University of New England

Learning in the Age of Distraction: Assessing the efficacy of technology integration on adolescent learning

A dissertation submitted by

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Abstract

Technology permeates daily life to the extent that, in modern western civilisation at least, its prevalence is tantamount to society's dependence on electricity or running water. Its ubiquitous role has significant implications for how society functions and interacts, and this is no more evident than in the ever-evolving landscape of education. If educators are to cater to an audience that has developed a diet for rich, interactive, and engaging technology use as part of their learning experience, a range of considerations must be afforded to its integration.

This mixed methods research sought to identify how varying levels of access to technology affect retention of lesson content and how the key educational stakeholders in parents, teachers and students perceived the efficacy of technology for learning. The mixed methods research uses quantitative measures to provide an insight into how Australian secondary school retain lesson content under different conditions of technology use within the Year 10 science classroom. The three procedures, or instructional methods, from the traditional pen and paper method of note-taking, to an unrestricted approach where students were permitted to use their device for whatever purpose they saw fit, were implemented in a naturalistic quasi-experimental design. Students were presented video content as part of their lessons, with a subsequent test used to measure their content retention under the varying conditions. Quantitative analysis found that students at School A (all boys) and School B (all girls) were not impeded by any technological distraction to a statistically significant extent. Qualitative semi-structured interviews gathered insights on the perceived efficacy of ICT integration from the three key educational stakeholders in parents, teachers, and students. Whilst opinions varied between individuals across all groups, the recurring theme of perceived distraction proved to be the greatest concern for learning. The incongruity between the quantitative results and the qualitative responses highlighted that negative perceptions can often skew how ICT's efficacy is valued as a learning tool. Harnessing the educational benefits of ICT integration, whilst attenuating the distractive allure that so often impedes the ability to focus on content, proves to be a significant challenge presented to both teachers, parents, and students alike.

Certification of Dissertation

I certify that the ideas, experimental work, results, analyses, software and conclusions reported in this dissertation are entirely my own effort, except where otherwise acknowledged. I also certify that the work is original and has not been previously submitted for any other award, except where otherwise acknowledged.

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30/07/19

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Chapter 1: Introduction

The ways we communicate, work, educate and socialise are underpinned by interconnected information systems that ensure communities can function in the modern world. Digital technology has become so integral to society that its role can often be invisible. Philosopher Clay Shirky suggests that the Internet has permeated our lives to such an extent that it is becoming impossible to see:

> Imagining today minus the Net is as content-free an exercise as imagining London in the 1840s with no steam power, New York in the 1930s with no elevators, or L.A. in the 1970s with no cars. After a while, the trellis so shapes the vine that you can't separate the two. (Shirky, as cited in Snow, 2016, p. 1)

Just like 21st century expectations for basic electricity and plumbing to be present and functioning, the reliance on technology to work is paramount to civilised societies. It facilitates transactions, security, businesses, telecommunications, travel, infrastructure and societal needs, all of which are highly dependent on systems that are working in the background. We only become cognisant of these invisible technologies when there is a fault, breach or failure in their functioning. Security breaches and system crashes can send communities into crisis mode and it is moments like these that remind us how dependent we are on technology to function. Yet, the digital age and all its permutations bring with it critics and derision relating to how we are dumbing down future generations (Courage, Bakhtiar, Fitzpatrick, Kenny, & Brandeau, 2015; Greenfield, 2015).

Our reliance on instantaneous gratification (Greenfield, 2015), an absence of empathy in online communication (Turkle, 2017), shallow exploration of rich information (Carr, 2011), and a reliance on outsourcing memory and the responsibility of recollection to an external, yet readily accessible, data source that can do the hard work for us (Sparrow, Liu, & Wegner, 2011), are all cause for concern. However, the solution purported by many to remedy this technological overload with its removal is neither a viable, nor logical, solution to a society that is so dependent on technology to function (Colker, 2017). Futurist and academic, Yuval Noah Harari (2017, p. 1), predicts that advancements in technology will produce a 'useless class' by 2050, where those who have not adapted to a digital way of life will not only be unemployed, but unemployable. Nowhere is this more prescient than in our schools, where teachers are faced with the task of integrating technology into their teaching strategies, whilst being aware of the challenges it can present to the learning process (Erstad, Eickelmann, & Eichhorn, 2015; Selwyn, 2012b).

