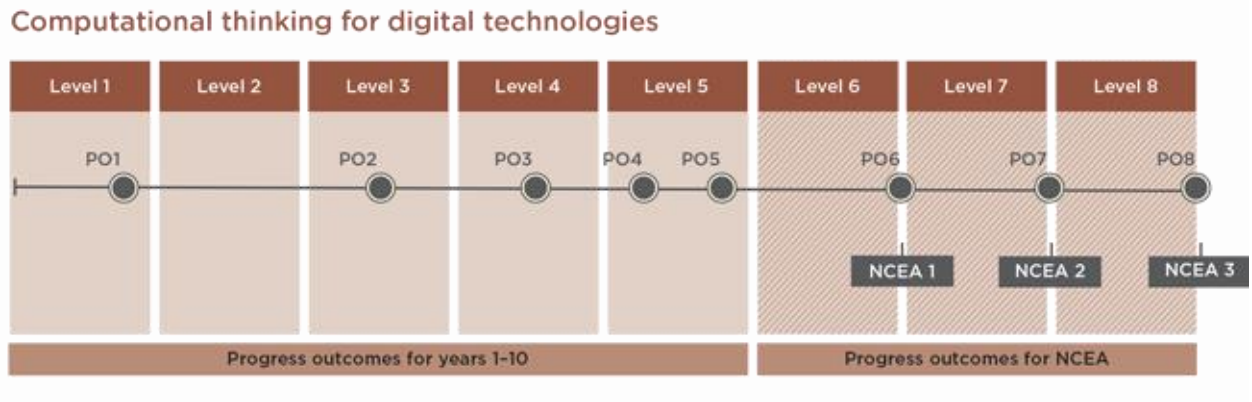

Figure 3. Progress Outcomes of Computational Thinking for Digital Technology Alignment to the New Zealand Curriculum’s Levels (TKI, 2018c, para. 4).

Algorithms or creating a set of instructions for solving a problem, are a large part of CT POs one to three. Junior students could create a sequence of steps or set of instructions, whilst senior students could use Scratch or similar, to create sequenced instructions. Debugging is also a fundamental aspect in computational thinking which is a process of checking algorithms accuracy, often using trial and error. Both should be completed without devices (unplugged) for PO one and with and without devices for PO two and three.

> CT POs 1-3 encompasses: Solving problems, designing systems and understanding human behaviour. It draws on the concepts fundamental to computer science. Does not mean sitting at a computer. Most importantly as teachers we need to understand that it doesn't matter if your students pursue medicine, farming, logistics, music, retail or sport. The future of all professions will need a deep understanding of computational thinking (Mindlab, 2019a. 9:05).

Designing and Developing Digital Outcomes

The second PO of the DTC is designing and developing digital outcomes (DDDO). DDDO is “the cycle of input and output and processing, and captures the essence of what digital devices do for us” (Mindlab, 2019b, 2:30) it also encompasses several other aspects including to:

- Understand digital applications and systems
- Develop understanding of technology people need
- Present digital outcomes
- Be aware of intellectual property issues
- Understanding of how to build and design computers
- Develop knowledge in creating digital content
- Manipulate and Share digital content (TKI, 2018d, para. 16)

For DDDO the curriculum outlines six POs shown in Figure 4, which students work on until year thirteen. Again, these do not align equally with curriculum or year levels and each PO can also be seen in detail in Appendix C.

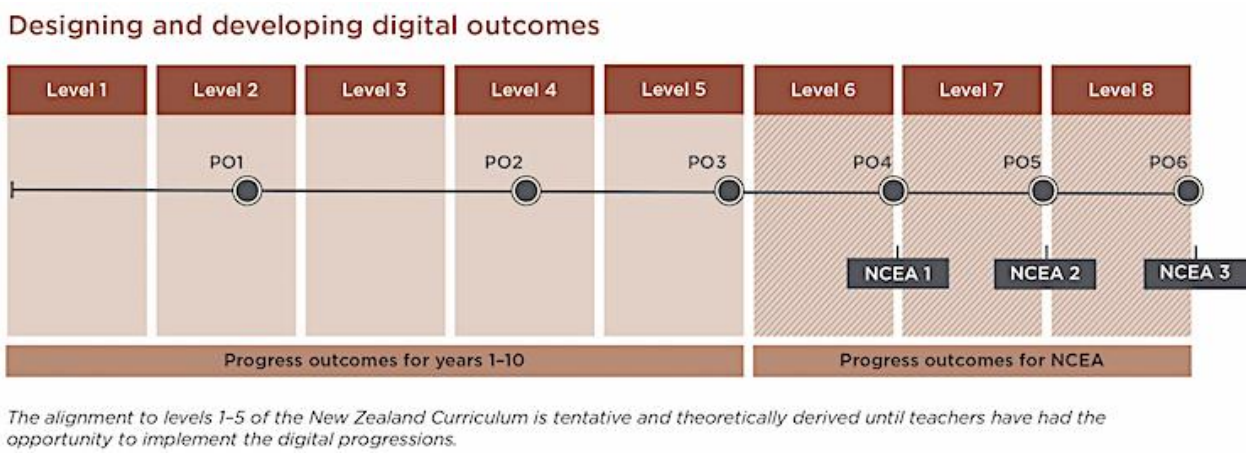

Figure 4. Designing and Developing Digital Outcomes (TKI, 2018d).

At primary school level there is only one PO that teachers need to include from curriculum level two.

> DDDO: Progress Outcome 1:
> In authentic contexts and taking account of end-users, students participate in teacher-led activities to develop, manipulate, store, retrieve, and share digital content in order to meet technological challenges. In doing so, they identify digital devices and their purposes and understand that humans make them. They know how to use some applications, they can identify the inputs and outputs of a system, and they understand that digital devices store content, which can be retrieved later (TKI, 2018d, para. 20).

Many of DTC POs link into other curriculum areas; algorithms link into both numeracy and literacy, whilst DDDO requires reading and processing skills, as well as art and science concepts. Additionally, many of the key skills needed in all these areas link into the New Zealand curriculum key competencies and values (MOE, 2007, p. 12).

Teacher's Readiness for DTC Implementation

Here, a brief explanation unpacks DTC and what they entail. This literature review has also highlighted the need for these DT components to be added to the

curriculum. However, will teachers have the required knowledge and skills to implement DTC? In 2018, New Zealand's Education Minister announced $38 million had been allocated to aid teachers with DTC implementation (Hipkins, 2018). Funding to access personalised PLD is through a process of application, where schools justify their needs based on their current levels of understanding and implementation of DTC and DT, whilst additional generic resources include web sites (MOE, n.d.). However, a recent paper has raised concerns over teachers' DTC readiness and content knowledge (Crow, Luxton-Reilly, Wünsche, & Denny, 2019) and in 2019 the Education Review Office (ERO) released a report which stated:

> Only seven percent of all schools reported they had quite a good understanding, and enough knowledge and skills to start to implement the DT curriculum content. The majority (88 percent) felt somewhat prepared. All schools that had teachers who understood the DT curriculum content quite or very well had provided support to those teachers. Most teachers who did not understand the DT curriculum content were in the schools that had not provided any support to their teachers...Over one-third (38 percent) had no understanding at all. There is clearly development work to be done in this area (ERO, 2019, p. 16).

Although 88% felt somewhat prepared, we could consider this is subjective and possible some schools' understanding of what DTC entails is perhaps not precise. Furthermore, since the release of this report the MOE has claimed there have been improvements (Gerritsen, 2019). However, the president of the Principals' Federation has expressed a varying degree of readiness around DTC, suggesting PLD around DTC was insufficient, as it was not readily available to all schools (Cormick, 2019). ERO (2019) also highlighted the need for teachers to understand the curriculum first and foremost. However, teachers' understanding of DTC might also be heavily linked to pedagogical approach, which is considered in the following section.

Pedagogy

There is often pressure for educators to provide an environment that enhances DT skills and fosters a complementary pedagogy. As discussed above, many of the skills needed for quality education in the twenty-first century include those that contribute to a world embedded with technology. Skills enabling participation in a DT driven future, are skills to promote understanding of DT creation and subsequently help DT evolve (Harris, 2007). Several authors have proposed DT integration is only effective when embedded with curriculum content and pedagogy (Aslan & Reigeluth, 2013; Hamilton, 2007; Hunter, 2015; Reigeluth & Joseph, 2002). Research over the last ten years attests that DT content is equally as important to the DT medium (Safar & AlKhezzi, 2013). A School principal speaking to teachers at a staff development meeting in Sydney suggested “(It) is the pedagogy that matters. Don't get carried away with thinking you have to know how every computer or every software program works” (as cited in Hunter 2015, p. 12). Suggesting that the pedagogical approach could be more important than teachers being experts at DT.

As DT evolves, so too does its associated pedagogy. Several authors and studies suggest the most effective pedagogy for DT integration is constructivism (e.g., Ertmer, 2005; Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012; Safar & AlKhezzi, 2013). Constructivism puts the student at the centre of their learning, where learners construct their own learning from their experiences. There are three main concepts associated with the constructivist approach to teaching; firstly, the learner constructs their own knowledge (it is not transmitted by the teacher), secondly knowledge is made from actively participating and interacting with others. Thirdly, although anyone can share their opinions and beliefs, it is all personalised to individuals, based on their own personal experiences and can never be experienced identically by others (Calvert, 2001; Mustafa & Fatma, 2013). Calvert (2001) offered three ways DT can support this approach to learning “(DT as) vehicles for exploring knowledge and solving real-world problems, a method of collaboration and communication with others and a partner for assisting students in sharing what they know” (p. 46). Many people construct their own knowledge

through the internet, teaching themselves an array of skills from experts on YouTube and other sites. Presently, this is considered an effective way to learn, so why not utilise and develop these skills at school? Effectively utilising the internet in classrooms enables us to individualise learning and shift the responsibility from teacher to learner, with a student centred or inquiry approach (Landis, 2008).

Other pedagogies have also been suggested to effectively embed DT. Such as Safar and Alkhezzi's (2013) *blended* approach to learning and Reigeluth and Joseph's (2002) *learning-focused* paradigm. Safar and Alkhezzi's (2013) research found that a blended approach to learning - one that uses both DT integration with traditional learning methods - with constructivist foundations, created students who were more motivated and gained better grades. These findings were also in-line with several other research projects (Abdel-Maksoud, 2019; Ahmad, Shafie, & Janier, 2008; Delialioglu, 2012; Dewiyani Sunarto, Hariadi, Jatmiko & Sudarmaningtyas, 2019; Hadiyanto, 2019). Others advocate for a learning-focused paradigm which meets educational needs through individualisation rather than the current homogenised model of education (Reigeluth & Joseph, 2002). In this pedagogical approach the teacher is a facilitator who allows students to move at their own pace, based on their own personal mastery of concepts. Although these approaches are possible without DT, DT integration makes them more achievable and personalised.

Models of Digital Technology Integration

Embedded within the pedagogies associated with DT integration, are several models of integration. In this section, an overview of several widely recognised models of DT integration will be identified. Considering these models of integration and their links to the curriculum and DTC, an overview of each is provided. Finally, several other models are identified which build on or are like the widely recognised models.

Two widely known DT integration models are frequently used in New Zealand; Technological Pedagogical Content Knowledge (TPACK) (Koehler & Mishra, 2009) and Substitution Augmentation Modification Redefinition (SAMR). Several other

models also exist, though they are not as well-known, they all often have considerable cross over in ideas. For the purpose of this study, TPACK and SAMR will be unpacked. Additionally, the following other DT integration models that are used in educational fields will be examined; High Possibilities Classrooms (HPC) (Hunter, 2015); Florida Technology Integration (TIM) (REMC Association of Michigan, n.d.); Bloom's Digital Taxonomy (Churches, 2008); Replace, Amplify and Transform (RAT) (Kimmons, 2018); Passive, Interactive, or Creative and Replace, Amplify, Transform (PICRAT) (Kimmons, 2012) and Attard and Holme's (2019) Technology Integration Pyramid (TIP). It is also considered that there might be other integration models, however these were chosen due to the available literature and appeared to be the most relevant.

The TPACK framework builds on Lee Shulman's Pedagogical Content Knowledge (PCK) framework developed in the 1980s (Koehler & Mishra, 2009) and was developed by Koehler and Mishra to include DT (Reyes, Reading, Doyle, & Gregory, 2017). They believed there are three main components to effective DT integration: "contents, pedagogy, and technology" (Reyes, et al., 2017, p. 62). Maintaining the relationship between all three is at the core of TPACK and all three are equally as important as seen in Figure 5. *Contents* relates to teachers' knowledge on the subject matter, *pedagogy* is teachers' knowledge relating to the ways in which they teach, and *technology* relates to the teachers' knowledge of DT (Koehler & Mishra, 2009). Although each of these can change over time, the DT component of teachers' knowledge is likely to be evolving as technologies change over time (Koehler & Mishra, 2009). TPACK maintains that it is teachers' use of these three elements and how they interact together, that will establish how effective teaching of any concept is (Scherer, Tondeur, & Siddiq, 2017). Figure 5 shows the three overlapping elements with equal importance, when entwined, lead to TPACK.

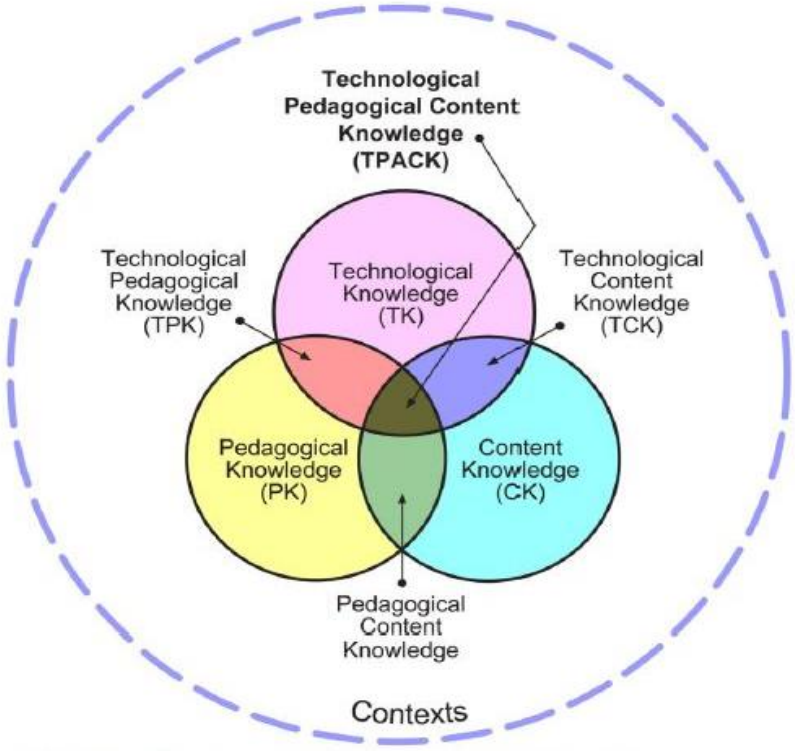

Figure 5. TPACK Framework and its Knowledge Components (Koehler & Mishra, 2009, p. 63).

Although developed around the same time, SAMR differs from TPACK as it is a continuum rather than a framework. Developed by Dr Ruben Puentedura, SAMR is a four-part process moving from “enhancement to transformation” (Hunter, 2015, p. 49). Through a SAMR lens, DT can be used with an array of depth and possibly enhance the quality of education (Romrell, et al., 2014). The SAMR model encompasses:

- ➔ “Substitution - Where DT is used to substitute a task that could have been performed without technology.
- ➔ Augmentation - DT is still used as a substitute, however there are practical enhancements.
- ➔ Modification - The task is redesigned using technology.
- ➔ Redefinition - The task would not have been possible without the use of technology.”

  (Hunter 2015; Romrell, Kidder & Wood, 2014; Walsh, 2017).

SAMR aids teachers to strive for DT tasks that sit in the redefinition domain, these tasks would not have been possible without DT and therefore they can transform education (Walsh, 2017). The SAMR continuum's modification and redefinition aspects are the most closely aligned to DTC. However, all aspects of SAMR can be found in the New Zealand Curriculum as substitution and augmentation can be seen in e-Learning guidelines (MOE, 2007, p. 36). This supports that all levels of the continuum are relevant and valuable in teaching DT and that any DT integration is important and valuable (Walsh, 2017). The continuum and real-life examples of each of these aspects can be seen in Figure 6.

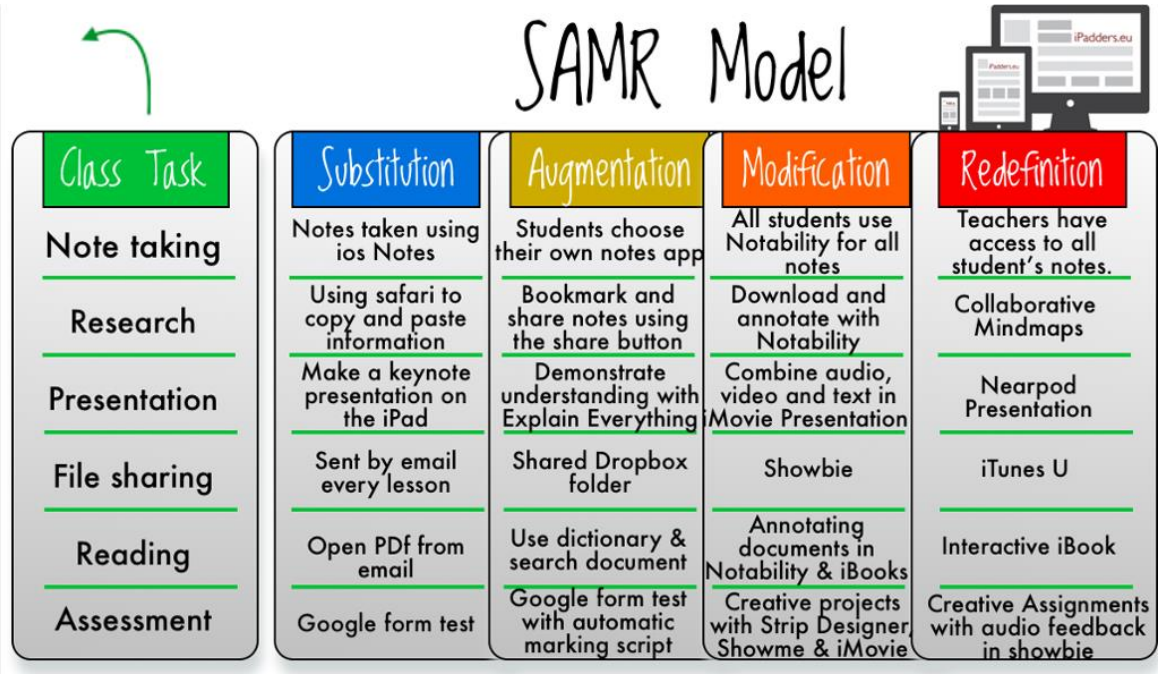

Figure 6. SAMR Model (Thinglink, 2015).

Perhaps the fast-moving nature of DT warrants continuously evolving and new models of integration. Several other models identified draw similarities to SAMR including: Bloom's Digital Taxonomy, TIM, RAT and PICRAT.

Like SAMR, Bloom's Digital Taxonomy links to the curriculum's key competencies (MOE, 2007, p. 12). Bloom's Digital Taxonomy has a variety of levels from knowledge through to evaluation and moving through these levels leads us to a greater depth of DT understanding (Churches, 2008; Meyer, 2010). Bloom first developed his Taxonomy in the 1950s, it was revised in 2000 and later by Andrew

Churches (2008) who took the Taxonomy and applied it to the ever-changing technological world, creating Bloom's Digital Technology (Lightle, 2011). Later Churches (2008) added new digital verbs to the six levels of the taxonomy and a separate collaborative section (see Figure 7).

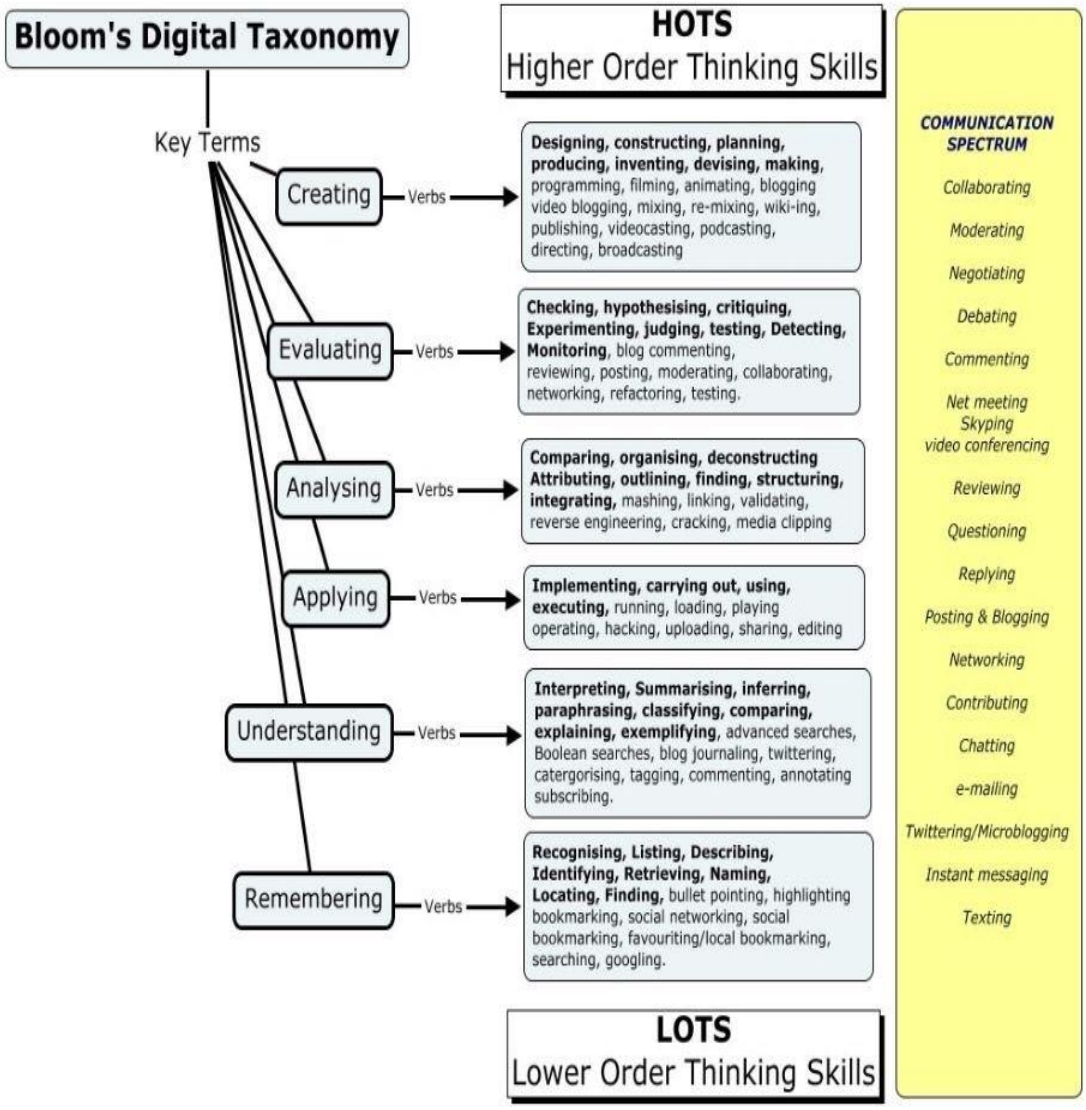

Figure 7. New digital verbs added to the six levels of Bloom's Taxonomy to create Bloom's Digital Taxonomy (Churches, 2008, p. 6).

TIM was created in 2006 by the Florida Centre for Instructional Technology and the Florida Department of Education (Welsh, Harmes, & Winkelman, 2011). Drawing together a range of elements to create best practices in teaching and meaningful DT integration; the framework was "created to be a comprehensive framework for

evaluating DT integration in instructional settings" (Welsh, et al., 2011, para. 3) and designed for teachers to identify how to use DT tools meaningfully. TIM has parallels with SAMR, though presents a far more multifaceted perspective, shown in Figure 8 (REMC Association of Michigan, n.d.).

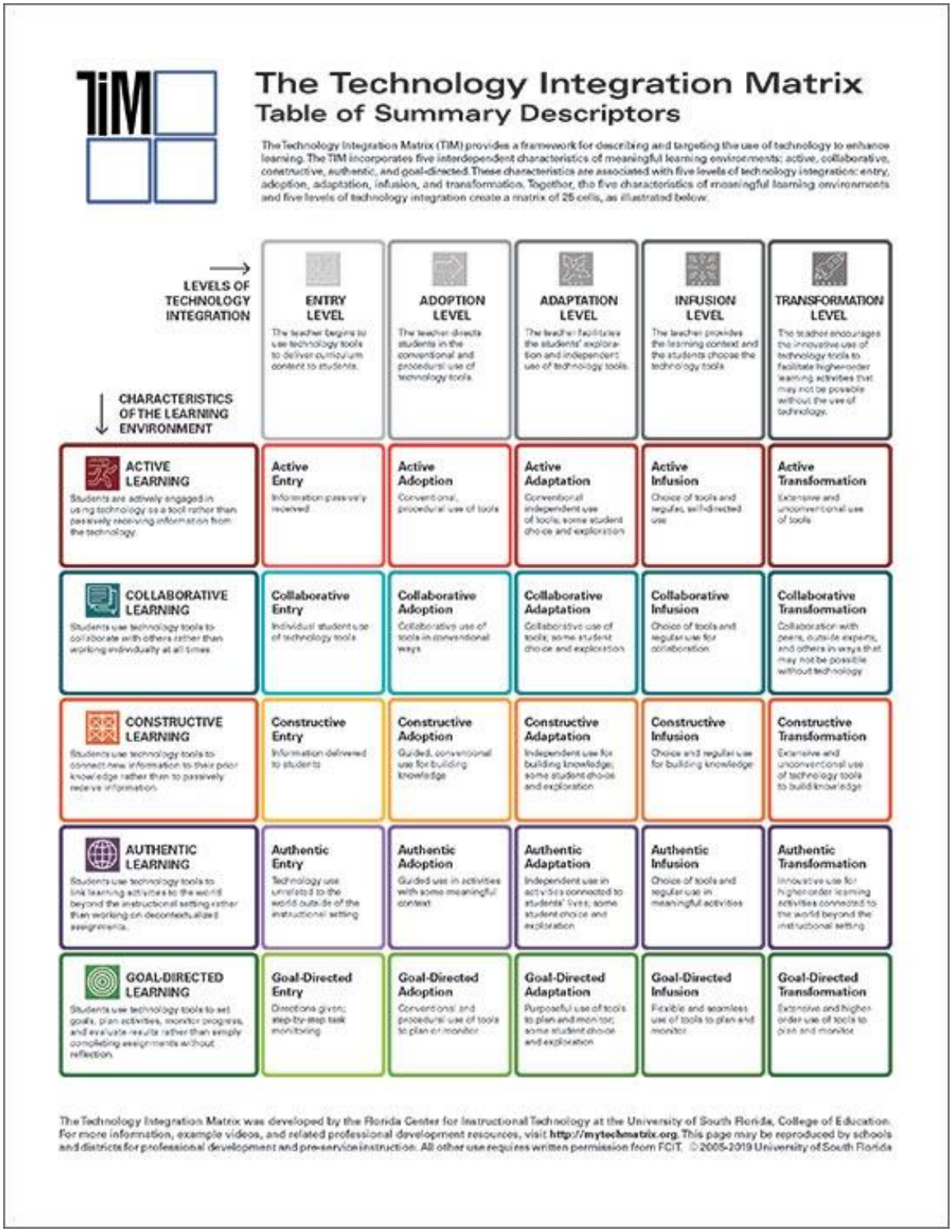

Figure 8. The Technology Integration Matrix, Table of descriptors (REMC Association of Michigan, n.d.). https://fcit.usf.edu/matrix/matrix/

RAT model also draws parallels to SAMR (Kimmons, 2018). However, rather than SAMRs four levels RAT has three; replace, amplify and transform. *Replace* directly corresponds to SAMRS *Substitution*, where DT directly substitutes the current teaching method. *Transform* links to SAMRS *Redefinition* where DT is redefined. Although the middle of the continuum in SAMR has two facets, RAT only has one. RAT's *Amplify* corresponds to both SAMRs *Augmentation* and *Modification*. As with SAMR the idea behind RAT is that educators will consider how deeply DT is used on the continuum and subsequently how meaningful it is (Kimmons, 2018).

Another model known as PICRAT extends RAT (Kimmons, 2012). In this model there are two questions users need to ask themselves:

1. "What is the DTs effect on practice?
    - Replacement
    - Amplification
    - Transformation
2. What are the students doing with the DT?
    - Passive
    - Interacting
    - Creating" (Kimmons, 2012, para. 2)

Kimmons (2012) suggested most teachers are still using DT as a passive replacement; however, best DT educational practice should be both creative and transformative.

Other DT integration models draw parallels to TPACK such as, HPC and TIP(M). HPC (Hunter, 2015) was derived from TPACK, but also suggested "creativity and imagination" (p. xii) are needed for meaningful DT integration. The HPC model (Hunter, 2015) outlined "five conceptions (theory; creativity; public learning; life preparation; and contextual accommodations" (p. 4.). Suggesting "twenty-two themes of pedagogical strategies and student learning processes dominate particular 'tech-savvy' teachers' practices" (Hunter, 2015, p. 51). These concepts can act as a guide, directing teachers to "quality teaching" (Hunter, 2015, p. 51) of DT integration.

Attard and Holme's (2019) TIP(M), is another recently developed model which hopes to capture the components teachers need to consider when including DT in the classroom (particularly when integrated with mathematics). It aims to remain relevant regardless of DT advancements. TIPs pyramid model's base, factors in both components that cannot necessarily be controlled by teachers; "community, culture, commitment and context" (Attard & Holme, 2019, para. 3) and those which can "tools, pedagogy, mathematics, engagement" (Attard & Holme, 2019, para. 3). TIP aims to highlight both the difficulties of teaching DT and presents a best practice, pedagogical guide for teachers (Attard & Holme, 2019).

These models of DT integration are all linked to changes in teachers' practice. They showcase a framework for teachers to move to a more meaningful and deeper thinking and level of DT integration. They also provide teachers with a guide and structure of what meaningful integration can look like. These models of DT integration have strong links with DTC. As DTC tends to be further along these continuums and use of each models' components. Most DTC content should take teachers to a deeper more meaningful level of integration. In the following section we explore some of the affordances that can affect DTs integration.

Affordances

Psychologist James Gibson (1977) first introduced the term Affordance, linking it to the actions' individuals choose to take with an object subject to their capabilities and restrictions (Chong & Proctor, 2019). However, later Don Norman broadened the term affordances as "perceivable action possibilities—i.e., only actions users consider possible (Chandler & Munday, 2016). Thus, an object's affordances depend on users' physical capabilities and their goals and past experiences" (Interaction Design Foundation, n.d., para. 2). Both Gibson and Norman's concepts of affordances highlighted an object's environment and their interrelationship (Chandler & Munday, 2016). Within classrooms, DT has a range of affordances (perceivable benefits and restrictions in relation to their environments) affecting what teachers can do. However, the nature of New Zealand school's curriculum means they are often able to adjust their school environments according to the

requirements of their learners, whanau and environmental capabilities. Therefore, having some ability to limit restrictions and improve capabilities. In the next section, the capabilities and restrictions (affordances) of DT and DTC integration are discussed.

Digital Technology Capabilities

Although (due to the vast array of affordances) pinning down the advantages of DT in our education system is complex, many specific benefits can be noted. A large study conducted from 1980s to 2000s, suggested “Educational (digital) technology has demonstrated a significant positive effect on achievement. Positive effects have been found for all major subject areas, in preschool through higher education and for both regular education and special needs students (Noeth & Volkov, 2004, p. 4). In this section some of the capabilities or advantages, including motivation and collaboration, will be reviewed. Next, how DT can assist with overcoming; social and geographical differences and finally learners with special needs will be explored.

Students are often motivated to learn independently but need to be afforded the opportunity and have the tools to do so. DT provides teachers with tools for students to be drivers of their own learning. Students' motivation can play an important role in their education and be a large factor in students’ outcomes (Côté & Levine, 2000). Several studies have found that DT, particularly when used in a blended learning approach, has increased students' motivation and subsequent grades (Ahmad, et al., 2008; Abdel-Maksoud, 2019; Delialioglu, 2012; Dewiyani Sunarto, et al., 2019; Hadiyanto, 2019). Through DT, teachers can adapt a more constructivist pedagogy, and allow students greater ownership and autonomy of their learning and subsequent motivation (Yu, Niemi & Mason, 2019).

DT allows a vast array of opportunities for students to collaborate beyond what is possible without DT. The internet provides a platform for collaboration. Many online systems such as; Google Drive, class blogs and YouTube sites are software that facilitate a collaborative environment for both teachers and students (Johnson et al., 2014; Preston, et al., 2015). Education systems around the world are starting to

understand the importance of collaboration and other skill sets outside of core subject areas. According to a report which aims to bring 21st century skills into education - collaboration is a fundamental skill needed for most employment (Partnership for 21st Century Skills, 2008). Anderson (2010) supported this view and suggested:

> Learning and innovation skills are what separate students who are prepared for increasingly complex life and work environments in the 21st century and those who are not. They include:
>
> - Creativity and Innovation
> - Critical Thinking and Problem Solving
> - Communication and Collaboration (p. 26).

There can be an array of differences in education, particularly when we consider geography, funding, resources and teacher training. However many of these can be assisted or improved by DT. Evidence suggested there was disparity between learners who have varying levels of access to DT in socioeconomic, ethnicity, gender, age groups and geographical location (Selwyn, Gorard & Williams, 2001) which can lead to a digital divide (Goode, 2010; Groundwater-Smith, 2009; Safar & AlKhezzi, 2013). Personal and educational institutions geographical location can play a large role in access to resources and educational opportunities. Rural schools often have less funding due to their smaller size and thus fewer physical resources. Computers allow students to access a vast amount of digital content, providing a plethora of resources and customized assessments that might not have been available otherwise (West, 2013). DT is a means for overcoming barriers, widening participation in education and reducing social inequalities (Safar & AlKhezzi, 2013; Selwyn et al., 2001). One study found DT could substantially close the gap in achievement levels for varying ethnicities and first-generation college students, due to greater interactivity in courses (Kincey, Farmer, Wiltsher, McKenzie & Mbiza, 2019). The internet has an ability to offer convenience to learners, and therefore improved access to education (Selwyn et al., 2001). New trends in online learning have become widespread, including online papers at universities and mixed methods or flipped classroom approaches, where learning

can be completed on the internet, leaving class time for student and teacher conferencing and peer collaboration (Johnson et al., 2014). Other online courses now available such as MOOCs (Massive Open Online Course) are available to anyone with the internet, have no entry requirements and minimal fees. Although completion rates of these courses tend to be substantially lower than other more traditional institutions, MOOCs are believed to bring empowerment to students and access to all (Aparicio, Oliveira, Bacao & Painho, 2019; Giddens, 2016).

One of the first benefits DT brought to schools was assisting learners with special needs. Over time, technology and DT development has played a significant role in assisting special needs; hearing aids for the hearing impaired, glasses, prosthetics and wheelchairs. But the development of DT has brought greater assistance to the masses. Voice typing, your computer or phone can read to you, and automated cleaning and lawn mowing robots. An array of DT is here to make our lives easier. Although DT is available to the masses, assisted technology “A systematical use of technology to compensate disadvantages that occur due to disabilities” (Sheehy & Holliman, 2018, p. 85) is specifically related to technology used for those with disabilities. An article by Blackhurst and Edyburn (2000) identified six areas that technology can assist those with disabilities: “life-sustainment, communication, mobility, control of the environment and learning” (as cited in Sheehy & Holliman, 2018, p. 88).

In education, generally the terms *special education* or *learners with special needs* are widely recognised and can span an array of needs and abilities. Depending on students’ needs, they can be in mainstream education or at specialist schools, either way, DT is playing a role in assisting schools with diverse needs and enabling more students to participate effectively in classrooms (Gardner, 1996). Florian and Hegarty (2007) discussed two ways DT can support our education system: enable greater access to the curriculum and using DT tools to ensure inclusion in classrooms. DT such as iPads can offer students with limited communication skills an opportunity to share feelings and ideas (Preston et al,.2015; Selwyn et al., 2001). Videoing social interactions can assist with understanding social cues and phonetic spelling software, electronic worksheets and audiobooks can aid in writing, reading and organising information for those with

different learning difficulties. When schools provide students with access to appropriate DT or assistive technology, they provide an inclusive environment, whether students choose to use it or not (Florian & Hegarty, 2007).

The above possibilities that DT affords our education system plays an important role in our modern world. DT, when entwined with effective pedagogy can make a difference to many. However, with access to DT improving student outcomes, there could also be new challenges on the horizon. One such challenge the "*digital divide*" (Anderson, 2010, p. 11; Selwyn, et al., 2001, p. 261), suggests access to DT is so consequential, that students without it are left at a disadvantage. Although DT should be an important part of education's future, it is important affordances are also considered in relation to the hindrances or restrictions they cause. Some of the very capabilities of DT discussed above, can play a dual role and can create restrictions.

Digital Technology Restrictions

Although DT is widely accepted in today's classrooms, there are still several barriers or restrictions which inhibit its use. Several factors need to be addressed before DT integration is a possibility. Several authors have suggested even when the environment and hardware is in place, DT use for students still tends to be comparatively low; because teachers tend to focus on using it for administrative tasks and find barriers hard to overcome (Ertmer, 2005; Kopcha, 2012; Lim & Khine, 2006; Vongkulluksn, Xie, & Bowman, 2018). Studies also suggest there are two areas in which traditional e-learning concepts experience problems (e.g., Su 2009; Tsai, Sing & Source, 2012). Firstly, external factors or "first order barriers" (Ertmer, 1999, p. 50), those items out of the teachers' controls, such as internet connection and devices available. Secondly, internal factors or "second order barriers" (Ertmer, 1999, p. 51), such as teacher's resistance or pedagogy. A 2014 Horizon report (Johnson, et al., 2014) identified six big challenges, across three categories, to integrating DT into classrooms. Solvable challenges (easily solved), where students "create authentic learning opportunities and integrate personalised learning" (Johnson, et al., 2014, p. 20). Difficult challenges (harder to solve), which

included “complex thinking, communication and safety of student data” (Johnson, et al., 2014, p. 24) and wicked challenges (unlikely to be solved), which included competition from new models of education and keeping formal education relevant (Johnson, et al., 2014, pp. 28-30). However, ever evolving DT means there will possibly be ever evolving challenges. Below each of these three challenges are explored in greater detail.

External Factors/First Order Barriers

Successfully integrating DT can be problematic. Problems can be found from external factors at schools or what studies refer to as “first order barriers” (Kopcha, 2012; Su, 2009). These barriers are those out of teachers’ control and include items such as; access to devices, teacher PLD (school led), time constraints, students’ behaviours, insufficient technical support and unrelated assessment tasks (Kopcha, 2012; Lim & Khine, 2006; Su, 2009). These barriers are the first that need to be overcome before teachers can successfully and meaningfully integrate DT in their classrooms (Kopcha, 2012). Some of the first order barriers to DT integration are discussed in greater detail below.

Schools need access to devices. By 2016 New Zealand schools were reporting they had a device ratio of 2.46 students per computer (Johnson, et al., 2017). However, devices and their software can quickly become outdated and run slowly due to a lack of device management such as updating or clearing memory space. As devices become outdated, overloaded with data or mistreated by students, they can begin to run slowly, and becoming a hindrance.

Other factors such as school networks being suitable, maintained and having policies that favour DT integration are also important factors. Policies filter through from government and curriculum policies down to the policies in individual schools. Recent reforms in curriculum policy around the world have seen DT become a requirement, with New Zealand following.

Socioeconomic status and geographical location can affect access to DT. A project by the National Centre for Educational Statistics (2019) found that when lower socioeconomic students had access to a computer at home it increased their academic outcomes. DT and the internet can provide unlimited resources to disadvantaged regions with poor access to tangible resources and help close the "achievement gap" (Safar & AlKhezzi, 2013. p. 617). A project undertaken by Statistics New Zealand looking at digital divides, found that homes who had a larger number of qualifications, higher income and children, were more likely to have access to the internet (Stats NZ, 2001, para. 9). Additionally, ethnicity, geographical location, youngest child's age and profession also played a role (Stats NZ, 2004). Groundwater-Smith (2009) found the digital divide is reducing, as DT becomes cheaper and new browsing systems increase speeds, however he believes a digital "fluency gap" (p. 152) will remain.

Another external factor that can be out of teachers' control is their PLD. Castek (2012) believed, to realise the potential promise of computers and new DT, teachers need increased opportunities for PLD which needs to begin in teacher training schools and continue throughout their careers. Many other researchers have also noted the importance of teacher training for DT integration, suggesting there is currently a disconnect between expectations versus PLD, and that a one-size-fits-all approach does not work (Ertmer, 2005; Hunter, 2015; Reyes et al., 2017;). Although teachers have the option to undertake their own PLD, many schools dictate PLD subject matter, or teachers are overloaded with other tasks and high student needs. PLD needs a shared goal across the school and its culture, there needs to be an understanding that DT can transform teaching and be integrated into other subjects (Ertmer, 2005). Additionally, PLD should be supported by in class workshops or mentoring and highlight practical activities that teachers can undertake with their students to be effective (Kopcha, 2012).

Lim and Khine (2006) suggested three ways that first order barriers can be managed "provision of time for teachers' professional development and curricular development, and technical, administrative, and pedagogical support for teachers" (p. 100). Often, teachers who hold a high belief in the value of DT will remain optimistic about integrating DT, even when first order barriers create problems

(Harris, 2007; Vongkulluksn, et al., 2018). However, various research into barriers to DT integration have shown that even when first order barriers are overcome, second order barriers might prevent integration (Belland, 2009; Ertmer, 2005; Vongkulluksn, et al., 2018).

Internal Factors/Second Order Barriers

Other important aspects for DT integration include internal factors or second order barriers, these are barriers which sit with the teacher and are much harder to overcome. Second order barriers are interwoven with teachers' skills, knowledge, attitudes and beliefs around DT. They include how to teach, pedagogy, operating programmes and devices, managing students' DT interactions, ability and time to select appropriate resources and thoughts on the role, value and links of DT in curriculum delivery (Vongkulluksn, et al., 2018).

Teachers' opinions of DT play an important role in their integration frequency and effectiveness. Teachers are more likely to include DT in their classrooms if; they believe DT is valued by their school policies and other staff members, and if they can personally see the teaching benefits (Vongkulluksn, et al., 2018). Teachers' technological "value beliefs (or beliefs about the value of something)" (Ottenbreit-Leftwich, Glazewski, Newby, & Ertmer, 2010, p. 1322) are fundamental in their inclusion of DT and how effective they think it will be in assisting with curriculum content. Teachers' beliefs also affect their interaction with the barriers to integration (Vongkulluksn, et al., 2018), as teachers often could not align their beliefs and practices due to the barriers they encountered (Ertmer et al., 2012). A study by Ertmer et al. (2012) found:

> Teachers' own beliefs and attitudes about the relevance of (digital) technology to students' learning were perceived as having the biggest impact on their success. Additionally, most teachers indicated that internal factors (e.g., passion for technology, having a problem-solving mentality) and support from others (administrators and personal learning networks) played key roles in shaping their practices. Teachers noted that the strongest barriers preventing other teachers from using technology were their existing attitudes and beliefs toward technology, as well as their current levels of knowledge and skills (p. 1).

Teachers' belief systems also impacted their confidence to use DT. Greener and Wakefield (2015) reported that although teachers were excited about using DT, confidence and beliefs around justifying class DT use were barriers teachers needed to overcome. Confidence, generally referred to as "a belief and a self-assurance in one's own abilities" (Kent, 2016) also closely aligns with self-efficacy, however self-efficacy tends to align to a person's belief they are able to achieve required outcomes and therefore have the skills and knowledge to do so (Bandura, 1997). Research by Tweed (2013) suggested that;

> Teacher age, years of teaching experience, teacher gender, and the hours spent in technology professional development did not play a significant role in the classroom technology use by teachers. However, the research indicated that the self-efficacy of teachers is significantly positively related to classroom technology use by teachers (p. 2).

Interestingly, an article by Hilbert (2011), identified that women are more likely to underestimate their DT use and subsequently have a lower self-efficacy in DT implementation. However, another report found that the more teachers used DT, the more their confidence grew, and they continued using it (Yeung, Lim, Tay, Lam-Chiang, & Hui, 2012).

As discussed, pedagogy also plays an important role in DT integration. However, what might be the right pedagogy and relevant now could quickly become outdated,

due to DTs fast evolving nature. For teachers to stay current they need to try new pedagogies that enhance DT, actively participate in using DT in their classrooms and stay current with DT research (International Society for DT in Education (ISTE), 2019). It is no wonder teachers become frustrated and burnt out as new DT tools and DT integration theory is consistently developed and released. Unlike other subject areas such as literacy and numeracy, keeping current with DT is a huge undertaking for any school, let alone an individual teacher. Ertmer (2005) suggested that many of the aspects needed to enhance DT in the classroom are already in place, but believes that a teachers' pedagogy and beliefs have not caught up yet. "Without the input and acceptance of teachers, the development of useful educational technology projects are hindered. Not only are teachers the gatekeepers of the classroom, they are the greatest source of information about curriculum design and educational content" (Martin, 2000, p. 8, as cited in Lim & Khine 2006, p. 98).

Teachers can be resistant to change, particularly if new thinking does not align with their current opinions. Time is needed to implement change and adjust perception. There are several process models which explain change, Su (2009) summarized these in Figure 9. "Precontemplation" (Su, 2009, p. 167) is usually the first aspect of change, where individuals deny that any change is needed and cannot see what is wrong with the status quo. Often peoples' attitudes will shift prior to their behaviours (Miller, 1994). The stages do not necessarily run in order, there could be some to-and-fro between, as the new behaviours become embedded over time (Su, 2009). Most importantly, without the correct training and support it will be difficult for teachers to progress successfully through the change process model. This suggests that although internal beliefs and attitudes (second order barriers) are integral to DT integration these are largely affected by first order barriers (Vongkulluksn, et al., 2018).

Hall & Hord (Stages of concerns)	Prochaska et al. (Stages of change)	Rogers (Stages in the innovation-decision process)	Scott & Jaffe (Phases of transition through change)
• Awareness • Informational • Personal • Management • Consequence • Collaboration • Refocusing	• Precontemplation • Contemplation • Preparation • Action • Maintenance • Termination	• Knowledge stage • Persuasion stage • Decision stage • Implementation • Confirmation	• Denial • Resistance • Exploration • Commitment

Figure 9. Stages of Change (Su, 2009, p. 167).

Fundamentally, changes to effective DT integration across schools will take time and patience, with many teachers at different stages of their journey. However, through effective PLD and an understanding of the change process, it is possible to create change. Fullan (1993) pointed out “successful schools do not have fewer problems than other schools – they just cope with them better” (p.26).

Literature Review Conclusion

The last forty years has seen vast changes in our education system due to DT. In this literature review, how DT fits into our education system has been considered. Examining the technology revolution and how DT is embedded into our schools through effective integration, DTC, DT pedagogies and models of DT integration have been identified. Although complex, studies have found positive correlations between DT and student outcomes (Abdel-Maksoud, 2019; Ahmad, et al., 2008; Delialioglu, 2012; Dewiyani Sunarto, et al., 2019; Hadiyanto, 2019; Machin, McNally, & Silva, 2006; Noeth & Volkov, 2004). Affordances; including both capabilities and restrictions of DT have been considered. There is no doubt that DTC are an important aspect in the world today, however, whether this is reflected in students' grades and outcomes is debated. As the literature shows, there is limited, New Zealand specific, research information regarding both DTC POs and how these are implemented. This research moves to fill part of this void and assist teachers by creating current research into teachers’ DTC implementation. The next chapter will identify the methodology used to undertake this research.

Chapter Three: Methodology

This research adopted an Action Research (AR) or specifically a Participatory Action Research (PAR) methodology, as it was most suitable to the aims and objectives of the study. This methodology chapter first discusses the rationale of the research method. Next the research design is discussed in detail, including the factors that affected the study in relation to its paradigmatic, epistemological and ontological foundations. Following this an explanation of the participants, the instruments used for data collection, and how the data was analysed. Finally, an in-depth analysis of the ethical considerations and any potential problems and limitations of the research will be considered.