The Organisation for Economic Cooperation and Development (OECD) advises that classroom technology is not necessarily the silver bullet. In research spanning over 40 countries, it was found that students who spent an above-average length of time on a computer at school scored lower on the same test than students who did not use a computer at all (Peña–López, 2015). Therefore, the success of technology in education is not simply in its mere presence, but in how it is used.

The ubiquity of technology demands that educators are constantly at the forefront of effective information and communication technology (ICT) integration to cater to the world of the digital native (Prensky, 2010). Teachers are therefore mandated to perpetually adapt to the rapid pace with which technology advances. It is imperative for schools to not only provide students with access to technologically rich resources, but to educate them in how to use them appropriately.

A paucity of relevant studies, specific to the impact of technology on adolescent learning, has led to this research. Presently, there are a range of studies undertaken in higher education environments that highlight the cognitive demands that dual tasking has on effective comprehension of learning materials (Aagaard, 2015a; Beland & Murphy, 2016; Dietz & Henrich, 2014; Fried, 2008). However, every tertiary student was once a secondary student. Therefore, attention needs to be afforded to the learning habits and behaviours of students before they enter higher education, where metacognitive strategies and an ability to self-regulate become a greater responsibility for the individual, and not the classroom teacher, to monitor (Devolder, van Braak, & Tondeur, 2012).

There is a need to investigate how adolescent students' learning is impacted by digital distractions in order to develop strategies to address this shift in attention and learning. This quasi-experimental design aims to determine how varying levels of ICT implementation impact Australian secondary school students' processing of lesson content through the delivery of controlled content and subsequent multiple-choice comprehension tests. The data collected aims to determine whether using an unmoderated ICT device (tablet, smartphone, personal laptop, etc.) can impact student learning compared to using traditional analogue resources or moderated ICT devices. Within the context of this research, the term moderated and unmoderated pertains to how actively the use of the students' device is monitored and controlled by the classroom teacher. The purpose of researching moderated and unmoderated devices is to identify under which conditions students are able to attend to tasks most effectively, focusing on how students self-regulate when the use of their devices are unmoderated. Within the classroom, Manolev, Sullivan, and Slee (2019) warns that a distinction should be made between supervision and surveillance. Whilst the former encourages responsible use, the latter enforces it.

Millennial and Generation Z students are increasingly wired to seek a steady stream of electronic engagement, both educationally and recreationally (Anderson & Rainie, 2012; Prensky, 2010). However, research suggests that oscillating between multiple tasks can hinder an individual's ability to complete a single task effectively and efficiently (Duncan, Hoekstra, & Wilcox, 2012; Fernandes & Moscovitch, 2000; McCoy, 2013). Rubinstein, Meyer, and Evans (2001) found that multitasking leads to a dramatic increase in processing time and memory errors when learning topics that involved a significant cognitive load. As students are now equipped with an abundance of ICT resources (Brand & Todhunter, 2015), with 99% of those aged between 15-17 using the Internet (Australian Bureau of Statistics, 2016), it is imperative to equip them with necessary skills to manage the distractions that come with such connectivity. Beyond an understanding of how to use software and hardware for a range of educational purposes, skills such as the ability to self-regulate and focus are key. The distractive allure of technology's more enticing offerings need to be mediated when attending to educational goals in order to achieve prescribed learning outcomes.

In a critical review on the evidence of digital natives, Bennett, Maton, and Kervin (2008) observed that "education has a vitally important role in fostering information literacies that will support learning" (p. 781). A comprehensive search of the relevant literature indicates that research on the impact of technology on adolescent learning, specifically distraction and comprehension, is limited. The majority of research has focused on the tertiary environment, where learning habits and attitudes have already been formed to a certain extent (Brinkworth, McCann, Matthews, & Nordström, 2009; Mutsotso & Abenga, 2010). Much of the existing research has relied on students' self-reporting their technology use, which has been found to be inaccurate when compared to actual behaviours (Junco & Cotten, 2012; Lepp, Barkley, & Karpinski, 2015). Teachers are mandated to integrate technology into the curriculum (Australian Institute for Teaching and School Leadership, 2015) in order to address the needs of a generation of students who are considered by Howe and Strauss (2007) to be optimistic, team-orientated achievers who are talented with technology. The assumption that students born of a certain age are equipped with inherent digital literacy skills, unlike previous generations of students, can be misguided (Prensky, 2010).