Research Method Rationale

In deciding the methodology for this research, consideration was given to multiple research approaches and paradigms. There were several factors that needed to be considered when selecting a suitable approach. Scholars have demonstrated that research is affected by the environment in which it is conducted, including the researchers' and participants' beliefs and the connections they choose to make (e.g., Bryman, 2012; Denscombe, 2014). In this research, there were several external factors that could not be extricated from the research and that affected the choice of research method. Firstly, at the time of this research DTC had recently been establishmed and only become mandatory in 2020. Therefore, teachers would most likely lack current knowledge of DTC and a quantitative approach could yield little or no results. Secondly, teachers are often tentative and concerned that they do not have the required skill set to implement DT in their classrooms (Ertmer et al, 2012) and any research approach needed to allow for this. For this reason, participating teachers ideally needed the opportunity to partake effectively, no matter their current knowledge or experience.

DTC implementation might require some shifts in teachers' thinking. For systemic change to take place, teachers often need to change their mindsets of what a school should look like and how it is meant to function (Joseph & Reigeluth, 2010). Therefore, as peoples' attitudes take time to shift, it was the researcher's intention

that teachers could enter a change continuum where they each felt comfortable. The study hoped that teachers would gain personally and professionally from their research experience, that they would be able to continue developing their knowledge after the conclusion of research, and that they would also be able to disseminate their findings and experiences to other (Miller, 1992; Su, 2009). To create lasting change, the research intended for teachers to have a sense of voice and ownership in the research, so they could develop knowledge and confidence that encourage ongoing change and mind shifts. Therefore, this research utilised AR and specifically a PAR methodology to enable teacher voice and ownership. Below, the methodological approaches of AR and specifically PAR, will be discussed further.

Research Design

Action Research

The main question this study aims to answer is:

How are New Zealand's provincial city primary teachers implementing the new technology curriculum's digital components (DTC) into their classroom practice?

To answer this, the following two questions will be considered:

- What affordances will primary school teachers find during their DTC journey of adoption?
- How does a professional learning development intervention help facilitate/enable teachers' implementation of DTC?

The democratic underpinning of AR can be traced back to John Dewey's work (Stark, 2014). Dewey surmised that classrooms and society should be places of democracy and believed in reflective practices (Stark, 2014). However, AR is understood to have originated in the early 1940s from researcher Kurt Lewin and was first used in an educational setting in the 1970s (Kotaman & Tekin, 2013). AR is a qualitative approach to research, it often addresses a social issue and utilises an inquiry spiral, which is discussed in greater detail below (Butroyd & Mills, 2014). AR is also a systematic and reflective inquiry process, where the researcher

collaborates with subjects in a democratic and holistic manner and there is no one-size-fits-all design (Marshall, 2011; Mertler, 2016; Wang & Hannafin, 2005). Due to ARs democratic processes, it enables participants to become actively involved and reflective, often helping researchers and participants to solve problems that directly affect them. Although, it can be a methodology where researchers might feel emancipated (Butroyd & Mills, 2014; Marshall, 2011). Subsequently, participants could also benefit personally from the research, through personalised PLD, which can have instantaneous effects on those directly involved (Mertler, 2016). Participants might also disseminate information and support peers with their new-found knowledge (Berg, 2001).

> One of the psychological values in action research is that the people who must, by the very nature of their professional responsibilities, learn to improve their practices are the ones who engage in the research to learn what represents improvement (Corey, 1954, p. 3).

There are three types of AR: first-, second- or third-person (Marshall, 2011). During first-person AR, an individual seeks to develop an inquiry that is personal to them, by reviewing individual perspectives and outcomes and interpreting personal behaviour (Marshall, 2011). Second-person AR is completed as a small group, where all participants have a similar problem or goal in mind; although there could be an individual driver, the group remains collaborative (Marshall, 2011). Lastly, third-person AR aims to create an inquiry across a community or organisation. From a teaching perspective, these forms of AR can translate into participation across a group, a team or even a whole school (Butroyd & Mills, 2014). This research draws upon a second person AR approach; however, it is hoped that the project might reach further, becoming third-person AR, through the dissemination of the data.

The above features of AR made it an ideal choice to meet the aims of this research. However, there are several limitations that were also considered before undertaking this research methodology. AR can blur the lines of who owns and controls the research (Denscombe, 2014). Several authors also proposed that the small-scale

and onsite nature of AR can mean it is less likely to be generalisable (Denscombe, 2014). Additionally, AR can create a high workload for participants and be hard for them to separate or detach themselves from the research, as they have a vested interest in the outcomes (Denscombe, 2014). Mertler (2012) discussed the notion that AR had historically been seen as a lower quality of research. As AR data tends to be from perspectives and opinions of participants these can be seen to be subjective. Rigor in AR refers to the “quality, validity, accuracy, and credibility of AR and its findings” (Mertler, 2012, p. 29). This project tried to ensure attention was paid to its rigor (discussed in greater detail the Ethics section), particularly as the dissemination of findings might be wider than the school itself (Mertler, 2012). Next, the inquiry spiral AR adopts will be unpacked further.

Action Research Cycle

AR utilizes a multi-tiered, inquiry spiral that can be repeated and follows a process of planning, intervention, observing and reflection (Cohen, Manion, & Morrison, 2007). The fundamental parts of AR: being set in teachers' own environments and utilising a dual-inquiry spiral, where adopted in this research. The process is completed in the hope of making change and improving students’ learning and teachers’ practice (Menter, Elliot, Hulme, Lewin, & Lowden, 2011). Two graphic examples of AR spirals are shown in Figures 10 and 11. Figure 10’s (Kemmis & Wilkinson, 1998) representation of the AR spiral shows two-stages of focus meetings, reflection, and inquiry.

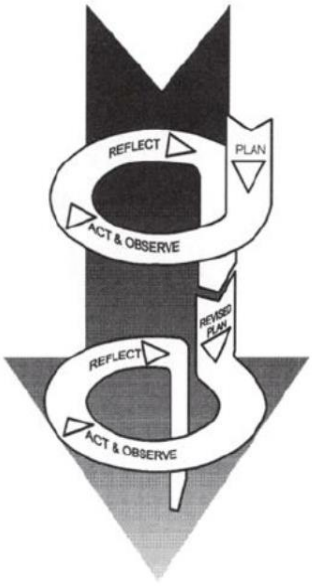

Figure 10. The Self-reflective Spiral in Action Research (Kemmis & Wilkinson, 1998, p. 22).

Another AR spiral, shown in Figure 11, also identifies two rotations, but separates the process into five parts, adding greater detail to each.

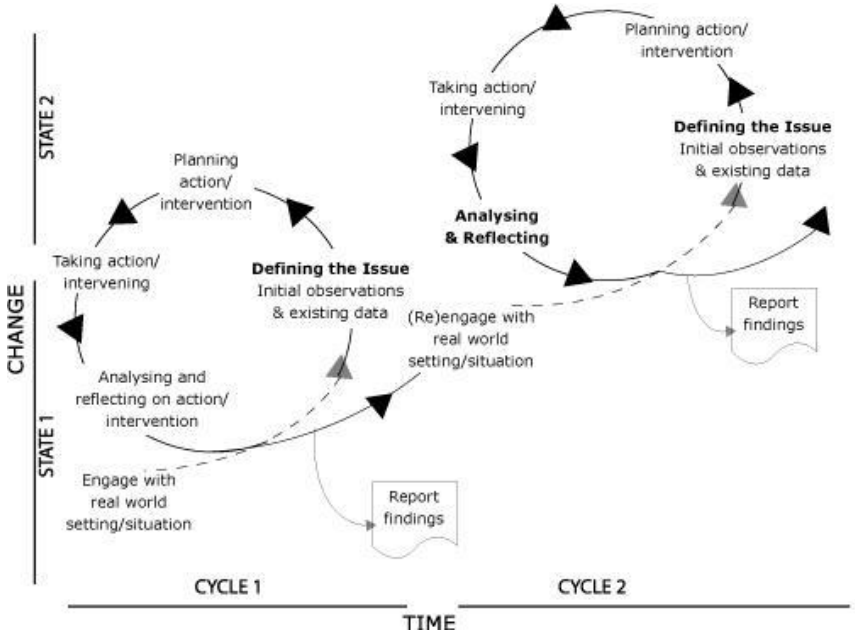

Figure 11. Action Research Spiral (as cited in Velasco, 2013, para. 7).

Specifics of the spiral are discussed and clarified in the instruments section below. However, the following gives an outline of how this spiral will be used in this research:

1. ***Engaging with real-world setting:*** Three classroom teachers' practices of implementing DTC were scrutinized. The research took place within the teachers' provincial inner-city primary school and their classroom environments. The teaching material used by the teachers all met the mandatory teaching requirements of the New Zealand Curriculum.

2. ***Defining the issues*****:** Initial data collection was through teacher pre-research questionnaires and focus groups which aimed to establish the teachers' current knowledge, beliefs and opinions of DTC.

3. ***Planning action/intervention***: An intervention or PLD session was chosen by participants and provided by the researcher. The PLD subject matter was chosen by participants.

4. ***Taking action/ Intervention:*** Teachers created personal goals from the PLD session. They planned and implemented lessons related to these goals which were observed by the researcher.

5. ***Analysis and reflection***: Teachers completed a reflection in relation to their goals and lessons.

6. **Second spiral:** The AR spiral was then repeated, beginning with a focus meeting to identify understanding of DTC at that point. A final post-research questionnaire was sent to teachers to identify any of their new understanding of DTC implementation.

Figures 12 and 13 also show these instruments' order specific to this study and in relation to the AR spiral. Morales (2016) suggested that using AR for teachers' professional development enables them to ensure and maintain quality education. However, studies have found that AR is often not made a fundamental part of teachers' work, and therefore classrooms often lack adequate and continual reflection (Kunlasomboon, Wongwanich, & Suwanmonkha, 2015).

Participatory Action Research

Under the AR umbrella also sit several other offsets. These all maintain ARs defining features of identifying real-world problems and work to improve these through a spiral of planning and action, but each possess subtle differences. One commonly used AR subset is PAR, which this research employed. Within PAR, researchers collaborate with participants at every step of the process (Morales, 2016). At the very heart of AR is the idea of empowering the people involved in the research process, with PAR, the research is conducted *with* rather than *on* subjects (Cammerota & Fine, 2008). PAR "is an ongoing organizational learning process, a research approach that emphasizes co-learning, participation, and organizational transformation" (Morales, 2006, p.159). In PAR "the researcher is not a facilitator of the process as in AR, but a 'co-producer of learning" (Morales, 2016, p. 161).

PAR processes enable participants to be involved; teachers and researchers share power and knowledge, discussing the most suitable plan of action and steering the research in an authentic and purposeful direction. Allowing the research findings to be presented in a practical and realistic manner, PAR enables one-to-one connection between researcher and participants. Through this process, issues could be resolved, and subsequent theories created, which, in turn, might contribute towards educational reforms (Morales, 2016). As curricular-change or reform might not be maintained in schools without the support of teachers, this can be beneficial to determine what teachers believe is valuable support (Schleicher, 2018).

Lawson et al. (2015) identified five features of PAR:

> First, PAR enables democratic practice in the real world-problem-solving by local stakeholders who typically lack formal research training and credentials when the research begins. Second, this democratic participation occurs in successive action research cycles which can be described simply as plan, do, study, and act. Third, new knowledge and understanding are generated as local problem-solving proceeds, thus qualifying PAR as research (e.g., Chevalier & Buckles, 2013; Foster-Fishman & Watson, 2011; Stringer, 2014). Fourth, this practice-generated knowledge responds to practitioners' and policymakers' knowledge needs because relevant, useful knowledge for policy and practice is derived from them. Fifth, PAR patently local knowledge provides a safeguard against an impending threat associated with globalisation namely, practice and policy homogenization (p. ix).

PAR was a good fit with the aim of this research, as it enabled the participants to learn about DTC and work at their own speed and pace according to their needs. Participants were able to make decisions about the direction of the research and what was important for them to focus on, such as the PLD sessions and DTC lessons, which potentially enabled the research to be beneficial to both researcher and participants. Because the research was conducted in the participants' (real-world) setting, with the researcher and participants working together to find suitable

outcomes, the research could facilitate immediate change (Reason & Bradbury, 2001). Shared collaboration between researcher and participants, meant all participants were able to contribute to the research ideas and outcomes (Macdonald, 2012). Utilising a PAR approach, it was hoped would allow engagement and participation to create a sense of ownership and an opportunity for the participants (who are experiencing the problems first-hand and therefore have the most in-depth knowledge) to solve associated problems and solutions (Cohen et al., 2007). It was hoped, through PAR, teachers would be more likely to adjust their pedagogy, attitudes and actions, as they are involved in the problems and participated in the research at every step (Stringer, 2014). Finally, PAR might also facilitate the dissemination of findings if teachers share what they have learned and support others to implement DTC (Cohen et al., 2007; Reason & Bradbury, 2001). Next, consideration will be given to the paradigm, epistemology and ontology which underpin AR and PAR.

Paradigm, Epistemology and Ontology

In this section the paradigm or researcher's worldview is examined. Next, ontologies and epistemologies which align with the researcher's paradigm are considered. Researchers need to contemplate their worldview and ensure they are approaching their research through a critical lens, as each research paradigm, ontology, epistemology informs methodology and methods (Scotland, 2012).

A researcher's view of the world can affect the way data is collected and interpreted. From an educational stance, the word paradigm is used to describe "a researcher's worldview" (Bawa, Kuyini, & Kivunja, 2017, para. 2). "It is the conceptual lens through which the researcher examines the methodological aspects of their research project to determine the research methods that will be used and how the data will be analysed" (Bawa, et al., 2017, para. 2). Several authors identify AR as its own paradigm (e.g., Bargal, 2006; Cherry, 1999). However, AR can be interwoven with both critical and interpretive paradigms of research (Cohen, et al., 2007).

AR links to critical theory through its process of working with small-scale groups; it not only identifies problems or helps the researcher understand a situation (like some

other research), but also intends to alter participants' perceptions and make change (Cohen et al., 2007). The democratic and egalitarian principles of critical theory can also be observed in AR, as the researcher works with and alongside the participants to identify problems and solutions (Akdere, 2003). Additionally, the interpretive paradigm can be seen in AR through the use of social interactions, such as rich conversations and debates between researchers and participants, in the hopes of creating a greater understanding and truth of reality. This approach is also linked with interpretivism in that the qualitative data and research is contextual to a specific moment of place and time (Cohen & Crabtree, 2006b; Kotaman & Tekin, 2013).

In contrast, positivism was not an appropriate view for this research. Positivism believes research sits independently to the outside world, often relying on facts and figures with the researcher being isolated (Denscombe, 2014). Positivism assumes we can predict what will happen next and that "reality is context-free" (Alharthi & Rehman, 2016, para. 7). Therefore, positivism was not suitable, as rich conversations, debates and social interactions (found in PAR) were needed for participants to unpack DTC and have ownership and investment in the research.

Each paradigm holds its own ontologies and epistemologies. Ontology refers to "the ways of being" (Calder, 2018, personal communication, March 19, 2018) and epistemology refers to "the ways of knowing" (Calder, 2018, personal communication, March 19, 2018). There are many different scholars' views about ontologies and epistemologies and how they link into various research designs. Critical theory aligns with historical ontology and modified transactional or subjectivist epistemology (Cohen & Crabtree, 2006a). Whereas, interpretive theory aligns with relativist ontology and transactional or subjectivist epistemology (Cohen & Crabtree, 2006a). Interpretive and critical paradigms' ontology and epistemology have subjective foundations (Farren, 2005), where a persons' beliefs and knowledge are subjective to the world around them (Siegel, 2014). Although the theory behind this research lay within subjectivity and was recognised as an important aspect during the research, AR first and foremost lies within the critical paradigm, due to its intention to foster change. In the following section, the participants and instruments used in this research will be unpacked in greater detail.

Participants

The participants were teachers from a provincial primary school who showed an interest in the research. Participation was on a voluntary basis and all teachers interested were considered. Three teachers out of five were nominated from those who volunteered. Teachers were nominated based on the inclusion of a range of year levels (junior, middle and senior), and a range of capabilities and confidence teaching DT (low, moderate and high). This was purposeful to enable the research to ascertain as broader perspective as possible from such a minimal sample. The three participating teachers are described in greater detail below varied in age, teaching experience, personal DT use, and DT integration in their classrooms.

- Mia is in her early twenties and a beginning teacher in her second year of teaching. She oversees the school DT, alongside a team leader. She felt particularly confident in her personal DT use and rated herself four out of five on a scale of personal and professional DT expertise. Mia's class were seniors at the primary school, and she felt very comfortable implementing DT.

- Laura is in her thirties and has been teaching for five years. She felt she had moderate understanding, knowledge and confidence with DT both personally and professionally. Laura's class were part of the middle school and she placed herself as a three out of five for her digital technology expertise and a two out of five for her ability to integrate DT into her class programme.

- Cacey had been teaching for over thirty years and is in her mid-fifties. She placed herself at the lowest point for both her DT expertise and integration, giving herself a one out of five on both continuums. Cacey had a junior school class of year ones and believed she had little knowledge of DT.

Instruments

This research used several methods of data collection, each is explained in more detail below with the AR spiral shown in relation to this researches' instruments in Figures 12 and 13. The process of AR allowed flexibility in the appropriate timing of each session (Cohen et al., 2007).

Figure 12. Action Research Phase One Spiral: Research Instrument Order.

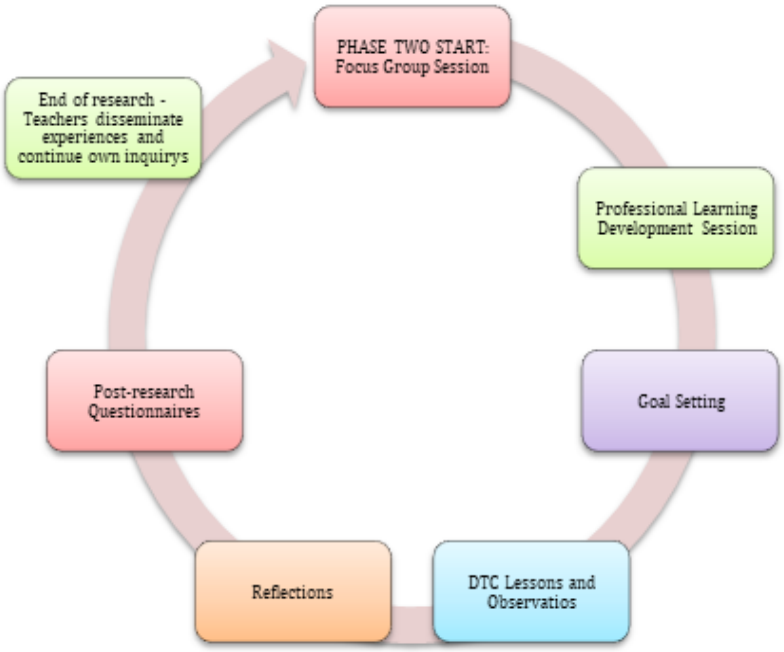

Figure 13. Action Research Phase Two Spiral: Research Instrument Order.

Questionnaires

Initial pre-research questionnaires and final post-research questionnaires were sent out by Google Drive forms and completed by participants. Both questionnaires aimed to enable participants to respond personally, without others input. Questionnaires aimed to gain an insight into the initial understanding and ideas of DTC (pre-research) and later any change teachers had made throughout the research, both professionally and personally (post-research). An important concept in selecting questionnaires was that they enabled anonymity and respondents might be more honest (Curtis, Murphy, & Shields, 2014; Morrel-Samuels, 2002), this therefore provides heightened reliability of the data collected (Curtis et al., 2014; Morrel-Samuels, 2002). Questionnaires are a strategic way of collecting data. They enable both open and closed questions, which respondents could take time to answer. Additionally responses are owned by respondents, rather than researchers recording answers that could lead to misinterpretation (Curtis et al., 2014).

In this research, consideration was given to the limitations associated with questionnaires, such as respondents failing to complete correctly, accidental mistakes, illegibility, participants unable to recall information correctly or not having the knowledge to answer questions. Additionally, the respondent's personality or motivation might affect the time and effort put into completing the questionnaire or they might fail to see the importance of questions or the subject matter (Cohen et al., 2007, p. 216).

Focus Groups

Focus-group sessions aimed to explore the teachers' current beliefs and perspectives of DTC. Focus groups aided the discussion of ideas and the ability to add to and extend each other's thinking (Ivey, 2011; Mertler, 2012). Typically, a focus group consists of five to ten people and a moderator or facilitator guides the group through a series of questions or activities, encouraging or drawing out answers and managing the sequences of questions (Scott, 2014). They differ from interviews as participants are encouraged to interact with one another and work together to generate and develop ideas to create an outcome or form opinions

(Cohen et al., 2007; Ivey, 2011; Scott, 2014). Therefore, focus groups can produce outcomes that would not have been identified in other data collection methods (Mertler, 2012). The new nature of the DTC dictated that there needed to be collaboration between teachers to unpack and review DTC. It was feasible that some participants might have no or limited knowledge or understanding of DTC and therefore would need to participate in a focus group to draw out any existing understanding.

Consideration was given to areas where focus group limitations could occur. Focus groups can produce less data and can be harder to analyse than individual interviews or questionnaires. Power dynamics and trust were considered, to make sure all participants felt they could be forthcoming and that no one dominated the discussion or pushed their opinions onto others (Johnson, 2012; Mertler, 2012). Time was taken to ensure the participants felt comfortable with the researcher and other participants; even though teachers worked together and were already familiar with one another. Based on the teachers' focus group comments, a DTC PLD session was created and delivered to teachers.

Goal Setting and Reflection

Teachers set goals after the PLD session and from these created and taught a DTC lesson to their class. Class observations took place during these lessons to observe teachers and their classes undertaking DTC tasks. Teachers' goals and reflections were used as evidence in the study and considered integral concepts in the research, as shown in the AR Spiral above. Individual goals were set by teachers which acted as the planning element of PAR. Often researchers will reflect on their research process, however, in PAR participants are co-researchers and need to reflect themselves. Teacher goal setting and reflection is important. Hine (2013) suggested that after leaving teacher training, teachers often get little time for critical reflection; however, AR offers the opportunity to do so. Reflection is a fundamental part of PLD and can assist in finding answers to complicated problems (Castleberry, et al., 2016). Through reflection, clarity of a problems and content can be increased (Thompson & Burns, 2008) and this could also increase participant confidence (Castleberry, et al., 2016).

Data Analysis Approach

According to Oxford University Press (2020), evidence is “the available body of facts or information indicating whether a belief or proposition is true or valid” (para. 1). The choice of research design and data collection methods should be relative to a researchers’ paradigm (Efron & Ravid, 2014), and based on *best fit* with the research aim (Ryan, Gandha, Culbertson, & Carlson, 2014).

PAR methodology enabled the collection of evidence such as opinions, beliefs, informal knowledge, and other anecdotal information. The PAR cycle enabled this research to review evidence in a systematic, continuous and reflective cycle. PAR allows for flexibility in data collection methods, with constant reflection and review (Johnson, 2012). Mertler’s (2016) notion that the research is there to benefit researchers and their participants was maintained; therefore, if new and beneficial information came to light, it might have been justified to alter the direction of any part of research. In this research, data analysis began as soon as the data was collected. The data analysis utilised the following phases of thematic analysis as identified by Braun and Clarke (2006) in Figure 14.

Phase	Name	Description
1.	Familiarise with data	Transcribe; re-read the data, note down initial idea

2.	Generate initial code	Code interesting features of the data
3.	Search for themes	Collate code into potential themes, gather all data relevant to each potential theme
4.	Review themes	Check if the themes work, in relation to the coded extract and the entire data set, generate a thematic ‘map’ of the analysis
5.	Define and name theme	On-going analysis to refine the specifics of each theme, and the overall story the analysis tells, generate clear definitions and names for each theme
6.	Produce the report	Select vivid, compelling extract examples, analysis of selected extracts, relating back to the research question and literature, producing a report of the analysis

Figure 14. Phases of Thematic Analysis (Braun & Clarke, 2006, p. 36).

After becoming familiar with the data, recurrent themes and similarities were identified and given codes, including patterns and making sense of participants’ opinions, beliefs and their current situation (Braun & Clarke, 2006; Cohen et al., 2007). Cohen et al. (2007) suggested that:

> Action research is open-minded about what counts as evidence (or data) – it involves not only keeping records which describe what is happening as accurately as possible . . . but also collecting and analysing our own judgements, reactions and impressions about what is going on (p. 300).

In PAR, small pieces of data are continually collected, rather than one single large data collection point. A literature review, conducted prior to the research, helped guide the process of data collection and identified themes. However, many themes

identified in the data were emerging themes, like those in grounded theory (Braun & Clarke, 2006). These emerging themes were those that might not have been known at the start of the research but were identified as the research unfolded and in situé (Braun & Clarke, 2006; Cohen et al., 2007; Creswell & Creswell, 2018).

Data collected in this research consisted of personal views and beliefs, therefore it was considered that the data might not be a true representation of what teachers actually do in their classrooms. Participants' views cannot necessarily always be taken to be precise and accurate evidence (Efron & Ravid, 2014). However, Cohen et al. (2007) suggested that "providing accounts are authentic, there is no reason why they should not be used as scientific tools in explaining people's actions" (p. 385).

Evidence and findings from this research could be used to inform individual classroom teaching, whole-school teaching expectations, philosophies and government policy. Nutley, Powell and Davies (2013) suggested that any evidence used in policy should be from research and not simply experts' opinions. Policymakers should use the best information available at the time, as the implications of policy can be far-reaching beyond those involved in research projects. Several authors argued that using scientific or quantitative data to inform policy is not always suitable, nor is it necessarily the best fit for every context (e.g., Burns, Schuller, & OECD, 2007; Wiseman, Whitty, Tobin, & Tsui, 2010). Essentially, there is no definitive answer to the best evidence collection method; rather it should be based on how applicable the evidence is to the policy and circumstance and reliability of the study (Burns, et al., 2007).

Instrument Thematic Data Analysis

Pre- and Post-Research Questionnaires

Pre-research questionnaires were administered prior to meeting participants. One of the questions the research aimed to examine was: *How does a professional development intervention help facilitate/enable teachers' implementation of DTC?* This meant that analysis of teachers' existing feelings and attitudes prior to (pre-

research questionnaire) and after the research (post-research questionnaire) were sought. The data obtained in the questionnaires were analysed for codes, which were then added to the rest of the coding from each phase.

The final post-research questionnaire aimed to identify what changes had taken place comparatively to the start of our PAR research journey. Pre- and post-research questionnaires provided insight into how the PLD interventions and the research process itself had assisted teachers' implementation. The questionnaires aided in obtaining a before and after view of participants feelings, beliefs and understanding before and after the research and subsequently seeing what immediate change might have taken place (Reason & Bradbury, 2001).

Focus Group Meetings

The first focus group meeting intended to gain a deeper understanding of the teachers' initial feelings of DTC and gain insights into the question: *What affordances will primary school teachers find during their DTC journey of adoption?* Both focus group meetings allowed time for teachers and the researcher to sit face-to-face, gain trust and share knowledge, including discussing and extending each other's ideas and concerns in relation to DTC (See Appendix J for focus group questions). Focus groups aimed to gain consensus of feelings from the teachers, including identifying their preferences for each of the PLD sessions. The focus groups were recorded and transcribed. Transcripts were then analysed with codes, sub-themes and main themes identified (see Appendix H and I).

Reading and re-reading the qualitative data in the transcripts was the first step in the thematic analysis. Appropriate codes were added to the side of the transcripts, with codes representing both explicit ideas and those underlying ideas, which were not mentioned outright but were instead underlying concepts and ideas, inferred from participants' comments. Table 1 provides an example of how the transcripts were colour-coded and codes identified. Some aspects fall into two coding categories, as can be seen in Table 1 where "*also*" is used with a corresponding bracket and code.

Laura	I used that with mine too - that's what we use as our reading rotation. Cos I find I can set them up and they can kind of go. At their own pace with it once they've had a bit of a go. But then I find that it does have aspects of like they can tell their character what to do using the blocks in that kind of thing. Then I know from then on you can sort of like - scratch does have things that you can Go and create things. But that's where I'm a bit like woah.	Integration Creating (also) integration(also) Coding Confidence (Also personal DT Knowledge)
Mia	stuff that takes time for you as a teacher.	Time
Cacey	Like you have to have a bit of input - I would imagine - I mean I've done that with my buddy class. But it's over my head a little bit. And there's where you came in (Mia) and I thought thank god for Mia.	Confidence DT professional knowledge PLD knowledge of curriculum
Mia	It's so fast for some of these kids that love it and are on it all the time. That they have no idea how you couldn't know.	Teacher DTC knowledge (also confidence) knowledge of curriculum
Cacey	I don't know what I don't know.	Confidence also
Cacey	That's the big thing I think, I don't know what I don't know!	Knowledge also (Pedagogy)

Table 1. Transcript example of coding analysis.

Professional Learning Development Sessions

Both PLD sessions were delivered by the researcher based upon subject matter selected by the participants during each focus group session. The first PLD session focused on providing an explanation of DTC, its location in the curriculum and greater detail of the CT PO and how this could be implemented through both an individual and integrated approach. This PLD also focused on building teacher confidence and demonstrating that much of DTC is embedded in existing curriculum and not as complex as teachers believed. (See Appendix K for first PLD presentation). Phase two's PLD session's selected focus was the DDDO PO.

Goals, Observations and Reflections

Teachers set personal goals after each PLD session. In line with AR principles, this was to enable the teachers to have ownership. These goals assisted teachers to develop individual lessons on DTC, which they taught to their classes. Teachers were observed taking this DTC session with their class. Teachers were joint researchers in the PAR process and these goals and subsequent reflections (see Appendix J), sought to ensure they could be actively involved in the AR cycle of action and reflection. It was hoped through this process of goal setting and reflection the teachers would continue to actively seek ways they could continue their PLD after the research (Mertler, 2016). The data from the goals and reflections were also considered when identifying codes and subsequent major themes in the research, which will be discussed in the following chapter.

Triangulation of Data

This research used a variety of data collection methods to triangulate data. Triangulating data is when two or more data collection methods are utilised in the study with the aim of cross-checking information against other data (Bryman, 2012; Cohen et al., 2007). By triangulating several data collection methods, the research aimed to ensure a more valid and reliable overall view of the data collected, which should, in turn, improve the overall picture gained, and the accuracy and authenticity of findings (Denscombe, 2014; Kern, 2018). Therefore, a variety of data methods were used including questionnaires, focus groups, goals and reflections. Mostly qualitative methods were used; however, an additional pre- and post-research questionnaire provided some quantitative data. If all data collection methods produce the same or similar themes and outcomes then the data is more reliable than if only one data collection method was used (Denscombe, 2014).

Ethical Considerations

This research gained ethical approval from Te Kura Toi Tangata Faculty of Education Ethics Committee, from the University of Waikato on July 22nd, 2019 and was given FEDU046/19 as an approval number. Discussed below are the ethical considerations for this project included validity and reliability, informed consent, anonymity and confidentiality, potential harm to participants and conflicts of interest.

There were several approaches used to ensure the reliability and validity of data collected in this project. The validity relates to how well the data collected addresses what the researcher intends to measure (Fowler, 1998) and reliability of data relates to the accuracy of the data collected (Sagor, 2019). It was considered that the students' or teachers' behaviour could differ depending on the setting, peers or personal emotions on any given day. The PAR process enabled adjudication throughout, and data results were shared with all participants to ensure transparency (Cohen et al., 2007).

Informed consent was an important consideration in this project. The school, teachers, students and students' guardians gave consent for the teachers and students to participate (see Appendix C, D, E and F). Informed consent helps participants to trust the researcher and opens clear lines of communication (Watanabe et al., 2011). Participants were made aware that they were able to withdraw at any time up to the point of analysis. Students were filmed in situ; the filming was not shown to anyone outside of the project and only used to obtain data specific to this research.

Pseudonyms were used for teachers' and students' names. Consent forms stated, *"While every effort will be made to protect the anonymity of all participants, this cannot be guaranteed" (*see Appendix C, D, E and F)*.* Participants were advised that the final research could be published and not remain confidential. To protect everyone's confidentiality, data collected was stored in a password-protected computer and each participant was given the opportunity to review manuscripts.

Consideration that the research could cause harm to participants was given at every step of the research. Identifying the participants or school's problems could have negative outcomes on their reputations; therefore, anonymity was paramount. Cohen, et al. (2007) "Cost/benefit ratios" (p. 51), were important considerations, including participants' feelings and motivations regarding the research. The study hoped to cause change and therefore had inseparable side effects on its participants (Zhao, 2017). Clear communication and sharing findings hoped to maintain participant motivation and ensure that positive implications of the study outweighed any harm to participants.

Power dynamics could also have affected responses between the researcher and participants (Lowes & Gill, 2006). The researcher tried to be aware of any power dynamics, ensuring equal contributions and that questionnaires enabled participant perspectives without peers being present. The research might also have other negative implications, such as inconvenience on teachers' and students' lives through time constraints; therefore, clear guidelines were provided regarding time expectations prior to the teachers' commitment.

The concept of remaining impartial and unbiased was necessary, as was the recognition that the researcher's own personal agendas and intricate ways of conducting and evaluating research could affect participants' responses (Guillemin & Gillam, 2004). This was particularly relevant as the researcher had pre-established interests and ideas about DT in classrooms, had undertaken other DT research work and led DT PLD sessions for schools. To mitigate this, the personal agenda for completing this research is clarified (see abstract), the researcher's personal opinions were not discussed with participants and questions aimed not to lead participants. The researcher attempted to ensure transparency in the study's motivation, what the researcher was hoping to achieve, and how the researcher might influence teaching and learning. For this research a scholarship was received from Waikato University, however, this should not have impacted or caused conflicts of interest other than ensuring the research was conducted rigorously.

Methodology Summary

This methodology section reviewed the research rationale and design of this project and aimed to provide evidence for why this was the most suitable methodological approach to meet the aims of the research. After reviewing AR and PAR, the participants, instruments, and how the analysis took place was identified. Finally, this section reviewed the ethical considerations and potential problems that might arise. This chapter has tried to address any concerns or bias the research might encounter; however, an appreciation that bias is not able to be completely mitigated in any research was also maintained, while I also endeavoured to be reflexive when enacting the ethical principles in the research practice.

Chapter Four: Results

These results aim to address the overarching question in this study: *How are New Zealand's provincial city primary teachers implementing the new technology curriculum's digital components (DTC) into their classroom practice?* To answer this, the following two questions were examined: *What affordances will primary school teachers find during DTC journey of adoption?* And *how does a professional development intervention help facilitate/enable teachers' implementation of DTC?*

As identified in the above methodology section, each teacher held varying levels of confidence and experience with DT and DTC. This was purposeful, as the study hoped to gain as broader perspective in the research as possible. In this section, phase one and then phase two's sub and main emergent themes are identified, unpacked and discussed. Although many of the codes and themes are separate ideas, most are interrelated and often mutually influencing. An additional comparison of the two phases also takes place. The discussion will include relevant links to literature which support, develop or scrutinise the data and ideas discussed; and attempt to ensure the data is viewed through a critical and unbiased lens. It is important to highlight here that although some of the DT integration was not seen as deeply set on DT integration models (discussed in the Literature Review), they were still considered by the researcher as valuable and positive forms of DT and DTC implementation. The themes are discussed in the following order: teacher knowledge, integration and confidence. In this chapter, participants' contributions are italicized and pseudonyms are used for names.

Data Analysis

Phase one and two's analysis saw several sub themes and three main themes emerge (Table 2 & 3). Two of the main themes were clearly identifiable and explicitly discussed by participants: integration and knowledge. However, an underlying theme: confidence, that was not frequently discussed outright, also became evident. In this section, each major theme and sub theme will be discussed with links to relevant literature provided and supported by participants' comments.

Codes were obtained from data collected in the researches' instruments. Once the initial codes were identified and organised according to frequency, they were then sorted into visual mind map representations, which highlighted interlinking and dominant themes (see Figures 15 & 19). Consideration was given to the main emergent themes, but also the frequency of occurrence as shown in the code's tables in Appendix H and I.

Phase One

Themes

Phase one of the project began by trying to obtain the current perspectives of participants via an initial pre-research questionnaire which was followed by a focus group meeting.

Figure 15. Mind Map Visual Representation of Phase One Themes and How They interlink.

Many of the codes put into the mind map show multiple interlinking features. Once the interlinking features were identified, several sub-themes emerged and then three main themes emerged from the sub-themes, as identified in Table 2.

Sub Themes	**Main Themes**
Integration	Integration
Time	
Personal Knowledge of DT	Teacher Knowledge: Initial Understanding
DTC Curriculum Content (knowledge)	
Pedagogy (knowledge and Understanding)	
Confidence	Confidence

Table 2. Sub themes and main themes identified in phase one.

Results and Discussion

Teacher Knowledge: Initial Understandings

Teacher knowledge, in relation to their initial understanding of DTC was a clear theme in the analysis of phase one. Two facets of knowledge were identified; personal knowledge of DT and professional knowledge of DTC. Both are mutually influencing, as it could be either difficult to understand DTC if participants' personal DT skills are insufficient or vice versa. When seeking to answer the question *What affordances will primary school teachers find during their DTC journey of adoption?* The research found that ‘knowledge’ was an affordance teachers related to their implementation of DTC. Below, both facets of knowledge are discussed in relation to the findings, first personal DT knowledge and secondly professional knowledge of DTC.

Teachers discussed a lack of knowledge in relation to their own personal DT expertise. They felt this hindered what they wanted and/or needed to do with their classes for DTC and meant they struggled to extend the students when using computer programmes related to DTC.

> *Laura: They can kind of go at their own pace with it once they've had a bit of a go. But then I find that it* (Scratch) *does have aspects they can tell their character what to do using the blocks and that kind of thing. Then I know from then on you can sort of like, you can go and create things. But that's where I'm a bit like woah.*

> *Cacey: You have to have a bit of input - I would imagine - I've done that with my buddy class. But it's over my head a little bit.*

> *Mia: It's* (DT) *so fast for some of these kids that love it and are on it all the time. That they have no idea how you couldn't know.*

These comments suggest the teachers feel they do not have adequate knowledge for all DTC tasks. Perhaps the most prevalent statement is the following excerpt from Cacey, suggesting that it is hard to know what knowledge you are missing:

> *Cacey: That's the big thing I think, I don't know what I don't know!*

This statement is also supported by the other teachers during their conversations *“I don't know what I don't know” and “I guess we just know what we know”.*

These comments show a consensus and appreciation that the teachers believe they could be lacking knowledge about DTC and its implementation and feel they need assistance to build this knowledge.

In another part of the focus group, Laura explains that at her previous school a designated teacher taught DT and she feels she would not have the knowledge to teach the same things.

> *Laura: I find that hard because at my last school we had a tech teacher and in our CRT they would go to Steve and they would make robots out of Lego and all this cool stuff. But you have no idea how to do that.*

Whilst here Mia mentions the pressure, she feels to learn new DT.

> *Mia: Where do I start? And it's something that you have to have some small understanding of before you just say "hey this is what we're doing". Sometimes if it goes wrong, I mean at least you've got something to learn from it, but this is the kind of thing that you need to at least have a little bit of knowledge on.*

When reviewing the answers in the pre-research questionnaire, teachers placed themselves on two continuums. One was their personal ability to use DT (Figure 16) and the second was their personal ability to implement any DT into their classrooms (Figure 17).

Figure 16. Pre-and Post-Research Questionnaire Results: Where do you currently rate yourself in terms of your personal technology and computer expertise?

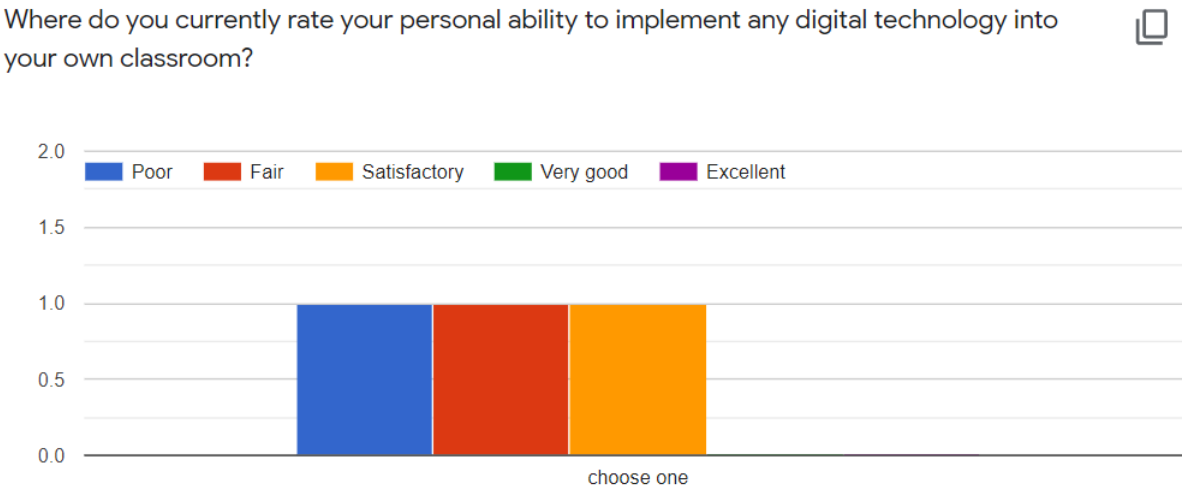

Figure 17. pre-research questionnaire results. Where do you currently rate your personal ability to implement any digital technology into your own classroom?

The graphs show inconsistencies between personal and professional use of DT. One teacher placed themselves as poor for both their personal DT expertise and DT integration with the class. However, two of the teachers felt they were better at personally using DT than they were at using it with their classes. The difference between these charts resonates with the ideas discussed by several authors; that teachers tend to focus on DT for personal and administrative tasks rather than incorporating it into their class programmes (Ertmer, 2005; Kopcha, 2012; Lim, et al., 2006; Vongkulluksn, et al., 2018). However, each teacher placed themselves either at the same place on the charts for each, or they placed their class DT integration only one place behind their personal DT expertise. Which demonstrates a possible link between the two aspects.

Professional DTC Knowledge

The most prevalent theme that occurred in the initial focus group meeting was a lack of understanding of DTC content. Teachers felt their knowledge of how DTC fitted into teaching and learning was vague. There are frequent conversations in the focus groups about the teachers' lack of understanding and knowledge of DTC and what it encompasses:

Laura: This is where I get confused on what it does and what it doesn't.

Cacey: And coding - what it encompasses, what it all really is, what it all really is in layman's terms.

Laura: The whole thing I find is the - I don't know how much I'm supposed to be doing.

Cacey: It's the what, what is it? And what do we do? And how do we do everything?

Laura: It's the what, what do we do?

Mia: And you want to know where you're going - moving forward because we've only got so much knowledge we can pass on, and how to make sense of it might not be the way it's intended to. I mean that'll be hard, we've all got such different backgrounds.

The teachers appear to feel frustrated at the lack of clarity around DTC. Discussions imply that teachers understand elements of DTC; but are confused about the order and sequence including how and what they are doing.

Mia: What do we need to do - sequencing? Have we leapt in doing, I don't know, like should I be, like what order do you do it in? I guess remembering these kids are digital natives, and they already know more than me. What order, or not order, what sequencing and progressions?

Cacey: Mine would probably be the real basic bit. Just knowing what the curriculum is and how it fits in. Or just knowing what the little guy's need. It's that progression thing I need to know, what they need to know before they come to you? Or do we do it another way? I don't know if we do it like that? That's how we do it in reading, writing and maths. That scaffolding thing?

The most confident teacher (Mia), expressed concern regarding weather or not their in-house PLD was correct or *“enough”* and if they had interpreted DTC correctly.

> *Mia: And I've tried to see it, but I don't even know if I'm right about it, but the way that James and I have gone about it is that instead of just using the device. You know whether it's an iPad or a Chromebook. I guess everything behind that and why we use that, how does the device work? and how can it help you?*

At another time Mia also states confusion over the curriculum and wants clarity on whether other schools are doing more or less than them.

> *Mia: That's where I kind of felt like - Are we behind the eight ball a little bit? All these schools are doing things. But then when you actually go digging, obviously the intermediates doing stuff, but we've approached other primary schools and they're like “oh we're not doing that”. But then James approached two schools in Auckland, and they were doing this, this and this. So it seems you've either gone really far ahead with it or you're not doing enough. So, it's hard to gauge where you should be at with it. And what it looks like, I guess it's going to look different for everybody. But what are we aiming for? I mean what is an ideal?*

Many of these comments link back to a lack of DTC clarity. At one-point Laura asks if DTC might fit into the technology curriculum demonstrating a clear link with this.

> *Laura: And can we make it link into the other technology areas? Are they separate or combined? Are they getting separated I would imagine it would fit into the other technology curriculum?*

Although the teachers articulate concerns over their DTC content knowledge, they highlight their existing knowledge and understanding of DTC and its POs. Within this, there is evidence that the teachers have had the opportunity to overcome

some of the first and second order barriers discussed by Ertmer (1999). The school has had a school wide focus on DTC for the year including PLD sessions and teachers completing inquiries on DTC. Here Cacey attributes her existing knowledge on DTC to a staff PLD session run by Mia and James (the two teachers in charge of school DTC PLD)

> *Cacey: Only because I remember what we did with Mia - sort of.*

Generally, there was a greater understanding around the CT PO than DDDO, most likely due to this being part of the PLD provided by Mia and James.

Several of the discussions amongst the teachers indicate their appreciation that DTC sits within a deeper teaching approach to e-learning (MOE, 2007, p. 36). These comments also seem to indicate that the teachers are moving deeper into a SAMR continuum (Hunter, 2015).

> *Cacey: What is the device doing for us?*
>
> *Mia: And looking at it big picture. Not just let's go on a Chromebook and type away.*

Mia also suggests (in her phase one reflection) that she can see the curriculum is valuable and learning is more meaningful for both her and her students:

> *Mia: Now that we have moved from just using digital devices to understanding how and why to use them, they as well as me, have gained much more insight. By tackling the teaching and learning this way, I think it has been more beneficial for my own learning and also for student understanding, particularly around computational thinking and the steps involved and how this can affect the overall outcome.*

The teachers' concepts of their existing and required knowledge on DTC was prevalent in phase one. However, comments by teachers were subjective, and

therefore led to a consideration that teachers' belief systems could affect implementation. Specifically, beliefs in their abilities regarding DTC and DT (seen as a first order barrier to DT implementation (Vongkulluksn, et al., 2018)) might play a significant role. Many of the above comments display a lack of clarity around what DTC entails, where it fits within curriculum content and a lack of confidence, both of which are discussed in the following two sections.

Integration

DTC Integration is discussed numerous times in the focus group meetings. This indicated that teachers believed DT and DTC integration was possible and that teachers were already doing this.

Throughout the first focus group meeting, the teachers were aware they could integrate DTC into other curriculum areas; but seemed unsure of how to do this effectively and what exactly DTC integration entailed.

> Cacey: *Is it a stand-alone curriculum and we teach it like we teach reading, writing, math, or do we? How do you do it as part of reading, writing or math? That's just knowledge isn't it? Knowledge of how it can be part of my guided reading, or my math program… But then how do you integrate that? Into a guided math group? That's what I would find hard. Or do I teach it separately?*

Again, these comments seemed to express a lack of clarity around DTC content. Although there seemed to be a desire to integrate DTC within other curriculum areas, there was a frustration at not knowing how to do so. These comments could indicate that teachers wanted to gain greater insight into DTC integration and move beyond substitution of tasks, deeper into a SAMR continuum (Walsh, 2017). Teachers other comments demonstrated a closer representation of Kimmons' (2018) definitions of DT integration, where meaningful integration is utilised to achieve learning goals.

Cacey: With our buddy class. We used Scratch and we made little hives. Because our inquiry was about bees.

Mia: So I think Shaun he's designing Blokarts, ...down the track of more just looking at the coding and the steps behind coding. I'm not sure what Cathy's doing? But I think she wants to integrate it with plant growing or something to do with next term. And I'm doing looking at a newspaper but looking at what is the need for a newspaper these days. Designing it for a purpose. The need for a digital vs hard copy and all of those types of things. We're all doing something slightly different but trying to merge the two.