1.1. Significance

The Digital Education Revolution (DER) saw the Australian Government commit $2.1 billion in 2008 to an initiative designed to "generate an immediate, large-scale boost to enhance the integration of information and communication technology into teaching and learning in Australian schools" (Dandolo Partners, 2013, p. 4). This saw every student from Year 9 to 12 (14 to 18 year olds) provided with access to digital technology. Digital tools are now integral to the fabric of the modern classroom and are just as familiar to the student as pen and pencil (Erstad et al., 2015; Wells, Demirjian, Hammel–Cobb, Kelly, & Riegner, 2018). Australian households now have on average six devices with which they can access the Internet, with those aged between 15-17 spending an average of 18 hours per week online (ABS, 2016). It must be noted that self-reporting of individual's screen time can often be underestimated. In spite of students spending increasingly more time online, their digital recreation does not necessarily provide them with the critical thinking and investigation skills necessary for effective use of ICT as a learning tool, where signal must be discerned from noise (Giedd, 2012). However, Borst, Taatgen, and van Rijn (2015, p. 2972) observed that deviating from primary tasks can result in considerable 'resumption lag' and difficulty in returning attention to the pertinent workload. Multitasking is commonplace in daily life and the digital space is certainly no different. Students can be working on an assignment whilst competing with the chorus of interruptions that social media, gaming and entertainment can bring.

Anderson and Rainie (2012) suggested that young people, accustomed to instantaneous information, will be less likely to undertake deep, critical analysis of issues and challenging information. They assert that the problem may not be technology, but the absence of digital literacy training provided to students. Individuals who multitask need to be aware that they have limited cognitive resources available to “attend to, process, encode and store information for later retrieval” (Sana, Weston, & Cepeda, 2013, p. 24). Therefore, the use of a device that inherently divides attention has the potential to detract from completing certain tasks effectively and efficiently (Pashler, 1994). Studies have found that the ability to self-regulate and remain disciplined in the face of extraneous distractions can be a predictor of academic success (Voelke & Roebers, 2016). Teachers are now tasked with being more interesting than the school-sanctioned devices that they compete with if they are to maintain the attention of students who may not be intrinsically motivated by the subject material (Sana et al., 2013).

1.2. Statement of the Problem

A boundary between educators and their students exists when there is a refusal, reluctance or inability to adapt to the changing technological landscape of the classroom. Adolescents' propensity to be constantly engaged with their technology has led to a generation of students who access information, communicate and socialise in a digital space, yet often find their medium of choice is not replicated in the classroom. The distractive properties of the screen can lead students to become disengaged with lesson content, where the allure that their technology has to offer can become stronger than the motivation to focus on the school task at hand (Aagaard, 2016b; Dias, 2016). However, when ICT is integrated into teaching and learning activities, its rationale and subsequent function can often be incongruous with meaningful scholarship.

A generational divide exists which can fuel the disconnect between children and their parents and teachers who have matured in a predominantly offline world. A tension can arise between the perceived benefits of technology from parents, teachers and the children that their decisions are impacted by (Van Volkom, Stapley, & Amaturo, 2014). The boundary between school, home and socialising with friends is now blurred by the connectivity enabled by personal devices. Close to universal access to the Internet can see groups congregate on social media, study notes shared via online portals, and friends communicating whilst concurrently gaming across networks. Thus, an adult's cause for concern can often be borne out of not knowing what a life lived online actually entails (Bowe & Wohn, 2015). Yet, the fear of the new is something that has permeated the debate around emerging technologies for generations. From Conrad Gessner's fear, documented in 1545, that the printing press would create an abundance of books and a resultant information overload (Blair, 2003), to the growing concern in the 1970s that the rapid pacing of children's television shows such as Sesame Street led to distractibility (Courage & Setliff, 2009), new technology has always generated debate and cause for concern.

Therefore, educators, parents, and policy makers must address the challenges presented by a 21st century tool that is essential to not only teaching, but day-to-day life. With regard to Millennials (the generation born between 1982-2000) and Generation Z (born after 2000), Erwin (2017) suggested "faculty members must understand the distinct characteristics of each group and recognize their own personal biases" (p. 24) if they are to successfully educate these students. Thus, a critical need for research exists to help relevant stakeholders understand what best practice involves in a technologically rich classroom environment.

1.3. Research Objectives

The objective of this research is to provide a greater insight into the role that ICT plays both within the classroom and at home. This quasi-experimental design within the Year 10 science classroom depicts quantifiable evidence on how students perform under varying conditions of technological distraction within a 45 minute, single period. The semi-structured interview process seeks to provide a broader qualitative perspective on how the use of ICTs are viewed from parents, teachers and students.

1.4. Research Need

The most prominent deficiency in pre-existing evidence is the lack of research relating to the distractive qualities of ICTs below tertiary level. Researchers have capitalised on the ease of access to studying cohorts of their own students within the higher education setting; however, gathering similar data on school children has been somewhat limited. Erwin (2017, p. 25) observed that there are “relatively few scholarly publications about Generation Z”. Current research relating to the impact of technology on adolescents relates closely to mental health risks, addictive properties, and the psychosocial implications for this increased level of digital connectivity. There is a scarcity of research on how the distractive qualities of technology directly relate to the academic performance of young people within the secondary school classroom environment. Within the context of this research, the distractive qualities pertain to the range of ways in which a student can be drawn away from their primary learning task by way of intrusion, both extrinsic and intrinsic.

1.5. Research Questions

1. How do varying levels of access to technology affect lesson content retention?
2. Under which level of access to technology do students retain lesson content most effectively?
3. How do parents perceive the efficacy of technology for learning?
4. How do teachers perceive the efficacy of technology for learning?
5. How do students perceive the efficacy of technology for learning?

1.6. Educational Context

The Australian schooling structure comprises of primary, ranging from preparatory to Year 6 (or Year 7 in South Australia and Western Australia) to secondary from Year 7 (or 8) to Year 12. In 2009, the Council of Australian Governments instigated the National Youth Participation Requirement (NYPR), requiring all Australian children to participate in schooling up until completion of Year 10, and then undertake a minimum of 25 hours of education, training or employment until the age of 17 (Department of Education & Training, 2016). Within this system, there exists 9,444 schools, classified as either government (65.6%) or non-government, which includes both Catholic (19.9%) and independent schools (14.5%), educating 3,849,255 students (Australian Bureau of Statistics, 2017b). Within the national framework, the development of an Australian curriculum has brought about a greater level of harmony and consistency between states and territories with regard to key learning areas such as English, mathematics and science.

1.7. Audience

The results of this research aims to inform policy makers, teachers, parents, and adolescents, who all play an instrumental role in the academic landscape pertaining specifically to secondary education. Digital devices continue to permeate down through the education system, from higher education to early childhood settings (Lu, Ottenbreit–Leftwich, Ding, & Glazewski, 2017; Shanley, Cary, Clarke, Guerreiro, & Thier, 2017). Although the discussion around what age is most appropriate to introduce children to ICTs for learning, an acknowledgement of what determines appropriate and meaningful use for educators and parents is critical to its success.

1.8. Participants

Access was gained to two schools after an initial phase of seeking willing participant schools from metropolitan Melbourne, Australia. One coeducational school declined to participate due to a concern that their willingness to involve themselves with a research initiative would set a precedent for further studies to be undertaken at their school. Another girls' school declined to participate due to their concerns over how the data would be used. Access to School A and School B and confirmation of their willingness to participate in the research was granted from their respective school leaders, after meetings and an overall outline of the research plan being provided.

An opportunity to ask any questions or seek clarification was provided to all participating school leaders and teachers before final confirmation of their willingness to participate was provided. After establishing this agreement of cooperation between researcher and participant schools, the primary relationship between the researcher and school was through the academic heads of science at School A and School B.