These comments show a variety of ways teachers are linking and integrating DTC into other curriculum areas. However, how each individual teacher is planning for each activity, and therefore addressing DTC integration, is unclear. Although it is assumed, whether this was the teacher's intention or not (by natural default), many of the above activities would integrate across other curriculum areas, such as reading and writing. In some of the comments Hunter's (2015) definition of DT integration can be seen, where computers are simply included in the curriculum, such as a teachers use of the Scratch programme during a reading rotation. In this use of Scratch there is no specific learning goal highlighted, other than getting students onto devices. These comments could also be placed on several of the DT integration models. Placing this activity on the SAMR continuum (Hunter, 2015, p. 49) could hinge around several factors, it appears to sit at "Modification" (Hunter 2015, p. 49) level. However, the comments do not convey a specific purpose and therefore (it is hard to quantify and) could possibly sit closer to "Replacement" (Hunter, 2015, p. 49), where the activity is a direct replacement for playing a game. This use of DT also links to TPACK and its "device" (Koehler & Mishra, 2009, p. 62) component, but does not appear to give consideration to the components of "pedagogy or content" (Koehler & Mishra, 2009, p. 62). This type of DT use would be classed as *simple* integration according to Hunter (2015), and Reigeluth and Joseph's (2002) definitions, however it would not be classed by these authors as *meaningful* DT integration.

It was clear the teachers had participated in PLD on DTC tools, such as Scratch, to use with their classes:

> *Mia: I guess we just know what we know. And we're at the stage of just finding tools, so like Scratch or Kahoots or fun things that people can use that aren't above and beyond. Obviously, it takes a little bit of learning like Scratch or something. I guess we didn't want to make it this thing that scared everybody off. We're just trying to give everybody the tools and a little bit of background knowledge.*

Although certainly beneficial, the tools-based approach to PLD seemed to have left some uncertainty around DTC. The teachers' clarity of what DTC encompassed (discussed further below) appeared to be an important consideration for integration. Much of the integration taking place seems to manifest in the New Zealand Curriculum's e-learning concepts (MOE, 2007, p. 36). Although many of the teachers' comments link to aspects of the DT integration terms discussed in the Literature Review (Hamilton, 2007; Hunter, 2015; Kimmons, 2018; Reigeluth & Joseph, 2002). In the next section teachers' identification of time in relation to their DTC implementation is explored.

Time

Time was frequently mentioned by participants. There were two concepts of time that appeared during phase one. Firstly, time in relation to a teachers' personal or professional time to upskill themselves with DTC or DT; secondly, the concept of time in relation to finding time to teach DTC in the busy curriculum, or "crowded curriculum" as one of the teacher's states.

The first facet of time relates to teachers' upskilling and is entwined within the main theme; teachers' knowledge, discussed above. Teachers' time to upskill both personal DT skills and professional DTC skills where identified in adopting DTC. Teachers discuss concerns over where the time to upskill personally and professionally would come from.

Mia: Mine's definitely around coding. Having the patience and taking the time to learn that myself. I'm fine with sequencing and things like that side of it, but in terms of coding. That would be my thing.

This comment was in line with many others by teachers, as they discussed learning new concepts and curriculum content on several occasions. The pre-research questionnaire also identified time as one of all three teachers' main concerns around DTC.

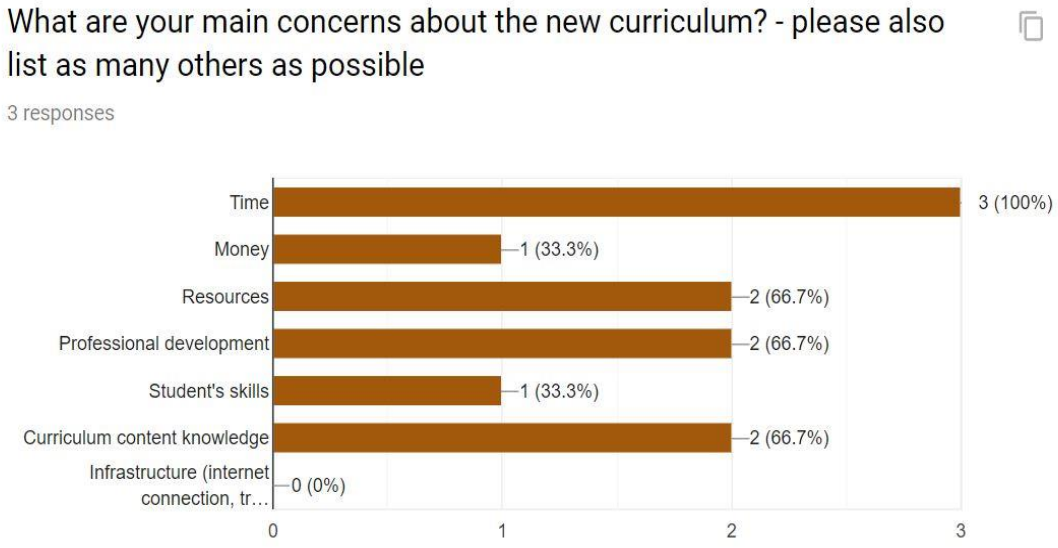

Figure 18. Pre-research Questionnaire Showing Teachers' Responses to the Question: What are your main concerns about the new curriculum?

The second concept of time; time to fit DTC learning into the busy curriculum is mentioned here by a participant.

Laura: Well the thing that I find is that it's another thing in the crowded curriculum. At the moment all I've really got is that I set them up on a coding program and they have to do that as part of their reading rotation… Stuff: that takes time for you as a teacher.

Again, this comment is in line with other comments that indicate teachers' concern at finding time for another subject. Consideration that the new POs are additional curriculum content and not replacing anything is relevant here. Although, if DTC is integrated into other curriculum areas this could negate the need for some additional time. Even with integration, time to find resources and plan the activities is still needed.

At one-point Mia (tasked with providing DTC PLD to the school) voices frustration of where they can upskill themselves. She suggests they have been unable to find any PLD within the local area "*There seem to be heaps of courses out of town - which is great but...*". Teachers having a lack of time and feeling overwhelmed is a concept that seems to be portrayed in some of their comments. Mia seems worried that the PLD they are providing to others is suitable and "*enough*". Several comments Mia makes appears to show that she feels overwhelmed being responsible for upskilling the whole school on DTC. This seems to link to both a lack of support for the teachers trying to train the rest of the staff and possibly misconception around DTC. Additionally, Mia's belief in her own abilities could be impacting how she feels the PLD is going. Beliefs, specifically confidence, is discussed further in the following section.

Confidence

The research sought to include a range of participants' confidence in DT skills, however confidence or self-efficacy also became a main underlying theme throughout the analysis. Only one question in the pre-research questionnaire sought to identify each teacher's confidence levels in DTC, however the focus group discussion led to an abundance of comments which implied a lack of confidence or self-efficacy.

There are many times confidence appears to be a fundamental aspect of teachers' feelings and concerns on DTC implementation. Here teachers explicitly discuss the desire to be confident in the DTC they are teaching:

Mia: And also depend on us won't it. And how quickly we take it on board, know what to do. I just want to be confident. Or slightly more confidence. Competent and confident.

Cacey: Slightly know what I'm doing, look like I'm walking the talk.

Mia expressed confidence in her use of DTC. She expressed a high level of confidence in her personal DT abilities, professional DTC capabilities and indicated a “giving DTC a go” mentality in the classroom.

Mia: Just takes having a bit of a play and seeing how far you can go with it yourself.

In contrast, Cacey seemed to lack confidence in her DT implementation, and at one-point attributes this to the generational divide:

Cacey: I think also for people like me who when I started teaching it was chalkboard and I can still remember these computers arriving at the school. And then we've got you girls who are - you young girls. I guess it's been part of your life the whole time. I think that's going to be a bit tricky. Or not tricky but I guess I've learnt along the way. But younger teachers it’s part of the things they've done all their lives. Like these kids, they've always had a phone or an iPad...I guess remembering these kids are digital natives, and they already know more than me.

In contrast to Cacey’s comments, a study by Tweed (2013) found that teachers’ age was not an indicator for how much DT was used in classrooms, however teachers’ confidence was significantly linked to frequency of use. Here Mia sums up how she believes many people feel about the curriculum:

Mia: There's a lot of people that feel apprehensive because they think this is so broad...

Further to this, below are some of the phrases used that where interpreted to demonstrate a lack of confidence or self-efficacy by the teachers in DTC implementation:

- *Cacey: Oh um coding? Not that I really know.*
- *Laura: This is where I get confused on what it does and what it doesn't.*
- *Cacey: I don't really know that developing digital outcomes. That's where I get stuck.*
- *Cacey: I only know a little bit like it's that coding and digital sequencing.*
- *Mia: I've tried to see it, but I don't even know if I'm right about it.*
- *Cacey: It's over my head a little bit.*
- *Laura: I have no idea how to do that stuff!*
- *Laura: The whole thing I find is that I don't know how much I'm supposed to be doing.*
- *Mia: That's where I kind of felt like are we behind the eight ball? It's hard to gauge where you should be at with it, and what it looks like. I guess it's going to look different for everybody. But what are we aiming for? I mean what is an ideal?*
- *Mia: I'd just like to know, I guess I feel like, I think, I have an understanding of the curriculum. But I'd just like to know from somebody else. That really knows whether there is another school or if that's somebody else from our PLD course or about what does it mean.*

These comments are subjective according to each teacher's opinion. However, in the first focus group meeting comments like this seemed to be consistent across all teachers. Several studies have highlighted the links between confidence and teachers use of DT in their classrooms (Ertmer, 2005; McLeod, 2016; OECD, 2010; Schunk, 2000; Tweed, 2013; Voogt & Knezek, 2008) and this is discussed further in the conclusion, limitations and implications section.

Phase Two

Themes

Once phase one had been completed, phase two began. Codes for phase two were obtained by analysing the second phase's PAR spiral's instruments. Phase two was clearly influenced by phase one and again three main themes emerged during the analysis.

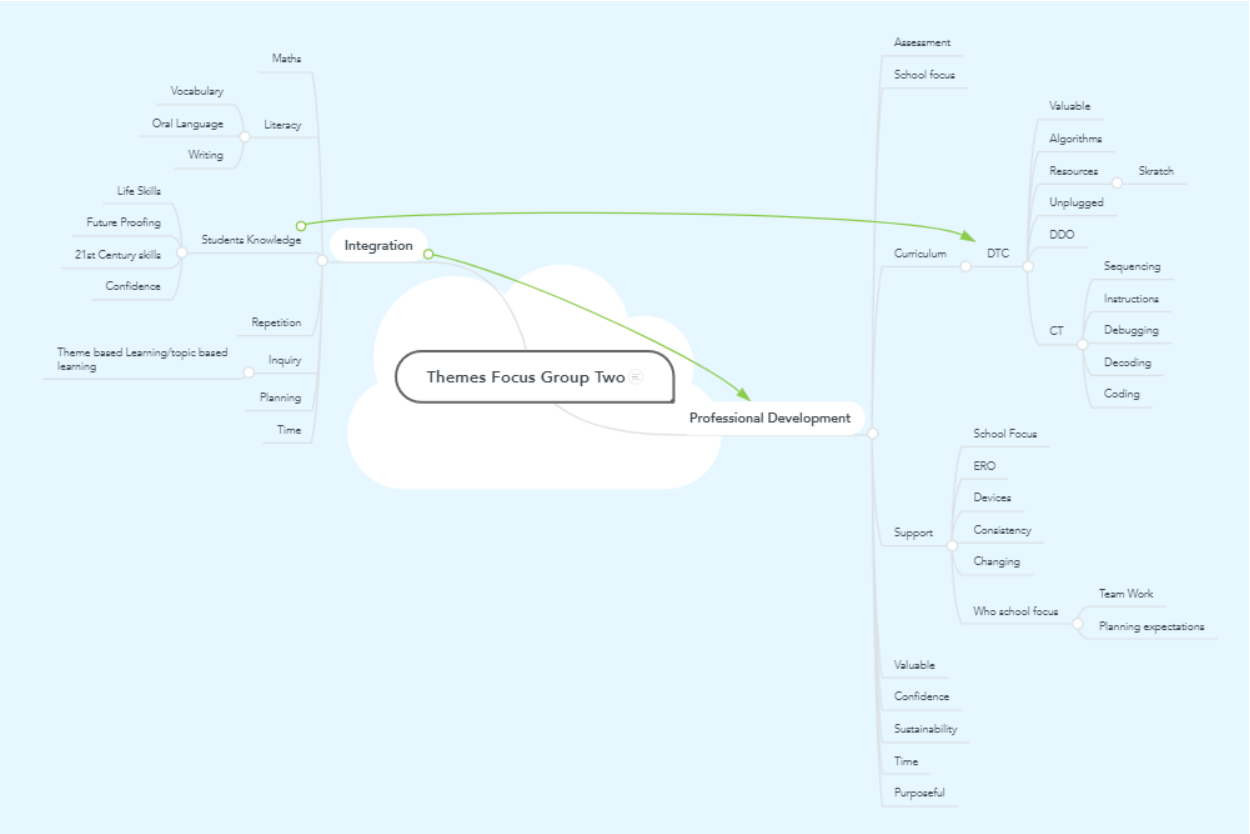

Figure 19. Mind Map Visual Representation of Phase Two Themes and how they Interlink.

Sub theme	Main Emergent Themes
Professional Development	Teacher Knowledge: Professional Learning Development
School Support	
21st Century Skills	Integration
Integration	
Confidence	Confidence

Table 3. Sub themes and main themes identified in phase two.

Discussion

Teachers' Knowledge: Professional Learning Development (PLD)

Professional Learning Development

Teachers' knowledge: PLD was a main theme which emerged from the researches' second phase. In this phase teachers discussed many aspects of their knowledge or future knowledge. However, this was associated with PLD rather than their initial understandings as in phase one. Many comments related to a change in their understanding of DTC and a general acknowledgement that previously they had misconceptions around DTC. Two areas within the themes teachers' knowledge: PLD, where identified. These were teachers' appreciation and desire for PLD and a whole school PLD support system.

The teachers' appreciation and desire for PLD appeared to be prevalent in phase two. The participants articulated that both the study's PLD session and the school's PLD had provided them with greater clarity of DTC and what it encompasses.

> *Cacey: Before you I didn't even know I was doing digital technology. And*

Cacey: Only because I remember what we did with Mia - sort of.

Teachers wanted to be actively involved in PLD, demonstrating a high level of teacher agency. Although, it could be considered that teachers who are willing to participate in research of this type are already showing high agency levels. Here, the teachers articulate that they wanted to continue their PLD around DTC and the goals they have regarding this.

> *Laura: It's less daunting than I originally thought. I do feel I need to continue to work on DDDO to develop my own confidence.*

And

> *Cacey: Now the goal will be to know the curriculum better, so I am aware of what I am doing in the classroom that has a DDDO component in it.*

As the comments suggest, the teachers would like further PLD and would like to focus on DDDO in their next PLD session. Here Mia says that they (James and herself) are looking to upskill themselves in DDDO and then subsequently the rest of the staff.

> *Mia: James said that's (DDDO) the next thing we need to look at that we need to know about, but I'm sure it will be the same as the CT.*

Mia also considers that they (James and Mia) have not had external PLD themselves on DTC

> Mia: *We've never had any PLD ourselves to be then able to pass on anything. So, it's like we can only go so far.*

This is supported by several other discussions which point to the consistency or longevity that the teachers would like to gain with DTC in their classes. Mia suggests that they want to "*sustain*" the work they are doing with DTC and does not want it to become a "*blip"* in their teaching. There appears to be consensus that all

participants have a desire to continue using DTC in their classes. Participants see the value in DTC and want continued PLD.

> Mia: *How to sustain it? I feel like I started off really strong and obviously that term I was really busy and I haven't done anything for quite a while. It doesn't have to be something every day, but even just something to slot it in and maybe once a week so it's integrated so that's regular and it's not just like oh we did that bit.*
>
> Cacey: *Even having that big bank of activities, to fit in with everything...*
>
> Laura: *I started off with a roar and then things petered off a little…need that consistency.*

Again, aspects of this conversation imply that the crowded curriculum is a difficult aspect to overcome. Participants seem to have a desire for DTC to become embedded and gain consistency in their teaching, but the need for further PLD and time restraints appear to be a restrictive factor.

School Support

School support is also discussed in the second focus group meetings in relation to PLD. Teachers express that having whole school support and emphasis from management is important in their PLD. Mia identifies that school leaders felt one year of in-house DTC PLD, and teachers undertaking their own inquiries on DTC, was enough.

> *Mia: The message was now we've had a year. People have had the opportunity to try things out to do a bit of research themselves. So, now it's on them now that we've kind of built a foundation…so you're kind of left on your own.*

Adding to this, other participants suggested that for DTC to gain traction they want continued whole school PLD, rather than individual independent inquiries:

Cacey*: But you still want a little bit.*

Mia: Personally, I think I do too. it's not in the forefront of your mind otherwise.

Laura: otherwise not everyone's talking about it all the time so it's not a school wide thing or if it was a school wide focus then we would all be doing stuff.

Two other comments articulate that outside organisations have also affected what PLD the school will undertake. Here Laura suggests that the school's focus and PLD will be relevant to what ERO are looking for if they come to the school.

Laura: *That just depends what they're* (ERO) *going to be looking for.*

The school is also part of the Community of Learners (COL) and teachers identify that the COL group leader dictates the school PLD

Cacey: I think we don't have a focus on DT and science because of the COL because we'd rather go along with what their PLD is.

Mia: You're always writing and then sometimes we get something else thrown in. And then something else and you're thinking?

Cacey: But it's been writing for years which is all part of the strategic planning.

The teachers seem frustrated that their school is required to focus on COL requirements and that writing is a dominant PLD with occasionally "*something else thrown in*". These comment show teachers seem eager to continue some form of PLD on DTC so that it becomes embedded in their teaching and learning.

Integration

Teachers discussed integration again in phase two. However, in this phase they discussed where and how they could integrate DTC into their teaching. The

teachers discuss that DTC can be integrated into all parts of the curriculum including maths, science, physical education, writing, and oral language. Additionally, different types of integration methods and how these can be embedded with 21st century skills were interpreted from some of their comments.

Here the teachers discuss how versatile DTC can be.

> *Cacey: And it's all across the curriculum, it integrates.*
>
> *Mia: Yes, it can be anything...It's recognising what you're already doing and being aware of that and making changes to what's needed.*
>
> *Laura: Now it's just knowing all the things that you can do to cover PO1. Or as you come across it and learning how to fit it into your science inquiries or your social sciences.*

The teachers also identify that DTC does not need to be completed on devices and can be taught *"unplugged"* or with *"non device activities"*, many of which can be integrated into other curriculum areas. Cacey expresses that she had a misconception around DTC "*I never knew there were non-computer activities". She* also links her DTC into oral language skills, which have been a large focus for the junior school and are important skills for students (Aldridge, 2005).

> *Cacey: Integrates with oral language activities… Oral language, a lot of that listening and speaking.*

and

> *Cacey: I think in juniors it's being aware of what CT is. I know in the juniors that it's lots of oral language and the maths it's all those instructions.*

Throughout the comments there are undertones that teachers recognise there are different levels of DT integration. Here teachers discuss using DT "*purposefully"* which appears to demonstrate the teachers delving deeper into the SAMR continuum (Walsh, 2017).

Laura: So, they're using it more purposefully or to share...Present or share with somebody else or share their learning.

Cacey: Enhance, not just play. Rather than an oral presentation or a written or a poster. So, it's not a game on a screen or a TV that's used for learning ...It's not just the screen, swiping things on or playing.

Mia: What's the purpose behind something and getting them to design something for that need.

These comments insinuate a shift in thinking about DTC from the first focus group meeting, and moving beyond SAMRs substitution phase (Walsh, 2017).

21st Century Skills

Integration can be seen to closely link with 21st century skills (discussed in detail in the Literature Review: Affordances section). Integrating DTC into other curriculum areas can make it more purposeful, students can make meaningful connections and build on their existing knowledge (Fraser, 2013).

Here the teachers talk about giving students the tools they will need in the future, recognising DTC as a 21st century skill.

Mia: (DTC is) like future proofing your learning, forwards proofing?

Laura: Like future proofing their learning. I guess, for future jobs as well.

These comments imply teachers see value in DTC for 21st century skills. This is beneficial as research suggests when teachers can see the value in things they are more likely to teach it (Vongkulluksn, et al., 2018). It also highlights that DTC

is an important aspect needed for a student's knowledge and skills in today's world (Reigeluth & Joseph, 2002).
DTC integration and 21st century skills could also be fostered by embedding DTC into students' inquiries, which is "future focused learning...it encourages connection, co-operation, and collaboration by allowing students to pose and solve problems together and with their communities in shared, authentic learning experiences" (TKI, n.d.g, para. 1).

> *Cacey: We can integrate and put it into our inquiries. Like their inquiry or probably maths, but really it just fits in with whatever their inquiries are.*

These comments seem to suggest an understanding of DTC integration and a newfound confidence about how to integrate DTC into teaching and learning. Next confidence is discussed in greater detail and how this has evolved from phase one.

Confidence

In comparison to phase one, many of the discussions in the second focus group meeting indicated the teachers had a growing belief in their DTC abilities. Again, confidence was seldom discussed. However, comments suggested teachers had a new-found confidence that seemed to stem from the realisation that teaching DTC was not as complex as they had first thought. It was indicated that this was a realisation gained from the PLD session they had participated in during phase one.

- *Laura: I think once we realised that it wasn't this big thing yer and we could. We don't have to be supercomputer geniuses.*
- *Cacey: You don't have to be flash to do it.*
- *Laura: It's not that difficult, it's not this complete overhaul.*
- *Laura: We're not having to learn a whole new thing.*
- *Cacey: It's not as hard as I imagined before.*
- *Laura: And the fact that we're already doing some sort of thing for it and*

towards that anyway is good to know.

The teachers' comments proposed a greater positivity around DTC and it being a purposeful aspect of the curriculum. A move to deeper integration on several of the integration continuums (identified in the Literature Review: Technology Integration Models section) and consideration of the pedagogy approach to DTC can also be seen in the following comments.

Mia: It's being purposeful not just using it because.

Cacey: Not just using it because it's a Bee-Bot just so people can have a turn.

Mia: And it also doesn't have to be standalone.

Cacey: Now it's just knowing all the things that you can do to cover progress outcome one. Or as you come across it and learning how to fit it into your science inquiries or your social sciences or...

In the teachers' final reflections two of them expressed their new-found confidence and attributed this to their new DTC knowledge. A realisation that DTC is more simplistic than first thought appeared to particularly boost confidence levels, as shown here in the teachers' phase two reflections.

Mia: Overall it was really good to see how simply it can be implemented...in some way we were each already incorporating aspects of the curriculum in our practice.

Laura: I feel more confident implementing the digital technologies curriculum after these lessons. It's less daunting than I originally thought. I do feel I need to continue to work on DDDO to develop my own confidence further.

Cacey: I feel that the DDDO curriculum isn't as big a deal as we first thought looking at it.

Additionally, Laura suggests that she now realises putting time and energy into DTC will help her feel more confident "*I need to continue to work on DDDO to develop my own confidence further".* This idea is supported by Schunk's (2000) concept that positive experiences foster confidence. There were few, if any comments in phase two which indicated low confidence, highlighting evidence of a change in teachers' beliefs.

Mia suggested in her post-research survey that she had found the biggest factor in developing her confidence in DTC was working with others and collaborating, an idea embedded in AR where there is an emphasis on learning together (Morales, 2016). At other times, participants made several references and positive connotations to how collaborating had helped them.

> *Mia: Meeting with Kate, as well as working alongside Cacey and Laura really helped with understanding and putting into practice both POs.*

There seems to be higher confidence around the PO CT, which was the focus of the school's and phase one's PLD.

> *Mia: Computational thinking as it seems to be the one that people are like oh yeah. You feel as if you're doing it already.*
>
> *Cacey: So computational thinking we feel pretty possible, but I'm not sure about DDDO.*

The new-found confidence appeared to be having a positive effect on teachers' DTC implementation. Even though participants considered they still had to work on DDDO concepts, there appeared to be a far more positive mind-set around how possible it was to implement DTC. In the following section a brief comparison of phase one and two's results are considered.