The science curriculum was chosen for several key reasons that would be required to undertake the quantitative data collection. Year 10 science is a core subject, which meant that all students within the cohort were completing the course compulsorily. This aimed to remove any bias that may have presented itself in elective subjects, where the intrinsic motivation of the individual may have potentially influenced their responses, academic performance, and willingness to participate in the research (Ginsburg & Bronstein, 1993; Ryan &

Deci, 2000). Additionally, the course content enabled a series of tests to be developed that removed any conflicting subjective interpretations. The nature of the tests relied upon students retaining and recalling information, as opposed to offering subjective interpretations or deeper analysis of the content. Thus, responses to the science questions were required to either be correct or incorrect, without scope for personal interpretation of either the student or the assessor. It was the role of the respective heads of science to nominate the classes that would be able to participate in the data collection. Factors that guided this decision were the selection of teachers within their faculties who would be willing to implement the study design, classes that were yet to complete specific parts of the curriculum, and classes who would have sufficient time to complete all tests within the proposed research timeline.

Once the participating classes and their respective teachers were nominated by the heads of science at School A and School B, extensive information (including face to face meetings and subsequent information sheets) were provided to teachers to enable them to understand the rationale of the proposed research, the timeline required to achieve the data collection, and the instructions required to ensure a consistent deployment of the quasi-experiment design across all phases of the data collection. Participating classroom teachers were once again provided with an opportunity to express any concerns or seek clarification before the testing phase commenced.

1.9. Definition of Terms

Distraction: Within the context of this research, distraction refers to extrinsic and intrinsic factors that interrupt a student's ability to focus on a learning task. Often, what is considered multitasking can be more accurately defined as divided attention, where one task is impeded by attention being diverted to another, even if only for a brief period of time (Aagaard, 2015b; Baumgartner, Weeda, van der Heijden, & Huizinga, 2014).

ICT: Within the context of this research, the term technology refers to digital technology. Information and Communications Technology (ICT) serves as an umbrella term for the technology used for educational purposes. Beyond just personal devices, this can encompass hardware and software such as interactive whiteboards (IWB), projectors, online resources, learning management systems (LMS), and other digital tools used to facilitate or complement the curriculum (Kumar, 2008).

BYOD: Bring your own device (BYOD) refers to the implementation of an organisational policy that mandates, or encourages, individuals to bring their own device to school or work. Some schools operate under a bring you own designated device (BYODD), where administrators will prescribe a list of sanctioned devices that are allowed to be brought into school.

Device: Any technological device that an individual has access to, whether it be for learning or otherwise. Within the context of this research, it primarily encompasses laptops, tablets and smartphones (a mobile device which performs functions similar to a computer, usually with an ability to access the Internet).

Attrition: Within the context of this research, it relates to participants who, for various reasons, did not complete all phases of the quantitative quasi-experimental design. De Winter and Dodou (2017, p. 30) describe it as "a decline of the number of participants over the course of a study. Attrition is common in cohort studies but also in experiments consisting of several phases, as participants may not return for the follow-up".

Apps: Applications, colloquially referred to as apps, are downloadable content that enable tasks to be completed through specific software. Content can either be paid for, consumed for free or accessed on a subscription basis. These apps can be for educational purposes or for other recreational activities, such as social media.

Social Media: Social media refers to websites accessed through computers or apps on mobile devices that provide users with the ability to share content and interact with networks online. Social media platforms are perpetually shifting, but in the context of this research, Snapchat, Facebook (including Messenger) and Instagram are the recurring sites that are referred to. Snapchat is a mobile device only app that allows users to send text, video and image messages to approved contacts. The messages have a limited time to be viewed before they permanently expire. Facebook is both mobile and desktop accessible and is a platform for communicating and sharing content with connections, who are usually approved contacts due to privacy settings. Instagram’s primary function is the sharing of images and short form video content, as well as having a private messaging feature. The content on Instagram can be made publicly accessible or private, depending on the individual user’s preferences.

1.10. Thesis Structure

Following is an outline of the structure of the thesis.

Chapter 1: Introduction – An introduction to the research and overview of the thesis

Chapter 2: Literature Review – Presents a critical review of the existing literature relating to technology and its role in teaching and learning.

Chapter 3: Methodology – Outlines the theoretical framework and rationale for using mixed methods for this research.

Chapter 4: Mixed Methods Research – Outlines the quasi-experimental design, instruments used, participants involved and collection of data for this research.

Chapter 5: Quantitative Method – Details the comprehension test, selection of participants, video delivery and limitations.