Phase One and Two Comparison

Phase one and two's results have uncovered three main corresponding themes teacher knowledge, integration and confidence. In this section a brief comparison will be undertaken of these, including links across each phase. Their similarities and differences will be discussed, given the transition in experiences and time lapse between phase one and two. The comparison of each phase hopes to identify that at different times in the research each of the themes were often viewed differently, highlighting that change had taken place as per PARs objectives (Menter et al., 2011). The comparison also aims to identify the affordances at each phase of the research in answering *What affordances will primary school teachers find during their DTC journey of adoption?* Additionally, teachers' attitudes and beliefs at the outset compared to the final phase are highlighted to clarify: *How does a PLD intervention help facilitate/enable teachers' implementation of DTC?*

Teacher Knowledge: Initial Understandings and Professional Development

Teacher knowledge was a strong theme that emerged in the research. In phase one the main theme identified was teachers' knowledge in relation to the teachers initial understanding of DTC. In phase one teachers attributed difficulties with personally not knowing enough about DTC, through comments such as "*you only know what you know*". They seemed to have a general frustration and belief that they personally lacked the knowledge and skills to implement DTC effectively aligning their lack of confidence with Bandura's (1997) notion of low self-efficacy.

Phase two also identified teachers' knowledge as a main theme. However, in this phase teachers' comments focused around upskilling or PLD. Teachers indicated a desire for further PLD to sustain DTC and continue to embed it into their classroom practice. Teachers mentioned wanting a *"bank of resources"* and indicated that their time to upskill was limited. The two phases' discussions suggested the teachers had shifted their opinions from; phase one believing they did not have personal knowledge and skills to implement DTC. To the second phase where a need for

greater PLD knowledge obtained externally and/or by the whole school was required. This indicated that teachers initially had misconceptions about DTC, lacked confidence and that it was less complex than initially thought:

> *Cacey: But before you I didn't even know I was doing digital technology*
> *and*
> *Laura: It's less daunting than I originally thought.*
> *and*
> *Cacey: I never knew there were non-computer activities*

Teachers also indicated that DTC would be more successful if the school hierarchy continued to maintain an ongoing focus, support and importance on DTC. Additionally, in both phases the co-teacher in charge of the school's PLD commented that access to external PLD had not been obtained as it was confusing and unclear where they could get this from.

Integration

Integration was identified by teachers as an important concept in DTC implementation. Phase one found that teachers understood DTC could be integrated into the curriculum; but a reasonable amount of uncertainty around where and how is expressed. There is evidence that teachers are both using DT tools as per SAMRs substitution phase and are considering elements of TPACKs devices and content aspects. Some of the teachers were completing units incorporating DTC, though it was not clarified if these were; technology subject units, student inquiries or other forms of curriculum integration. Phase one identified that teachers were putting time and effort into using DTC in their classes, and had some valuable DTC tools, implementation and integration. However, generally there was a lack of clarity on how, when and where DTC could be taught and if the teachers and school were implementing it correctly or frequently enough.

In the second phase of the research, the analysis also revealed a main theme of integration. However, in this phase, much of the conversations revolved around the teachers' current knowledge of where they could integrate DTC in their teaching

programmes. There was a general understanding of how DTC fitted within the curriculum and could be incorporated into most other teaching areas, particularly the CT PO. However, teachers identified that ongoing PLD was needed to pursue their understanding on DTC implementation and integration. Also, in phase two there was little emphasis placed on time restraints, which could have been due to teachers' growing confidence to integrating DTC or that they see its value.

Confidence

Confidence was an underlying theme that also emerged in both phases of the research. In the first phase it was evident teachers felt particularly unconfident in implementing DTC. Teachers felt they lacked direction and knowledge and believed they did not have the right tools, or in some cases personal abilities, to implement the curriculum - aligning this with low teacher self-efficacy. Even the most confident teacher implied she felt unsure that what they were doing was suitable and *"enough".*

Where teachers rated themselves for DT at each phase of the research is shown in Figures 20 and 21. These continuums show a before and after for teachers personal DT use and expertise, and personal ability to implement DT into their classrooms.

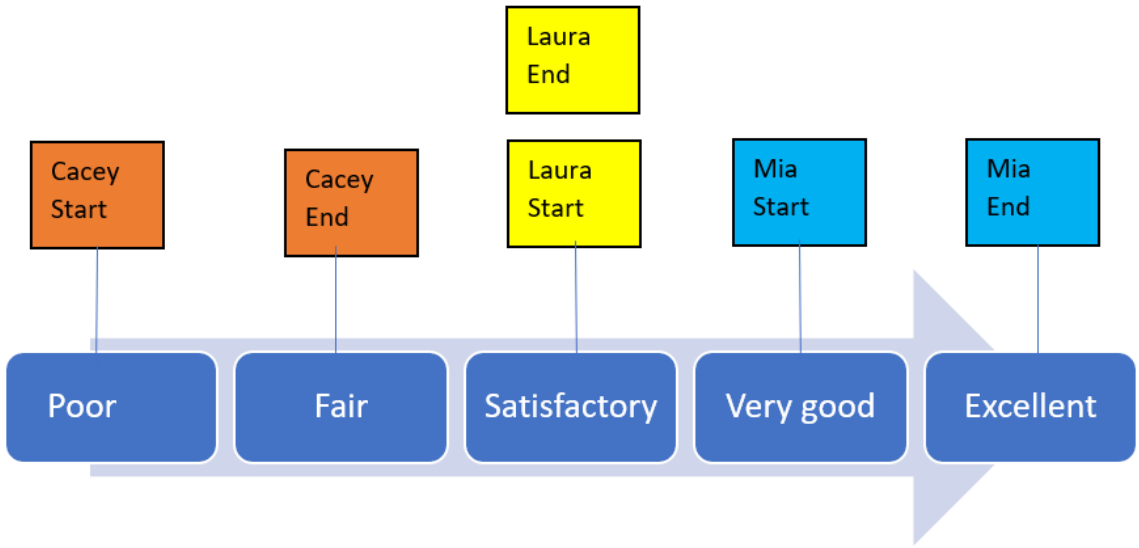

Figure 20. Pre- and Post-Research Questionnaire Results: Where do you currently rate yourself in terms of your personal technology and computer expertise?

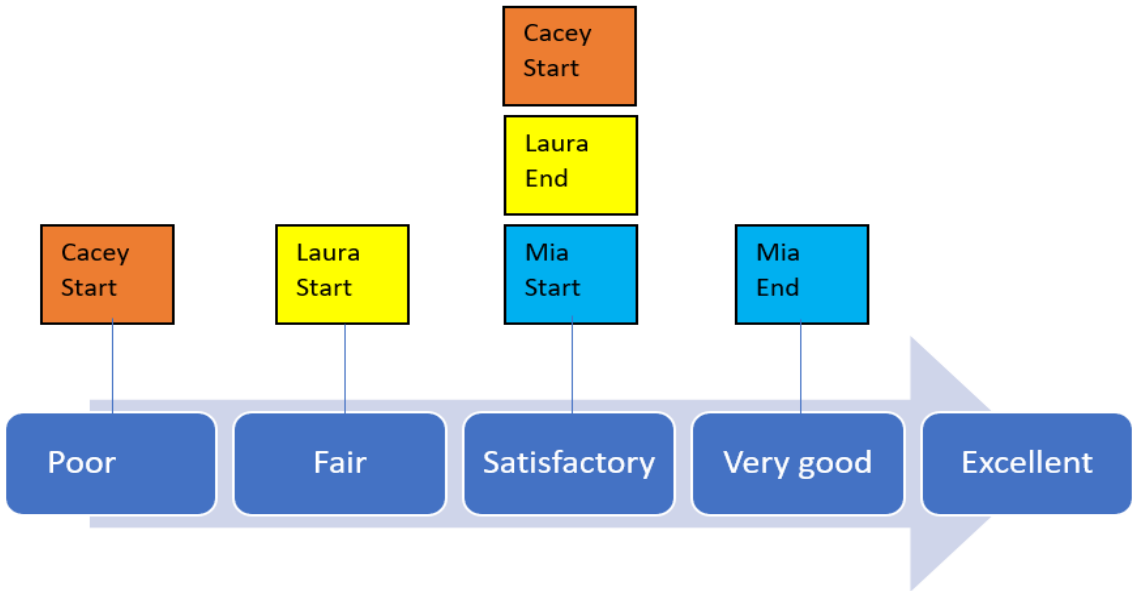

Figure 21. Pre- and Post-Research Questionnaire Results: Where do you currently rate your personal ability to implement any digital technology into your own classroom?

Interestingly, these figures show that two teachers have placed themselves higher on the continuum for personal DT in the second phase, even though there was no PLD around personally upskilling the teachers' DT. This could be because phase two saw a considerable change in the levels of confidence amongst teachers and

this appeared to foster a greater "*give DTC a go"* attitude. As opposed to phase one, phase two had few (if any) negative connotations in the way participants spoke and discussed DTC and its implementation. Generally, phase two comments were positive and appeared to reflect a change of mindset that DTC would be both possible and less complex than originally considered.

Results and Discussion Summary

These results and discussions have highlighted the themes found in the research and some of the changes that took place between the two phases. The research uncovered three main themes: teachers' knowledge, integration and confidence. These were identified and discussed in relation to each of the researches' phases. Many of the codes and themes identified were interrelated and often mutually influencing. The discussion aimed to include links to literature which supported, developed or scrutinised the findings in the hope that the data would be viewed critically. AR aims to create change (Cohen et al., 2007) and the difference between the teachers' understanding of DTC between phases suggested that changes in knowledge, integration and confidence had taken place. In the following chapter the themes identified here will be unpacked and synthesised. It will draw conclusions and share new findings, with links to literature. Additionally, any areas for further research, limitations of the study and implications for policy and practice will also be discussed.

Chapter Five: Conclusions and Implications

Schools have been required to incorporate DTC into classrooms from 2020. Some of these components encompass DT skills many teachers have never taught before, such as computer programming. However, DTC are envisaged as a positive step, helping teachers and students understand that computers can be used as more than just a substitutive tool. Instead DTC content explores creative skills, where students' learning is modified and enhanced by DT, and students learn 21st century skills and become global citizens.

The focus of this study was to unpack the research aim: *How are New Zealand's provincial city primary teachers implementing the new technology curriculum's digital components (DTC) into their classroom practice?* To do this, the following two questions were intended to be answered: *What affordances will primary school teachers find during their DTC journey of adoption?* And *how does a PLD intervention help facilitate/enable teachers' implementation of DTC?* These answers were sought through a PAR methodology, enabling participants to have some sense of ownership and empowerment in the process, and to potentially enter a change process at an appropriate place for each individual.

The first part of this chapter synthesises the research findings presented in the previous chapter. It will include links to literature and draw conclusions. Next, new findings or contributions to the field will be considered. The limitations of the study will then be identified. Finally, this chapter highlights the implications of this research for practice and policy and suggested further research

Teacher Knowledge: Professional Learning Development

The results in this study found that PLD was a significant aspect for teachers' implementation of DTC. The following aspects where the main findings in relation to PLD:

- Teachers lacked clarity around DTC and what it entailed.

- PLD could assist with clarity and implementation of DTC.
- There was a disconnect between MOE PLD resources available and those used by the teachers.
- External agencies impacted the school's implementation of DTC.
- The pedagogical approach to DTC should be considered.

Although teachers had in-house PLD on DTC, they expressed a lack of clarity around what DTC entailed. There were several aspects which could have influence this, such as that the staff providing DTC PLD were full-time teachers, with busy classes and had not undertaken any initial DTC PLD themselves. The in-house PLD also focused on DTC tasks and tools such as Scratch. Although this tools-based approach was beneficial, teachers identified they still felt uncertainty around DTC. Subsequently, teachers identified that they felt PLD could assist in clarifying DTC content and a continuous whole school focus was important to the outcomes of DTC implementation.

In the second phase of research, participants suggest that the lack of DTC clarity had been somewhat addressed by the study's PLD session:

> *Cacey: Before I didn't even know I was doing digital technology.*
>
> *Mia: Overall it was really good to see how simply it can be implemented...In some way we were each already incorporating aspects of the curriculum in our practice.*

These typical comments demonstrate how PLD can assist with teachers' implementation of DTC, specifically by aiding clarity around DTC content. Schmoker (2018) reinforces clarity as an important concept for schools, suggesting that schools often forget to focus on simplicity, clarity and prioritizing basic concepts to have the most effective outcomes for students. PLD to strengthen teachers' DT has also been recognised as important in several studies (e.g., Castek, 2012; Leary et al., 2016; Sung, Chang, & Liu, 2016). Teachers need increased PLD from training throughout their careers to realise the potential promise of computers

(Castek, 2012). A recent survey of principals found that 72% believed a lack of staff PLD was a barrier to DT integration (Johnson, et al., 2017).

The teachers expressed a desire for a whole school focus on DTC PLD. Teachers indicated that being tasked with completing their own personal inquiries was not enough to maintain ongoing consistency, clarity and direction in DTC implementation. They wanted the school leaders to maintain a strategic focus on DTC for their continued development. In line with these comments, research suggests teachers tend to value things that are valued by their leaders, and hence, leadership can influence a teacher's motivation and ability to accomplish goals (Pont, Nusche, & Moorman, 2008; Vongkulluksn, et al., 2018). ERO (2016) also points out that “promoting and participating in professional learning is the leadership activity that has the greatest impact on student outcomes” (para. 5). Ideas discussed in Kopcha (2012) are also evident in these findings, who identifies PLD should be supported by a variety of activities and practical tasks to be effective. However, here we need to consider that the leadership team could have outside agencies affecting what the school’s PLD focus might be (explored further below).

A disconnect between PLD resources available and those used by the participants was identified. In 2018, the New Zealand government developed several DTC resources and PLD processes to assist teachers with DTC implementation (Hipkins, 2018). However, the government funding and resources were not mentioned by participants during the focus group. This seemed to allude to a disconnect between what PLD resources were available and what teachers are accessing.

Two aspects of external influences were identified as potentially making a difference in the implementation of DTC. Firstly, teachers felt having external agencies provide PLD on DTC would be beneficial, and secondly it was believed that several other external agencies could affect the schools PLD choices. External agency PLD input was suggested by participants as having the potential to ensure the school provide adequate and accurate in-house DTC PLD. However, accessing external PLD for DTC appeared to be unclear, confusing and time consuming, only being able to identify facilitator led PLD out of the local area.

Mia: we never had any PLD ourselves to be then able to pass on anything. So, we can only go so far.

and

Mia: I'd just like to know, I think, I have an understanding of the curriculum. But I'd just like to know from somebody else. That really knows whether there is another school or if that's somebody else from our PLD course or about what does it mean?

Here Mia, who is tasked with providing school DTC PLD, articulates her uncertainty that what they are doing is accurate. Other participants also identified outsourcing DTC PLD as a positive step for clarity. With time constraints on teachers, this could be a valuable way to redirect resources. These comments also align with the New Zealand Principal Federations, that there is insufficient and arbitrary PLD for schools (Cormick, 2019). The findings are also supported in EROs (2019) report which highlights that schools need to first and foremost understand DTC content and that many schools did not feel prepared to implement DTC.

The second aspect of external agencies, which participants noted affected their DTC implementation, were the outside agencies who influenced the school's PLD focus. Two were specifically mentioned; ERO and COL. ERO are not tasked with providing guidance to schools, instead they are charged with evaluating (ERO, 2016). Although school evaluations and accountability are important concepts, it is possible schools feel pressure to perform well in specific areas that are believed to be focal points of ERO or COL. However, these areas could either be beneficial or detrimental to the schools, teachers and students' preferences or needs. Newmann, King and Rigdon's (1997) findings aligned with this notion, as they found caution should be taken as "high-stakes consequences are mandated by external authorities, this can deny school staff both the "ownership" or commitment and the authority it needs to work collaboratively to achieve a clear purpose for student learning" (p. 62). Participants stated there was an emphasis on writing as an ongoing PLD focus. Mandatory reporting of reading, writing and maths twice yearly is a requirement of each school (MOE, 2019). Mandatory reporting could cause schools to put greater importance on these subjects and hold them at higher value.

Additionally, high stakes testing in specific subjects can result in schools placing greater focus on these subjects to generate high test scores, rather than teaching a balanced curriculum that fosters creativity and 21st century thinking skills (Berliner, 2011). Medlen (2010) also suggested that teachers are being tasked with teaching more and more outside of the curriculum core subject areas, with pressure from outside agencies or interest groups often adding to that pressure. At times, there is barely enough time to teach what is already in the curriculum let alone anything additional or new.

In this study teachers indicated a general understanding of both integrating DT into other subject areas and DT tools. However, it is considered that what they do with these tools defines their use as either e-learning or DTC (Hunter, 2015). Therefore, benefits could be found in ensuring the PLD focus is on DTC content and pedagogical approaches, rather than only DTC tool introduction. A change in pedagogical approach might also assist with the time constraints teachers feel (finding resources and the crowded curriculum), as learners can become leaders of their own learning, sharing and collaborating to gain knowledge. A constructivist approach has been considered as one of the most suitable for DT integration and some researchers found that teachers who used this approach were also more likely to include DT in their class programmes (Ertmer, 2005; Ertmer, et al., 2012; Safar & AlKhezzi, 2013). A constructivist approach might help the teachers to maintain consistency with DTC as they allow students to be drivers of their own learning, with greater ownership and autonomy and where teachers do not have to hold all the answers (Yu, et al., 2019). Additionally, in the Literature Review Chapter, it was identified that many authors proposed DT integration was only effective when embedded within curriculum content and pedagogy (Aslan & Reigeluth, 2013; Hamilton, 2007; Hunter, 2015; Reigeluth & Joseph, 2002; Safar & AlKhezzi, 2013). A further element entwined in pedagogy is integrating DTC into the other curriculum discussed in the following section.

Integration

Participants in this research clearly articulated some understanding of DTC integration and saw its value. There is an array of complex and diverse definitions

of integration. However, for the purpose of this study we refer to integration in terms of entwining DTC or DT into and across other curriculum subjects (Fraser, 2000). Other terms such as inquiry learning, and theme-based learning were also classed as integration approaches for the purpose of this study. The following findings related to integration will be considered further below:

- Integrating DTC made it more meaningful and student centred.
- Integrating DTC aided in class and teacher time constraints.
- Integrating DTC assisted in the teaching of 21st century skills.

Participants seemed to feel that utilising an integrated approach to DTC was a way to make it more meaningful and student-centred. It was also a way to negate the need for another stand-alone subject in the busy curriculum, where time is a valuable resource. Additionally, teachers suggested integrating DTC into other parts of the curriculum assisted with implementing the New Zealand Curriculum key competencies (MOE, 2007, p. 12). The teachers' comments are substantiated in Castek's (2012) findings "technology has the power to; support learning inquiry, provide access to a wealth of information, facilitate ways to share content and ideas online and extend learning experiences that prepare students for their futures" (p. 212). It has also been suggested that new emphasis on STEM (Science Technology Engineering and Mathematics) in curriculums around the world, could provide teachers with a renewed emphasis on curriculum integration (Mockler, 2018). Many other researchers have also noted the importance of DT integration in teacher training. Suggesting there is currently a large disconnect between expectations versus PLD and that a one-size-fits-all approach to PLD does not work (e.g., Ertmer, 2005; Hunter, 2015; Reyes et al., 2017).

Integrated approaches to DTC were seen by teachers to assist with time constraints and the busy curriculum. To sift through DTC, unpack its requirements and separate DTC from e-learning participants identified that overwhelming amount of time was needed. Johnson (2019) suggests teachers' time is often undervalued in schools and that it can be a valuable resource. There is also considerable overlap between e-learning and DTC, and this could lead to confusion. The New Zealand Curriculum tends to be open to interpretation, which enables integration,

empowerment and ownership for teachers and students (MOE, 2007); while schools can choose their own approach to DTC implementation (MacGregor-Reid, 2019). However, these interpretations might cause some confusion on what exactly teachers should be doing and when, as there are no mandates set in stone.

Confidence

Teacher confidence was an underlying theme which became particularly apparent during phase one of the research. The following findings in relation to confidence appeared in this study, each of which is examined in greater detail below:

- Confidence plays a role in DTC implementation.
- Confidence affects a teacher's beliefs that they can successfully implement DTC.
- Confidence in DTC can be increased through practice and PLD.

Confidence was a factor for teachers in the implementation of DTC. Participants appeared to lack confidence in DTC in phase one, with negative connotations and a general lack of belief in their own abilities evident in many of their comments. However, in phase two teachers' comments generally had positive connotations and were associated with a much greater "*give it a go*" attitude as shown in Table 4.

Phase One Comments or Reflections	**Phase Two Comments or Reflections**
...there's a lot of people that feel apprehensive because they think this is so broad...	*It's not as hard as I imagined before.*
This is where I get confused on what it does and what it doesn't ...	*It's not that difficult it's not this complete overhaul.*
I have no idea how to do that stuff!	*I feel more confident implementing the digital technologies curriculum after these lessons. It's less daunting than I originally thought.*

Table 4. Comparative comments and reflections from phase one and phase two, demonstrating change in confidence levels.

Table 4 demonstrates that confidence can be increased in DTC implementation. This increased confidence appears to have been driven by teachers; firstly, practicing DTC implementation in their classrooms and secondly participating in PLD around DTC content, with ownership and collaboration taking place. Terrell (2018) agrees, suggesting that although most people believe confidence in one's self is innate, people can in fact learn to become more confident in themselves. Researchers and policymakers have known for years that attitudes (which confidence often forms part of) play an important role in creating positive outcomes (Ertmer, 2005; McLeod, 2016; Schunk, 2000; Voogt & Knezek, 2008). The OECD (2010) identifies confidence as playing a key role in engagement in DT, which they suggest reaches far beyond a simplistic view, having complex foundations bound in a person's psychology, social-economic, cultural and pragmatic stance. Furthermore, Duncan et al. (2018) suggests that if teachers are unconfident when teaching elements of DTC, they might pass on negative connotations to students. These findings indicate a correlation with Schunk's (2000) notion that positive experiences can foster confidence. Teachers need to be given time to experiment

with DT and DTC, have relevant PLD to foster successes in DTC instruction and subsequently move into a positive mindset and deeper into the implementation of DTC.

Summary of Findings

There is no single answer to the research questions that were posed. Any new curriculum brought in will create a process of learning. However, the findings from this research would suggest that if teachers are given appropriate DTC PLD, then it is possible for them to develop their understanding and subsequent confidence of DTC and overcome some of the negative affordances found in its implementation.

Teachers lacked clarity around DTC and what it entailed. A DTC PLD intervention can help to facilitate/enable teachers' implementation of DTC, mostly through clarity around DTC content, as many teachers appeared to have misconceptions. In this research a disconnect between available government PLD and what was being accessed was also found. Benefits could be found in PLD exploring appropriate integration and pedagogy and should be supported by leaders and external school influences.

Confidence played an important role in teachers' DTC journey of adoption. Confidence affected the teachers' beliefs that they could successfully implement DTC. Although teachers' confidence was found to be heavily entwined within the misconceptions and lack of understanding around DTC. Through PLD and practice teachers' confidence could be increased. By integrating DTC teachers felt it was more meaningful and this assisted in time constraints and restraints, fostered collaboration and 21st century skills. In the following section the finding that are new and contribute to the field are discussed in greater detail.

New Findings and Contributions to the Field

Through a PAR approach, this study has uncovered the following new findings around DTC implementation.

- Teachers have misconceptions and lack clarity around what DTC content is and its complexity.
- Misconceptions caused teachers to lack confidence in DTC implementation.
- Disconnect between available PLD and teachers accessing this.

Firstly, this study has identified that teachers have misconceptions about what DTC content is and its complexity. An example of this is found in DTC PO CT, where no devices are needed (unplugged) until year five. That is: until year five, teachers are not expected to use a device or teach programming for CT, instead the focus is on "non-computerised algorithmic thinking... and simple debugging" (TKI, 2018c, para. 8). Teachers were initially concerned due to the belief they are expected to teach complex programming to all age levels. However, DTC encompasses far more than programming on computers. Unplugged activities and elements are important throughout primary school, with many of DTC elements are already entwined in current teaching and learning, particularly at junior levels.