Chapter 6: Quantitative Analysis – Details the statistical analysis and procedures required to process the quantitative data collected from School A and School B.

Chapter 7: Qualitative Method – Details the semi-structured interview process, including questions, participants and validity.

Chapter 8: Qualitative Analysis – Details the transcribed semi-structured interview process and subsequent analysis from the triangulated perspectives of teachers, students and parents.

Chapter 9: Discussion – Outlines the implications, limitations and recommendations developed as a result of this research.

Chapter 10: Conclusion – Provides an overall review of the research and identifies possible future directions and considerations, as well as the significance to scholarship.

1.11. Summary

This chapter presented an introduction to the research, including its significance, the research questions and the statement of the problem and how the research objectives will address this issue. It also highlighted the need for more evidence and how it will benefit a broad audience of stakeholders relating to education. Also included was an outline of the thesis structure and key definition of terms relating to this research.

Chapter 2: Literature Review

2.1. Introduction

The purpose of this chapter is to review literature relevant to the current state of technology in the classroom, its implications for teaching, and how an individual's ability to learn is influenced by the brain's capacity to manage multiple streams of information. The exploration of existing research intends to identify how the issue of technology distraction in the classroom has been assessed in the past. It aims to highlight the various ways in which individuals process information and how this can be instrumental to the comprehension, and retention of lesson content.

It can be argued that the prevalence of technology, not only in the ecology of the classroom, but in permutations beyond school, are encouraging adolescents to outsource a range of functions to a device that were once the province of memory and retention (Goundar, 2014). The need to retain information such as addresses, directions, phone numbers and birthdays can now be called upon with ease from a device that does the remembering for the individual. Therefore, the onus on the brain to retain such arbitrary data for later recall is significantly diminished.

The existing literature on the state of technology and its implication for learning is constantly evolving due to the rapid rate with which software, hardware and the accessibility of these devices increases. As of 2017, Australia had 13.7 million Internet subscribers and 26.3 million mobile handset subscribers (Australian Bureau of Statistics, 2017a). This level of accessibility indicates that society, in Western civilisation at least, has moved to a position where access to technology and the Internet is essential to facilitate the needs of daily life (for most), tantamount to the modern-day expectation that electricity and running water are ubiquitous. The Internet was once the province of a select few in Western civilisations, with fewer than 1% of the world's population using the Internet in 1995, yet now the rapid rate sees 10 new people get online every second (InternetLiveStats.com, 2018). This global reliance on access to the Internet presents a range of challenges for a world that now functions on digital connectivity. Yet, one must be conscious when using the term 'global' to describe the entire situation of technology's role within society. McMillin (2007) has criticised the Anglocentric generalisation of experiences for the rest of the world as an 'embarrassment', with Selwyn (2012a) calling for "a more internationalised and comparative analysis of educational technology" (p. viii). The role that technology plays in any educational setting around the world is therefore influenced by a complex relationship between diverse cultural issues, economic influences and motivations of individual actors within the localised environment. Thus, the perspectives gained through a Western lens may not always be directly applicable to the heterogeneity of a more global arena.

Jeff Hancock, who studies the social and psychological processes related to online communication at Stanford University, observed that his proposal to students to remain off the Internet for 48 hours almost instigated a revolt. He suggested that most of the Internet is designed for one purpose, "to allow us to communicate with each other" (Nuwer, 2017, para. 19). This observation can often be at odds with those who argue that the constant need to be connected online is what is leading us to be disconnected as a people offline (Gazzaley & Rosen, 2016; Rosen, 2010; Turkle, 2017). This connectivity presents a multitude of challenges for adolescents in particular, such as the pressures of social media and its implications on mental health (Kuss, 2017), the risk of cyberbullying (Hinduja & Patchin, 2010), online predators (Byrne, Katz, Lee, Linz, & McIlrath, 2014), and the addictive properties of gaming and streaming (Markey & Ferguson, 2017). However, the negative risks associated with online activity can often cloud the academic benefits that meaningful use of ICTs can have on learning. The accessibility of technology and the Internet contributes to the evolution of education and the way in which students interact, learn and create within the school environment (Domingo & Garganté, 2016; Stošić, 2015). It would be a disservice to the learning needs of students for educators to ignore the necessities of a generation of children who are predisposed to interacting through their devices, consuming content via the screen, and accessing information in short bursts.

As previously mentioned, the majority of research relating to the implications of ICTs on learning relate to the tertiary sector of education. The environment, expectations, and structure of learning in higher education varies significantly from the confines of the primary and secondary school classroom, and it is necessary to understand the learning habits of adolescents who are still in the stages of developing behaviours that will facilitate their learning throughout school and beyond. The purpose of this literature review is to identify where gaps exist and position the current research within the literature.

Although there are a range of implications relating to the psychological and neuroscientific implications relating to technology dependence, distraction and integration, this literature review primarily focuses on ICT's role within the context of teaching and learning. Additionally, this literature review does not extend to the early childhood setting of infants, pre-schoolers and primary school students, with Courage et al. (2015, p. 7) highlighting that "children's attention processes, especially the executive processes needed to resist distraction, sustain, and shift focus as appropriate, are not fully mature until late childhood or adolescence". The current state of technology and its implications for teaching practice are investigated from the perspective of advancements in ICTs, the challenges faced by an individual's cognitive capacity, and the way in which the distractive qualities of these devices can impact the ability to focus.

2.2. Gap in Research

A call for further research is reiterated by a multitude of researchers who have studied a range of implications of technology on learning in recent years (Ackerman & Goldsmith, 2011; Duncan et al., 2012; Mangen, Walgermo, & Brønnick, 2013; Mueller & Oppenheimer, 2014; Sana et al., 2013). Schmid et al. (2014, p. 285) suggested that "learning is best supported when the student is engaged in active, meaningful exercises via technological tools that provide cognitive support," whilst acknowledging that we are still in need of greater understanding of how to precisely integrate cognitive support tools into instruction. Thus far, the majority of research conducted in this field have focused on higher education students, predominantly in North America, where the constructs of the classroom, content delivery and learning behaviours vary significantly from those of an adolescent within a school classroom. This further highlights the need for research specific to adolescent education in order to advance the knowledge required to effectively implement technology for meaningful learning.

The predominant focus on technology's efficacy and distractive qualities within the learning environment has studied adult behaviour, which varies greatly from that of the developing adolescent mind (Konrad, Firk, & Uhlhaas, 2013), where the prefrontal cortex can continue to develop until mid 20s for females and up to late 20s for males (Lenroot & Giedd, 2006). There is a need to turn attention towards secondary level education, where learning behaviours can be established, developed, and carried through to post-compulsory education (Pendergast et al., 2005).

The demand for further research in this area is echoed by many researchers who have begun to assess the efficacy of technology integration for learning. Wang, David, et al. (2012, p. 974) suggested that investigating how we optimise the allocation of resources when multiple tasks are competing for our attention is an exciting area of research. Within the classroom specifically, the competition for an individual's attention is considerable. Kraushaar and Novak (2010) acknowledged that research on how students use laptops does exist; however, they highlight a lack of research that addresses the "unstructured or unsanctioned use of computers in the classroom" (p. 241). Selwyn (2012a) suggests that the limited critique has impeded the advancement of understanding educational technologies, where any naysayers are decried as "luddites or technophobes" (p. 11). Evidence is needed to provide informed rationale behind technology's implementation in the classroom, as it can be met by resistance for those ready to decry the advent of technology and its implications for learning (Fauquet–Alekhine, 2015; Yamamoto, 2007). Shirky (2008) makes the vivid analogy about how society has little control when it comes to resisting ICT's influence and the pace at which it develops:

> Our control over [digital] tools is much more like steering a kayak. We are being pushed rapidly down a route largely determined by the technological environment. We have a small degree of control over the spread of these tools, but that control does not extend to being able to reverse, or even radically alter, the direction we're moving in. (p. 307)

A comprehensive search of the relevant literature indicates that research on the impact of technology on adolescent learning, specifically distraction and comprehension, is limited. There is a need for research that looks at emerging platforms in the evolving digital space to address the fact that one stream of social media or distraction may be rendered obsolete as new trends and offerings emerge. Previous classroom studies on specific social media platforms such as Facebook (Beland & Murphy, 2016; Kirschner & Karpinski, 2010; Rosen, Carrier, & Cheever, 2013), now have diminished relevance as young people move onto the next wave of social media (Duncan, 2016). For broader applicability, future studies should not confine themselves to the implications of just one social media or application as it is likely to be usurped (Matthews, 2014). Preliminary studies have looked at the impact that instant messaging and texting can have on academic performance (Kirschner & Karpinski, 2010; Levine, Waite, & Bowman, 2007); however, many of the studies were prior to the advent of the smartphone and its capabilities which are far richer than just synchronous communication.