It might be considered that without suitable PLD teachers could not be fully aware of what DTC entails and misconceptions might be commonplace. As in this study, teachers overestimate DTC content complexity; although, some teachers could also underestimate DTC content. Either way, this could be problematic. An example of a misconception found in this study is identified above, which demonstrates that teachers had mostly overestimated DTC content, believing it was far more complex than intended. However, there might be far more misconceptions held by teachers and schools that were not specifically found in this study. Duncan, et al. (2018) articulates that many teachers are often unaware of what teaching CT entails. Additionally, much of DDDO is already embedded within e-learning and design processes in the curriculum (TKI, 2018c). Although these examples demonstrate there are aspects of CT and DDDO in the curriculum, it could be valuable for teachers to gain clarity around these from appropriate PLD or resources. The following section moves to the pedagogical aspect of DT integration and how this might aid DTC implementation.

As discussed in the literature review, it was not surprising that this study found that teachers' lacked confidence in personal and professional use of DT and DTC.

However, the reason teachers in this study were confused and unconfident about their use of DTC in the classroom appeared to be mostly due to a lack of clarity on what DTC encompassed and their misconceptions (discussed above). It was demonstrated that through PLD and opportunities to use DTC, teachers' confidence levels could be increased. Often these confidence levels could also be attributed to now found clarity on the simplicity of DTC, which could also be attributed to the participation in appropriate PLD.

There appears to be a large disconnect between what PLD is available to teachers and what teachers are utilising or know is available, which is the study's third major finding. These findings support the Principal Association's comments that there is not enough DTC PLD in place for all schools (Cormick, 2019; ERO, 2019). Government PLD is meant to be available to teachers (Hipkins, 2018), but this does not seem to be being utilised. This could be due to several aspects; such as a lack of clarity on where and how to obtain resources and PLD; principals applying for funding and being unsuccessful; or that the available resources are not seen as helpful by teachers. It might also be considered that if these resources were utilised, they could assist in aiding clarity around DTC content and subsequently overcoming teachers' lack of confidence, which are the other two major findings of this study.

This study holds a unique perspective due to its provincial city primary school context and the PAR approach that was utilised. The above new findings are specifically relevant and differ from other research and findings due to the new nature of DTC and it becoming mandatory the year after this study was undertaken (2020). There is little other research that has been undertaken specifically in relation to primary school level DTC in a New Zealand context (discussed in greater detail in the Literature Review Chapter). Most other research and findings similar to this study are driven from a DT or CT perspective, rather than a primary school level DTC perspective. Additionally, other similar curriculums around the world are also new, only recently developed and therefore also have limited associated research.

Limitations of Research

As with all studies limitations occurred. Therefore, the following limitations should be considered in relation to the findings of this study. The size and scale of the research was small, with only three teachers participating from one school, notably they were also all female. Due to the small-scale sample and all comments being subjective to the opinion of the participants, they might not be applicable to all teachers. However, many of these findings were supported by other literature and therefore this adds to the applicability for other teachers.

Remaining impartial and unbiased was important. All comments and findings were subjective to the researcher's own personal agendas, preconceived ideas and intricate ways of conducting and evaluating research (Guillemin & Gillam, 2004). Data analysis was particularly subjective due to its reflexive nature and affected by the researcher's preconceptions. It is noteworthy to consider that although some use of DTC were not deep on DT integration models, I believe any use of DT in teaching, when purposeful and entwined with good learning intentions, is a positive step on a learning journey to DT implementation. This is related to my teaching experiences where I fostered a passion for DT integration and a subsequent small amount of work undertaken in DT and DTC PLD. Therefore, during analysis I tried to ensure the comments remained in the context intended and distinctly related to each theme.

Due to utilising a PAR approach, the researcher was inseparable from the participants and could have influenced their responses. Nevertheless, a large amount of qualitative data was collected and reviewed and two PLD sessions undertaken. Therefore, it is hoped the research will cause lasting change to the participants' use of DTC, by continued development of DTC skills and that the insights gained will be disseminated further (Miller, 1994; Su, 2009).

As PAR aims to empower participants as they become involved and entwined in the study, this could have been very time consuming for them. Time constraints were considered, as teachers participating were full-time with busy classes. Teachers

could have been constrained with their class time on DTC, considering the busy curriculum and need to focus on other necessities of daily teaching and learning. The research was above and beyond their normal classroom expectation and much of it was above the expectation for standard research.

Although participants' comments were their personal views and beliefs and therefore subjective (Efron & Ravid, 2014), the research regarded them as suitable and authentic evidence (Cohen et al., 2007). Consideration was given to participants' behaviour changing depending on the setting, peers or personal emotions on any given day. It is possible elements of a teachers' personal lives or workday could have affected their contributions and motivation. It was noted that during the first focus group participants were particularly enthusiastic. However, the second focus group took place on a particularly hot day, and teachers were noticeably tired and jaded from the heat. Although participants volunteered so could be assumed to have an existing motivation to implement DTC. Additionally, the purposive sampling undertaken in this research was due to the small number of participants but could have also affected the outcomes of the research.

Finally, the school was in a time of change with the principal leaving halfway through the study and an acting principal was at the school for the second phase of the research. Teachers identified that a new principal had been chosen and would be starting the following year; however, there was uncertainty around ongoing staff expectations, particularly with regards to DTC implementation. Keeping in mind these limitations the following further areas for research are indicated.

Further Research

It is not surprising that there is limited research regarding DTC implementation as it is new and only became mandatory in New Zealand in 2020. However, considering this research and its findings, the following areas would warrant further research to gain a deeper understanding of DTC implementation.

- Further research on teachers' DTC misconceptions.
- Further research on teachers' DTC confidence hinderances.

- Further research on the access and availability of government PLD on DTC.

Although there is a large amount of evidence about the barriers to DT integration and the opportunities DT affords, there appears to be little information around the current barriers and benefits to implementing DTC specifically at New Zealand primary school levels. Here, the above areas for further research are explained.

DTC misconceptions are prevalent and appear to impact teachers' confidence around DTC implementation. How and why are these misconceptions arising? Where are these misconceptions coming from? And why is it difficult for schools to overcome these?

Further research regarding teachers' confidence and its impact, specifically aligned with DTC could also be beneficial. Although in this study this appeared to align with teachers' misconceptions, this could differ once put under greater scrutiny. The additional areas of research that might be associated with this are; self-efficacy and the gender divides observed within confidence and self-efficacy and DTC implementation.

Why are teachers not accessing or using the online and facilitator PLD that is available for its intended purpose? Is it too difficult to understand? Is it unclear what is available? Or have funding and access applications been submitted and not been successful? Many of these questions would require a review of several teachers and principals to see where and why the inequity or confusion lies.

A lack of research in the above areas and specifically aligned with DTC implementation would be beneficial. The only official New Zealand report and research found at the time of this study appeared to be EROs report (ERO, 2018) and Duncan, et al. (2018) CT study that specifically aligned to DTC; however, both were conducted prior to DTC becoming mandatory and did not encompass the same elements as this study. Although several news articles do contain aspects of each, these were not official studies with findings, but rather opinion pieces (e.g., Kenny, 2018; Long, 2019; MacGregor-Reid, 2019; Richards, 2018).

This section has identified the need for further research around DTC. Taking these and the limitations of the research into account, with relation to the findings of this study the next section explores and recommends suggested implications for policy and practice.

Implications for Practice and Policy

The conclusions that have been discussed highlight the main findings in this research. Several of them allude to possible changes in policy or practice that could assist with the implementation of DTC. In this final section the implications for practice and policy will be identified, specifically in relation to the two research questions and against the main themes identified in the research and in consideration to the limitations of the study.

Implications for Practice

There is little doubt this study has found a greater need to upskill teachers on DTC. Much of the literature also supports the importance of upskilling teachers' DT through PLD sessions (Castek, 2012; Leary et al., 2016; Sung, et al., 2016). From lack of confidence and clarity, to teachers having the ability and support to embed DTC into their teaching programs continuously, it could be seen that PLD is warranted and might be delivered for a diverse range of components. The data from the study were relatively cohesive regarding the following aspects of PLD for practice:

- Initial PLD focus should be on unpacking DTC content and overcoming misconceptions.
- Initial PLD to be facilitated by outside experts.
- Ongoing PLD could take different forms suitable to teachers' and schools' needs.
- A whole school approach is warranted.

- Ongoing PLD should be multifaceted and not only consider DTC content but also include pedagogy, integration elements and building teachers' confidence.
- Teachers participate in PLD suitable to their DTC level and confidence.

Firstly, PLD needs to focus on clarifying DTC, how it is broken down and its progressions which appeared to be largely misunderstood. Several misconceptions seem prevalent regarding DTC and these therefore DTC should be unpacked to gain greater clarity. This could take place through appropriate PLD, which should support understanding and ease of DTC implementation. Unpacking and identifying DTC could be a waste of valuable time and resources for each individual school. Therefore, initial DTC PLD could be facilitated by expert external agencies which should assist schools with the elements discussed above. I would also argue that initial external PLD would be best delivered to the whole staff for greater clarity, rather than individuals who spend time disseminate information.

Once initial external agency PLD is undertaken, further ongoing PLD would be ideal to maintain consistency and fully embed DTC. In this study, teachers indicated that they wanted continued, broader PLD. Teachers felt that this would help them to maintain their DTC implementation. Although there is limited time for school PLD with a busy curriculum, it was suggested that continuous emphasis is being placed on a narrow curriculum subject matter. Given that DTC is new, schools should employ continued varied PLD mediums such as face-to-face sessions, personal inquiries, and school/peer buddy systems (Kopcha, 2012). Ongoing support could take the form of either; COL focuses; buddy school systems; continued monitoring and support by an external facilitator PLD; or an external facilitator who works with the DTC expert at the school. Other options could be empowering students to become DTC leaders and aid teachers' implementation. Either way continuity is considered important in PLD, as there is "need for ongoing participation in order to process the concepts under consideration and adapt them to her (their) own practice" (Hadar & Brody, 2016).

Participants indicated that they wanted school leaders to value DTC. A whole school DTC initiative is important and would demonstrate leaders' value of DTC, for

it to become embedded in their schools. If school leaders employed some of the above PLD forms, they could in turn demonstrate their ongoing support of DTC implementation. Teachers like to teach things they can see the value in. Often teachers value subject matter that is a school focus and that school leaders also place value on (Pont, et al., 2008; Vongkulluksn, et al., 2018).

Ongoing PLD should be multifaceted and not only consider DTC content, but also pedagogy, integration and building teacher confidence. Through these elements, the research found that they could assist teachers with their implementation of DTC and negate some of the negative affordances. Schools should access relevant, individualised PLD plans that work for their teachers and students' participating in PLD that is suitable to them and facilitates collaboration and ownership. An underlying element here is that first and foremost schools need to focus on the basics of DTC. As Buckingham (2005) mandates, often more can be achieved if we focus on less and this could be relevant for DTC implementation. Next, PLD needs to ensure teachers are experiencing positive outcomes from their DTC implementation, which will subsequently foster greater confidence and motivation to teach DTC (Schunk, 2000).

Implications for Policy

In this section, the implications related to the main themes will be highlighted regarding policy and the following main points unpacked:

- There appears to be lack of clarity around available PLD.
- Resources from MOE need to be more user friendly.
- Initial whole staff PLD is needed for clarity.
- Ongoing PLD, specific to the needs of individual schools and teachers is required and could be mandated.
- Include integration and pedagogy aspects into DTC PLD.
- Encourage whole school initiative and external agency support for DTC to become embedded in schools.
- PLD to foster teachers' confidence.

First and foremost, teachers in this study did not mention the PLD resources the government had made available to schools in the focus group sessions. Teachers indicated they had accessed some of the government websites, however these were not discussed in comments around needing greater clarity on DTC. This implied that teachers were not utilising the DTC PLD provided to schools. These comments are also supported in several articles (Cormick, 2019; ERO, 2019), suggesting there is uncertainty around where and how to obtain suitable PLD by many schools (Cormick, 2019). Consequently, I would recommend that schools are provided with greater clarity around DTC PLD resources. Although perhaps the resources are not known by schools, resources and websites lack clarity for teachers and leaders, or might require a rethink in terms of their layout and content for teacher and school clarity.

Drawing from the evidence found in this project, teachers knew about MOE DTC resources, but these was not being used for their intended purpose. Available websites and resources appear to be difficult to follow, time consuming, confusing and often muddled up with e-learning concepts. I would recommend that there needs to be clearer resources available with clear explanations of DTC and its POs, which is also clearly identifiable from e-learning. These resources could also be clarified at an initial PLD session.

A change in policy could ensure that initially, every school is provided with DTC PLD, therefore all schools and staff are on equitable grounds and obtain a first-point of clarity around DTC. I would also argue here that the current self-evaluative questionnaire that the MOE asks principals to complete to see if they are eligible for DTC PLD is not suitable (MOE, 2020); as schools subjective comments could contain misconceptions regarding their abilities of DTC and therefore hinder their PLD needs.

As stated in the Implications for Practice section, after the initial PLD, there should be opportunities for schools to have ongoing support around DTC, which are relevant; easily accessed; ideally chosen by schools to enable a best fit scenario; include pedagogical approach and integration. This might help schools to consider that DTC should not merely be seen as a standalone subject, as it has the power to

support other learning areas and vice versa, heighten student and staff motivation, and foster 21st century skills (Abdel-Maksoud, 2019; Ahmad, et al., 2008; Delialioglu, 2012; Dewiyani Sunarto, et al., 2019; Hadiyanto, 2019; MOE, 2007). The curriculum is crowded, but policy should place importance on any new curriculum if it is to gain footholds within current teacher and learning.

Another aspect that would be beneficial to embed into DTC PLD would be the pedagogy for delivery. Studies have identified the benefits of constructivist pedagogical approaches, which can assist in implementing DTC (Ertmer, 2005; Ertmer, et al., 2012; Safar, & AlKhezzi, 2013). Through this pedagogical approach teachers no longer need to be the experts, as students construct their own learning through participation (Calvert, 2001; Mustafa & Fatma, 2013). The idea of using this pedagogical approach could have a significant impact on a teacher's confidence, as they might no longer feel the need to be the expert in the room and instead support their students to develop a new learning mindset.

This research found that some of the school's PLD appeared to be mandated by COL or focused on due to a perceived importance by ERO. There was also a suggestion that an ongoing focus of the school's PLD was writing. It is considered here that policy could apply one of two methods to overcome external influence narrowing schools' PLD. Firstly, MOE mandates a broader PLD perspective requirement each year, that is valued by leaders, COL and ERO or other external agencies. Through this method COL supports could play a role in assisting with PLD continuity. A second option for PLD is that policy could emphasise the importance of appropriate PLD geared towards meaningful pedagogy and integration across all subject areas, so DTC focus is to be embedded into other curriculum areas, such as those that hold emphasis or importance (reading, writing and maths). It would be difficult for schools to provide PLD on every subject each year. However, PLD focus on integration and pedagogy could support all learning areas.

The final recommendation is related to confidence and how this appeared to be an important aspect of DTC integration. This researches' evidence suggested teachers' lack of confidence in DTC implementation could be overcome through

appropriate PLD interventions and successful DTC teaching. Therefore, specific PLD interventions that focus on building teacher confidence around DTC would be recommended. Through the literature, we can see that confidence levels (within teachers' beliefs systems) can play an important role in teachers' teaching practices (Duncan, et al., 2018; Ertmer, 2005; McLeod, 2016; Schunk, 2000; Voogt & Knezek, 2008). However, confidence can be obtained from successes (Schunks, 2000). Therefore, by policy ensuring there are multiple opportunities for PLD interventions (which foster simplicity and unpack teachers' misconceptions), teachers would then have time to practice and have success with DTC implementation and subsequently confidence could be increased.

Overall, for both policy and practice this research has found one recurring concept, that all themes hinged on ***appropriate PLD***. Although, this is far more complex than tasking teachers with undertaking their own inquiries or asking staff who have an interest in DT to educate the rest of the staff.

PLD needs to encompass these elements:

- External expert agencies who are available to all schools, to clarify and unpack DTC content and progressions.
- Encourage a collaborative approach amongst staff and other schools.
- Ongoing PLD with a whole school focus, where school leaders acknowledge DTC value.
- Explores DTC integration and pedagogy.
- Focus on building gradual success in teaching DTC to build confidence.

Table 5. Aspects identified in this study that PLD should encompass for successful DTC implementation.

The implications for policy and practice have been identified above. Although there are many areas that cross overs between both policy and practice, this demonstrates that schools and government agencies could work towards a common goal to embed DTC into teaching and learning practices.

The first part of this chapter aimed to synthesise the research findings, drawing links and conclusions. Secondly, it has highlighted new findings of the research and identified areas where it is believed other research would be valuable regarding implementing DTC. After identifying the limitations, the suggested areas for further research are discussed. The chapter finally identifies implications for both policy and practise that have been drawn from the conclusions. With one of the overarching implications being that suitable DTC PLD needs to be accessible for DTC to overcome many of the affordances in its implementation.

Final Words

There is no doubt that DT is creating changes to our society and our schools. DT has been part of the New Zealand Curriculum as e-learning since 2007 (MOE, 2007), with components of ICT existing since 1995 (MOE, 1995). However, in 2020 new DTC have been added to the technology subject area. The new DTC aim to assist students in becoming creators of DT, rather than passive users. There are multiple barriers and benefits associated with DT implementation, each affecting what teachers and schools can achieve. Much of the literature around DT implementation focuses on DT overall and not on DTC, which are becoming mandatory parts of curriculum not only in New Zealand but around the world.

The study has aimed to answer: *How are New Zealand's provincial city primary teachers implementing the new technology curriculum's digital components (DTC) into their classroom practice?* With the following two sub questions posed: *What affordances will primary school teachers find during their DTC journey of adoption?* And *how does a PLD intervention help facilitate/enable teachers' implementation of DTC?*

In the process of this research, several aspects have been identified as affecting teachers' DTC implementation, and how a PLD intervention has enabled/facilitated them with this. The study utilised a PAR methodology and enabled the participants to have ownership and personally benefit from the study. The main affordances

which appear to affect implementation have been identified as; teacher knowledge, integration and confidence. Many of these can be overcome or strengthened by appropriate PLD which builds both confidence and is ongoing and individualised to schools' needs. The PLD sessions chosen by participants also demonstrated how a PLD could help/facilitate DTC implementation, by improving clarity around DTC content and subsequently improving teachers' knowledge and confidence. This project is likely to be of value to schools, teachers and policy makers who are tasked with building teachers' knowledge on DTC. While there are several articles that articulate the importance of DTC, there is limited research about the implementation of DTC, particularly from a primary school teacher's perspective.

This project's findings justify the need for greater research into DTC implementation to aid teachers in overcoming misconceptions and gaining confidence and accessibility to PLD. My personal hope and agenda in completing this project, is that it will help schools, policy makers and ultimately teachers to implement not only DTC but DT into classrooms with greater clarity and confidence. An aspiration for these findings is that the need for the adoption of DT and DTC will be taken seriously in schools; so the students of today are not disadvantaged as the workers of tomorrow, and the digital divide is not able to prevail. Instead students will be encouraged to foster meaningful DT and DTC skills, and become well informed and equipped to deal with the social and professional needs they will face as digital citizens.

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Appendices

Appendix A: Computational thinking Progress Outcomes 1-8

Progress outcome 1:In authentic contexts and taking account of end-users, students use their decomposition skills to break down simple non-computerised tasks into precise, unambiguous, step-by-step instructions (algorithmic thinking). They give these instructions, identify any errors in them as they are followed, and correct them (simple debugging).

Progress outcome 2: In authentic contexts and taking account of end-users, students give, follow and debug simple algorithms in computerised and non-computerised contexts. They use these algorithms to create simple programs involving outputs and sequencing (putting instructions one after the other) in age-appropriate programming environments.

Progress outcome 3: In authentic contexts and taking account of end-users, students decompose problems into step-by-step instructions to create algorithms for computer programs. They use logical thinking to predict the behaviour of the programs, and they understand that there can be more than one algorithm for the same problem. They develop and debug simple programs that use inputs, outputs, sequence and iteration (repeating part of the algorithm with a loop). They understand that digital devices store data using just two states represented by binary digits (bits).

Progress outcome 4: In authentic contexts and taking account of end-users, students decompose problems to create simple algorithms using the three building blocks of programing: sequence, selection, and iteration. They implement these algorithms by creating programs that use inputs, outputs, sequence, basic selection using comparative operators, and iteration. They debug simple algorithms and programs by identifying when things go wrong with their instructions and correcting them, and they are able to explain why things went wrong and how they fixed them. Students understand that digital devices represent data with binary digits and have ways of detecting errors in data storage and transmission. They evaluate the efficiency of algorithms, recognising that computers need to search and sort large amounts of data. They also evaluate user interfaces in relation to their efficiency and usability.

Progress outcome 5: In authentic contexts and taking account of end-users, students independently decompose problems into algorithms. They use these algorithms to create programs with inputs, outputs, sequence, selection using comparative and logical operators and variables of different data types, and iteration. They determine when to use different types of control structures. Students document their programs, using an organised approach for testing and debugging. They understand how computers store more complex types of data using binary digits, and they develop programs considering human-computer interaction (HCI) heuristics.

Progress outcome 6: In authentic contexts and taking account of end-users, students determine and compare the “cost” (computational complexity) of two iterative algorithms for the same problem size. They understand the concept of compression coding for different media types, its typical uses, and how it enables widely used technologies to function.
Students use an iterative process to design, develop, document and test basic computer programs. They apply design principles and usability heuristics to their own designs and evaluate user interfaces in terms of them.

Progress outcome 7: In authentic contexts and taking account of end-users, students analyse concepts in digital technologies (e.g., information systems, encryption, error control, complexity and tractability, autonomous control) by explaining the relevant mechanisms that underpin them, how they are used in real world applications, and the key problems or issues related to them.
Students discuss the purpose of a selection of data structures and evaluate their use in terms of trade-offs between performance and storage requirements and their suitability for different algorithms. They use an iterative process to design, develop, document and test advanced computer programs.

Progress outcome 8: In authentic contexts and taking account of end-users, students evaluate concepts in digital technologies (e.g., formal languages, network communication protocols, artificial intelligence, graphics and visual computing, big data, social algorithms) in relation to how key mechanisms underpin them and how they are applied in different scenarios when developing real world applications.
Students understand accepted software engineering methodologies and user experience design processes and apply their key concepts to design, develop, document and test complex computer programs” (Ministry of Education, 2017b, p. 11-13).

Appendix B: Designing and Developing Digital Outcomes Progress Outcomes 1-8

Progress outcome 1
In authentic contexts and taking account of end-users, students participate in teacher-led activities to develop, manipulate, store, retrieve and share digital content in order to meet technological challenges. In doing so, they identify digital devices and their purposes and understand that humans make them. They know how to use some applications, they can identify the inputs and outputs of a system, and they understand that digital devices store content, which can be retrieved later. 24

Progress outcome 2
In authentic contexts and taking account of end-users, students make decisions about creating, manipulating, storing, retrieving, sharing and testing digital content for a specific purpose, given particular parameters, tools, and techniques. They understand that digital devices impact on humans and society and that both the devices and their impact change over time.
Students identify the specific role of components in a simple input-process-output system and how they work together, and they recognise the "control role" that humans have in the system. They can select from an increasing range of applications and file types to develop outcomes for particular purposes.

Progress outcome 3
In authentic contexts, students follow a defined process to design, develop, store, test and evaluate digital content to address given contexts or issues, taking into account immediate social, ethical and end-user considerations. They identify the key features of selected software and choose the most appropriate software and file types to develop and combine digital content.
Students understand the role of operating systems in managing digital devices, security, and application software and are able to apply file management conventions using a range of storage devices. They understand that with storing data comes responsibility for ensuring security and privacy.

Progress outcome 4
In authentic contexts, students investigate and consider possible solutions for a given context or issue. With support, they use an iterative process to design, develop, store and test digital outcomes, identifying and evaluating relevant social, ethical and end-user considerations. They use information from testing and apply appropriate tools, techniques, procedures and protocols to improve the quality of the outcomes and to ensure they are fit-for-purpose and meet end-user requirements.

Progress outcome 5
In authentic contexts and with support, students investigate a specialised digital technologies area (e.g., digital media, digital information, electronic environments, user experience design, digital systems) and propose possible solutions to issues they identify. They independently apply an iterative process to design, develop, store and test digital outcomes that enable their solutions, identifying, evaluating, prioritising and responding to relevant social, ethical and end-user considerations.

They use information from testing and, with increasing confidence, optimise tools, techniques, procedures and protocols to improve the quality of the outcomes. They apply evaluative processes to ensure the outcomes are fit-for-purpose and meet end-user requirements.

Progress outcome 6
In authentic contexts, students independently investigate a specialised digital technologies area and propose possible solutions to issues they identify. They work independently or within collaborative, cross-functional teams to apply an iterative development process to plan, design, develop, test and create quality, fit-for-purpose digital outcomes that enable their solutions, synthesising relevant social, ethical and end-user considerations as they develop digital content.
Students integrate in the outcomes they develop specialised knowledge of digital applications and systems from a range of areas, including: network architecture; complex electronics environments and embedded systems; interrelated computing devices, hardware and applications; digital information systems; user experience design; complex management of digital information; and creative digital media.

(Ministry of Education, 2017b, p. 23-24)

Appendix C: Letter to the Principal requesting permission for the project and consent form returned to researcher

Kate Rhodes
The University of Waikato, Tauranga
Private Bag 3105
Hamilton 3240
15/7/2019

The Principal
xxxxxxxx

Dear xxxxx
I am writing to request permission to work with three teachers and their classes on a small action research-based project in your school:*Teachers' journeys of adoption: Implementation of New Zealand's new (2020) Digital Technology curriculum into a provincial city primary school.* The aim of the research is to better understand how teachers are implementing the digital technology curriculum which will be mandatory for NZ primary-school aged children in 2020 (see http://nzcurriculum.tki.org.nz/The-New-Zealand-Curriculum/Technology).

The project will work with teachers through an action research approach, carrying out a critical analysis to ascertain potential problems implementing the curriculum, providing professional development to assist with its implementation and reviewing teachers' personal progress of implementation. Through using the action research process the project can be utilised as teachers' individual inquiries for the year and therefore aims to be minimal additional work. In order to achieve the aim of the study teachers will be asked to complete a pre and post research questionnaire (15 minutes each), participate in up to five focus group meetings of which two will involve professional development around the new curriculum (one and a half hours each), each class taking part (including students) will be videoed working on an aspect of the digital curriculum (twice for forty five minutes). Therefore, consent will also be sought from parents and students in these classrooms.

This research has been approved by the Faculty of Education Human Research Ethics Sub-
committee of the University of Waikato. The outcome of the study may be presented in academic journals and at conferences. All information about the participants will be treated confidentially, with pseudonyms. While every effort will be made to ensure confidentiality, this can't be guaranteed. Participants have the right to withdraw at any time during the study up until the analysis has begun. At the end of the study, a copy of the researches' findings will be sent to your school.
If you wish to contact me directly for further clarification, please call me at +64 210338890 or email me at ktleg99@gmail.com. If there is a need, you may contact my supervisor at Waikato University: AProf Nigel Calder at nigel.calder@waikato.ac.nz
Thank you.
Yours faithfully

Kate Rhodes
This research has been approved by the University of Waikato Faculty of Education Ethics Committee on [date]. Approval number: FEDU015/19.

Consent Form
Project title: *Teachers' journeys of adoption: Implementation of New Zealand's new (2020) Digital Technology curriculum into a provincial city primary school*
Please tick the boxes if you agree with the following:

- I have read and understood the information sheet that provides information and explanation of the nature and purpose of the research project.
- I consent for the school to participate in this study.
- I understand that I may withdraw the school from the research project at any stage, up
  until the analysis has begun.
- I understand that the school's participation in this study is confidential and that no material, which could identify the school or teachers, will be used in any reports on this study.
- I consent to participating classes being videoed completing specific digital technology activities.

Name of Principal:……

Signature……Date……

This research has been approved by the University of Waikato Faculty of Education Ethics Committee on [date]. Approval number: FEDU015/19.

Appendix D: Information Letter and consent form for Staff Participants

Kate Rhodes
The University of Waikato, Tauranga
Private Bag 3105
Hamilton 3240
15/7/2019
Dear Teachers
I am writing to request permission to work with you and your classes on a small action research-based project:*Teachers' journeys of adoption: Implementation of New Zealand's new (2020) Digital Technology curriculum into a provincial city primary school.* The aim of the research is to better understand how teachers are implementing the digital technology curriculum which will be mandatory for NZ primary-school aged children in 2020 (see http://nzcurriculum.tki.org.nz/The-New-Zealand-Curriculum/Technology).

The project will work with teachers through an action research approach, carrying out a critical analysis to ascertain problematic tendencies of the curriculum, providing professional development to assist with its implementation and reviewing teachers personal progress of implementation. Through using the action research process the project can be utilised as teachers individual inquiries for the year and therefore aims to be minimal additional work. In order to achieve the aim of the study teachers will be asked to complete a pre and post research questionnaire (15 minutes each), participate in up to five focus group meetings of which two will involve professional development around the new curriculum (one and a half hours each), each class taking part (including students) will be videoed working on an aspect of the digital curriculum (twice for forty five minutes). Therefore consent will also be sought from parents and students in these classrooms.

This research has been approved by the Faculty of Education Human Research Ethics Sub-
committee of the University of Waikato. The outcome of the study may be presented in academic journals and at conferences. All information about the participants will be treated confidentially, with pseudonyms. While every effort will be made to ensure confidentiality, this can't be guaranteed. Participants have the right to withdraw at any time during the study up until the analysis has begun. At the end of the study, a copy of the researches' findings will be sent to your school.
If you wish to contact me directly for further clarification, please call me at +64 210338890 or email me at ktleg99@gmail.com. If there is a need, you may contact my supervisor at Waikato University: AProf Nigel Calder at nigel.calder@waikato.ac.nz
Thank you.
Yours faithfully

Kate Rhodes

This research has been approved by the University of Waikato Faculty of Education Ethics Committee on [date]. Approval number: FEDU015/19.

Consent Form
Project title: *Teachers' journeys of adoption: Implementation of New Zealand's new (2020) Digital Technology curriculum into a provincial city primary school*

Please tick the boxes if you agree with the following:

- I have read and understood the information sheet that provides information and explanation of the nature and purpose of the research project.
- I volunteer to participate in this study.
- I understand that I may withdraw from the research project at any stage, up until the analysis has begun.
- I understand that my participation in this study is confidential and that no material, which could identify me personally, will be used in any reports on this study.
- I understand that the interview will be audio recorded.
- I consent to my class being videoed when completing specific digital technology activities.

Name of participant:……

Signature……Date……
This research has been approved by the University of Waikato Faculty of Education Ethics Committee on [date]. Approval number: FEDU015/19.

Appendix E: Information Letter and consent for Parents to allow their children to participate in the project.

Kate Rhodes
The University of Waikato, Tauranga
Private Bag 3105
Hamilton 3240
15/7/2019

Dear Parent/Caregiver
I am writing to request permission to work with your child on a small action research-based project in your school:*Teachers' journeys of adoption: Implementation of New Zealand's new (2020) Digital Technology curriculum into a provincial city primary school.* The aim of the research is to better understand how teachers are implementing the digital technology curriculum which will be mandatory for NZ primary-school aged children in 2020 (see http://nzcurriculum.tki.org.nz/The-New-Zealand-Curriculum/Technology).

In order to achieve the aim of the study, your child will be observed and video-recorded using digital technology resources specified by their teacher (twice for 45 minutes). The work they do will be part of their usual classroom programme and a part of the New Zealand Curriculum.

This research has been approved by the Faculty of Education Human Research Ethics Sub-committee of the University of Waikato. The outcome of the study may be presented in academic journals and at conferences. All information about the participants will be treated confidentially, with pseudonyms used. However, while every effort will be made to ensure confidentiality, this can't be guaranteed. Participants have the right to withdraw at any time during the study up until the analysis has begun. At the end of the study, a copy of the researches' findings will be sent to xxxx school.
If you wish to contact me directly for further clarification, please call me at +64 210338890 or email me at ktleg99@gmail.com. If there is a need, you may contact my supervisor at Waikato University: AProf Nigel Calder at nigel.calder@waikato.ac.nz
Thank you.
Yours faithfully

Kate Rhodes

This research has been approved by the University of Waikato Faculty of Education Ethics Committee
on [date]. Approval number: FEDU015/19.

Project title: *Teachers' journeys of adoption: Implementation of New Zealand's new (2020) Digital Technology curriculum into a provincial city primary school*
Please tick in the boxes if you agree with the following:

- I have read and understood the information sheet that provides information and explanation of the nature and purpose of the research project.
- I consent for my child to participate in this study.
- I understand that I may withdraw my child from the research project at any stage, up until the analysis has begun.
- I understand that my child's participation in this study is confidential and that no material, which could identify them personally, will be used in any reports on this study.

- I understand that the digital technology lessons my child participates in will be video-recorded.

Name of participant:……
Name of parent:……

Signature……Date……
This research has been approved by the University of Waikato Faculty of Education Ethics Committee on [date]. Approval number: FEDU015/19.

Appendix F: Information and Assenting Form for Students

Kate Rhodes
The University of Waikato, Tauranga

Dear Student

Compulsory coding in New Zealand schools: *Teachers' journeys of adoption: Implementation of New Zealand's new (2020) Digital Technology curriculum into a provincial city primary school.*
I am happy for Kate Rhodes to:

Film me working in the class		
Take copies of my work		
Use my comments		

I understand that if I do not want to my work or comments used I can say so.

Name:……

Signature……

This research has been approved by the University of Waikato Faculty of Education Ethics Committee on [date]. Approval number: FEDU015/19.

Appendix G: Focus group Questions Lead Questions and Possible prompts for Focus Groups

1. **Group Activity to engage participants:** Can you write as many things that come to mind as possible when we say “digital technology” (brainstorm activity - large paper provided)
2. What knowledge do you have about the new Digital Curriculum?
3. How might we include more elearning in our classroom programmes?
4. How might we include e learning that enables students to be creators of technology rather than passive users?
5. Where do you think are key areas to integrate the digital curriculum?
6. What have you already done that could be in the digital curriculum?
7. What do you think are your personal next steps for the new curriculum implementation?
8. What would be your main focus to implement this curriculum?
9. What professional development would you like to help with this curriculum?
10. Do you have any concerns about its implementation?
11. What do you think will be the main benefits of the new curriculum?
12. Where do you feel you personally sit on this e learning framework? Why did you choose that phase? (Teachers have already been asked this in their pre research questionnaire but will be asked to expand on their answer and explain their choices).
13. **Group activity:** Where do you think your school sits on this e learning framework? Why did you choose that phase? (Teachers have already been asked this in their pre research questionnaire but will be asked to expand on their answer and explain their choices)

Phases of the e-Learning Planning Framework
Key characteristics of the phases
Pre-emerging: There may be little awareness of what e-learning is or the role it can play in teaching and learning. No deliberate actions may yet have been taken to explore e-learning. The use of technologies may be ad hoc, and there may be no reference to technologies in the school’s strategic planning.
investigating, raising awareness, and planning

Emerging: Your school may be focusing on investigating, raising awareness, and planning for ways to integrate technologies in your school's vision and curriculum. You may be finding out about particular technologies and their use across the dimensions. In the classroom, you may see technologies added on to teacher-directed tasks possibly as a substitute for non-digital approaches.
trialing and establishing

Engaging: Your school may be focusing on establishing and connecting planning across the school as well as trialing ways to use technologies appropriately to meet staff, community, and students’ needs. In the classroom, you may begin to see technologies used as part of higher-order (deep), collaborative teaching, and learning. The technologies begin to improve aspects of the learning experience.
effectively aligned processes and practices

Extending: Your school may have effectively aligned processes and practices across the school and community. The use of technologies is appropriate and allows significant adaptation of learning experiences to meet all learners' needs. In the classroom, teachers

and students may work together to use technologies as part of authentic, higher order, co-constructed learning.
technologies make new ways of learning possible

Empowering: Your school and community regularly plan, review, and evaluate in partnership. Technology use is "anytime, anywhere", virtual, open, and equitable. It enhances needs-based, co-constructed learning within and beyond the school community. In the classroom, technologies make new ways of learning possible. It is collaborative, personalised, higher-order, and embedded in the real world.

From: http://www.elearning.tki.org.nz/Professional-learning/e-Learning-Planning-Framework

Appendix H: Phase One Codes and their recurrence

Code	Number of times codes were mentioned in focus group meeting
Access	1
Access to Professional Development	1
Big picture	1
Comparison against other schools	1
Convenience	1
Critical thinking	1
Crowded Curriculum	1
Different levels of students	1
Digital Natives	1
Exemplars	1
Expectations	1
Funding	1
Instructions	1
Kahoot	1
Organisation	1
Planning	1
Problem solving	1
Students content knowledge	1
Unplugged	1
When to implement what	1
Competence	2
CT	2
DDO	2
Debugging	2
Interpreting the curriculum	2
Sharing	2
Tools /devices	2
What do students need to know	2
What should teachers do	2
Maths	3

Models of DT integration	3
Previous DT experience	3
Robotics	3
Scratch	3
Sequencing	3
Tech as a tool	3
Vagueness	3
Professional Development	4
Resources	4
Technology Advancement	4
Creativity with technology	6
Students previous DT experience	6
What and how in depth	6
Pedagogy	7
Time	8
Coding	9
Curriculum knowledge	9
Confidence	11
Progressions	11
Curriculum Content	14
Integration Designing	17
Knowledge broad sense or DT, curriculum and other experience	18

Appendix H: Phase two Codes and their recurrent themes

Codes	Recurrence
Assessment	1
Curriculum	1
Student's knowledge	1
Life skills	1
Whole school	1
Devices	1
Algorithms	1
Team work	1
Consistency	1
Valuable	1
Literacy	1
Repetition	1
Changing	1
Skratch	1
Vocabulary	1
Support	2
Focus	2
Create	2
Code	2
Future proofing	2
School focus	2
21st century skill	2
Writing	2
Theme based learning	2
Sharing	2
Knowledge of resources	2
Confidence	3
Sustainability	3
Instructions	3

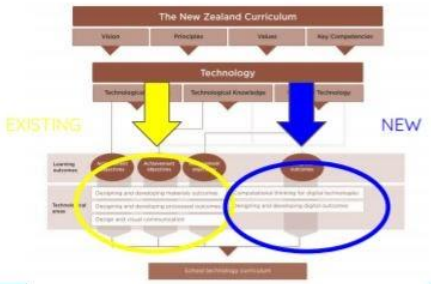
Decoding	3
Inquiry	3
Oral language	4
planning	4
Math	4
Unplugged	5
Consistency	5
Time	6
Purposeful	6
Simple	6
Debug	7
Resources	7
PD	8
Sequencing	8
CT	10
DDO	11
Integration	24

Appendix J: Goals and Reflections from phase one and two

	Laura	Cacey	Mia
Goal 1	Integrate (CT) po1 into different aspects of the curriculum such as maths, writing, oral language etc.	Be aware of how, where I am using, and when I can use (CT) PO1 in daily planning and teaching. Unplugged teaching.	To implement non-computerised activities into my teaching and learning tasks that align with the digital technology's curriculum.
Reflection 1	It has been very useful to learn more about the digital technologies curriculum and how it can fit in with other curriculum areas. It has also been good to find out that the biggest focus for children in Primary is unplugged activities. It has also been helpful to learn that we are addressing the digital technologies curriculum in many ways already. I would like to learn further ways in which I can include the Designing and developing digital outcomes area of the digital technology's curriculum into my classroom programme as well. My class has really enjoyed the different activities we have completed to address Po1 so far. It has been challenging but beneficial for the children to complete unplugged activities and has helped them	It has been great to be introduced to the digital technology curriculum in a small group with Kate. I am beginning to see where the digital technology outcomes will fit into the learning and teaching, we are already doing. The unplugged component of the DT curriculum will be something that I think will be easy to integrate with many other activities we do with junior children- particularly with oral language activities- which has been our focus for the last two years. Using the language and sharing the knowledge of how and why we use digital devices - outcome 1- instead of just using them will be a goal for me and the children in future teaching around the digital technology curriculum. For future learning for myself I would like to think about ways to integrate, use outcome 2 into my teaching.	So far I feel as though my students have varied knowledge around what is involved with the D.T. curriculum. Now that we have moved from just using digital devices to understanding how and why to use them, they as well as me have gained much more insight. I've tailored my lessons around more unplugged lessons this year with the occasional use of bots to consolidate those learnings. By tackling the teaching and learning this way, I think it has been more beneficial for my own learnings and also for student understanding, particularly around computational thinking and the steps involved and how this can affect the overall outcome. My class has found the sorting network activities really fun particularly as they become more challenging. After today's lesson and observation, we are going to create our own e.g. Roman Numerals, Greek Alphabet,

	to develop their understanding of computational thinking. I plan to continue to focus on simple unplugged activities whilst including some device based activities as well.		coins/notes etc. This will be interesting to see and was great to hear the ideas they had! Really enjoying teaching and learning this year around the D.T. curriculum! Reflecting on future practice, I would like to link my unplugged activities/lessons more to follow up with a device based lessons and make the link between the two.
Goal 2	Introduce concepts of DDO progress outcome one - design an app that could help someone plan a party or celebration	To introduce DDO vocab from progress outcome one. Input, output, end users, store, retrieve when using Seesaw to share work with our whanau. Sharing a piece of work on Seesaw - cards we made for retirement village. manaakitanga Use vocab when discussing sharing of our work.	Designing a digital concept e.g. robot, game, app etc. - link it to topic learning this term- beach safety (amphibious beach buggy to help with rescues)
Reflection 2	I feel more confident implementing the digital technologies curriculum after these lessons. It's less daunting than I originally thought. I do feel I need to continue to work on DDO to develop my own confidence further.	I feel that the DDO curriculum isn't as big a deal as we first thought looking at it. I can see ways we can integrate through our weekly teaching- now the goal will be to know the curriculum better, so I am aware of what I am doing in the classroom has a DDO component in it.	Meeting with Kate, as well as working alongside Cacey and Laura really helped with understanding and putting into practice both outcomes. Overall it was really good to see how simply it can be implemented and that without our knowledge, in some way we were each already incorporating aspects of the curriculum in our practice.

Appendix K: Phase One Professional Learning Development Session Presentation



Two New Technology AOs/POs

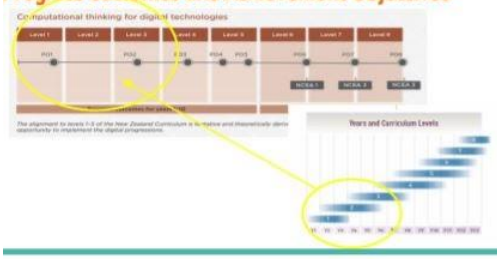
Instead of calling them Achievement Objectives

MOE have decided to call them Progress Outcomes :O)

Computational Thinking for Digital Technologies

Designing and Developing Digital Outcomes

Progress outcomes and Achievement Objectives



Progress Outcome One

In authentic contexts and taking account of end-users, students use their decomposition skills to break down simple non-computerised tasks into precise, unambiguous, step-by-step instructions (algorithmic thinking). They give these instructions, identify any errors in them as they are followed, and correct them (simple debugging).

Algorithm vs Programme

Algorithm

- Turn to person next to you,
- make eye contact and smile
- Bring your hand up (palm out)
- Move your hand in an arc pattern, side to side

Algorithm

Set of instructions for solving a problem

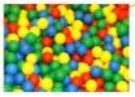
Algorithms are not language dependent or computer dependent

Programme

Using a language the computer understands

Ball Pass

1. Sit in a circle distribute the balls evenly -
2. No one can have 2 of the same colour
3. One person will only have one ball



- ONLY passing to the people next to you
- One move/pass at a time
- Pass the balls around so you end up with each person having two balls of the same colour

Computational Thinking

Computational thinking is a two-step process:

1. Identify the steps needed to solve a problem.
2. Use your technical skills to get the computer "working" on the problem.

For example, if you're going to make a video animation, you need to:

1. start by planning the storyboard
2. then, use computer hardware and software to help you get the work done.

The thinking undertaken before starting work on a computer is computational thinking.

CAS Barefoot

1 - Computational Thinking

Computational thinking enables students to express problems and formulate solutions in ways that means a computer (an information processing agent) can be used to solve them.

In this area, students develop algorithmic thinking skills and an understanding of the computer science principles that underpin all digital technologies. They become aware of what is and isn't possible with computing, allowing them to make judgments and informed decisions as citizens of the digital world.

Students learn core programming concepts and how to take advantage of the capabilities of computers, so that they can become creators of digital technologies, not just users. They develop an understanding of how computer data is stored, how all the information within a computer system is presented using digits, and the impact that different data representations have on the nature and use of this information.

ACTIVITY:
In groups of three - deconstruct this, simplify or put into bullet points. Discuss what each part means. Can you think of examples as you go?

Computational Thinking

- Enables students to express problems and formulate solutions in ways that a computer understands.
- Students develop algorithmic thinking skills and an understanding of the computer science principles.
- Become aware of what is and isn't possible with computing, make judgments and informed decisions digital citizens.
- Students learn core programming concepts and become creators of digital technologies, not just users. Develop an understanding of how computer data is stored, how all the information is presented using digits. The impact that different data representations have on the nature and use of this information.

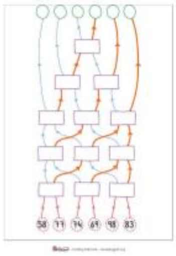
Activity

SORT THE NUMBERS

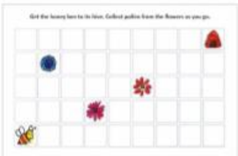
- Big follows orange
- Small follows blue

This is what a computer does - it is given a simple instruction that it repeats… and repeats… and repeats until it has reached the desired outcome (output).

What other ways could we use this simple sorting machine with our students?
From: CS Unpluged



Activity



What language will you use?

1. ARROWS
2. WORDS
3. SENTENCES

Get the bee to the hive using the squares, the bee must collect pollen from all flowers on the way.

How else could we use this in our class?
From: TKI exemplars for PO1

Activity
Creating Activities - Google drive

Activity	Link to other curriculum	Year Level appropriate?
Write out instructions for waving (algorithm) (replace waving with any other task). Ask friend to follow instructions and find any mistakes (debugging).	Literacy	1-6
	https://docs.google.com/spreadsheets/d/1lap7cJPbxdJP72Su9mdMnoBlku5CCbnV63NyITvT8Cs/edit?usp=sharing	

Other Examples PO 1

- http://technology.tki.org.nz/Technology-in-the-NZC/CT-Progress-outcomes-exemplars-and-snapshots
- https://docs.google.com/spreadsheets/d/1C9bC85TW7OQSHll6G0GLlwJguBPFvX7OSjCNkJEAD7k/edit?usp=sharing
- https://nzdigitalcurriculum.weebly.com/coding-without-a-computer.htm
- http://elearning.tki.org.nz/Teaching/Curriculum-areas/Digital-Technologies-in-the-curriculum#js-tabcontainer-1-tab-3
- https://www.digitaltechnologieshub.edu.au/teachers/assessment/assessment-framework/achievement-standards
- c

PO 2

In authentic contexts and taking account of end-users, students give, follow, and debug simple algorithms in computerised and non-computerised contexts. They use these algorithms to create simple programs involving outputs and sequencing (putting instructions one after the other) in age-appropriate programming environments.

Activity: What is the main difference between this and PO1?

Activity
Creating Activities - Google drive

Activity	Link to other curriculum	Year Level appropriate?
Write out instructions for waving (algorithm) (replace waving with any other task). Ask friend to follow instructions and find any mistakes (debugging).	Literacy	1-6
	https://docs.google.com/spreadsheets/d/15vySWIAS_94eJp0Rs01_rBdD8S41ZWaFrEsbcg-Ve4o/edit?usp=sharing	

Benefits - Activity

What are the benefits to this?

Why teach it?

Why is it important children learn this?

In groups create a brainstorm on the importance of using Digital Technology in the class both for E-learning AND the Digital curriculum?

Goals??

Activity

Digital Divide

One of the most striking findings of this study is that the digital divide in education goes beyond the issue of access to technology. A second digital divide separates those with the competences and skills to benefit from computer use from those who do not. These competences and skills are closely linked to students' economic, cultural and social capital. This has important implications for policy and practice. Governments should clearly convey that computer use matters for the education of young people, and they should do their best to engage teachers and schools in raising the frequency of computer use to a relevant level. Such an increase would not only be a clear indication of teachers' and schools' implication in the development of 21st century skills and competences, it would also lead to gains in educational performance.

Pedró, F., & Organisation for Economic Co-operation Development. (2010). *Are the new millennium learners making the grade? technology use and educational performance in PISA*. (Educational research and innovation). Paris: Centre for Educational Research and Innovation, OECD.