One of the main challenges evident in many studies assessing students' use of classroom technology and its perceived efficacy is the reliance on self-reporting (Jacobsen & Forste, 2011). For a variety of reasons, students might provide responses or indications of their technology use that are not truly representative of their digital behaviour (Fried, 2008). Known as the Hawthorne Effect, research participants who are aware they are being studied may alter their behaviour as a consequence (McCambridge, Witton, & Elbourne, 2014). Kraushaar and Novak (2010, p. 250) suggested "self-reported perceptions of use or anecdotal descriptions" would provide data that explicitly measures learning outcomes and actual use. One individual's perception of their use might be in stark contrast to another if their understanding of what constitutes as *heavy use* varies.

As the majority of studies are quasi-experimental, or in lab conditions, it is important to develop research that can best replicate the conditions of the standard classroom, with minimal disruption and inconvenience to students and teachers. Kuznekoff, Munz, and Titsworth (2015, p. 362) suggested that future research "should expand to include data from a more naturalistic setting". Aagaard (2015b, p. 887) conceded some scepticism regarding the evidence that overtly refutes claims about digital natives' media multitasking abilities, stating that "it is unknown to which extent these artificial situations correspond to real life situations". With direct applicability to this research, Kraushaar and Novak (2010, p. 249) suggested that an investigation of a "direct causal relationship between the frequency of multitasking and requires an in-class assessment at the end of the class period".

As this is an emerging field, there are a variety of avenues that still demand further research. Although experimental psychology has investigated multitasking and the resultant significant memory disruptions (Baddeley, Lewis, Eldridge, & Thomson, 1984; Craik, Govoni, Naveh–Benjamin, & Anderson, 1996; Jacoby, Woloshyn, & Kelley, 1989), Rosen et al. (2013) suggested that very little research has been conducted into how often students switch tasks during actual schoolwork. Academics have identified a need for further research relating to loss of volitional control with mobile phones and its long-term effects (David, Kim, Brickman, Ran, & Curtis, 2015), the influence of devices on everyday social interaction (Aagaard, 2016b), memory recall of "lecture material with interruptions in the classroom environment" (Rosen, Lim, Carrier, & Cheever, 2011, p. 166), the need to examine the effect of multitasking on educational outcomes (Junco, 2012), the difference between children, teens and young adults in task switching behaviour (Rosen et al., 2013), and an urgent need for research on self-control in school-age children (Duckworth, Gendler, & Gross, 2014, p. 212). Beyond this, future research needs to clarify the relationship between learning activities and characteristics of each ICT, as well as the frequency of use and whether it is used for social or academic purposes. With regard to further research, Aagaard (2015b, p. 894) outlines additional factors that could potentially influence media multitasking, such as “the rhythm of lessons, social norms, presented material, or even the physical layout of a classroom influence media multitasking”. In an increasingly technology-reliant workforce, Junco and Cotten (2012) suggested that future research could also focus on how Internet skills and learning activities relate to employability. Whilst difficult to address all perceived concerns communicated in the relevant literature, this research seeks to gain a greater insight into the role and perceived efficacy of technology for learning.

Wood et al. (2012, p. 373) advocated that “we must fully identify, understand and overcome potential shortcomings resulting from inappropriate use of technology in the classroom” if we are to maximize the educational benefits associated with it. The call for further studies is voiced by researchers who have begun to look at the pedagogical benefits of ICTs. Tallvid, Lundin, Svensson, and Lindström (2015, p. 246) suggested that further research is needed “to investigate the relationship between rules and students’ use of laptops in the classroom”. Kuznekoff et al. (2015) highlighted the pressing need for this area to be investigated further:

> Focusing attention on the effects these devices and services have on student learning and the college classroom is of paramount importance if we, as educators, are to continue to work with students effectively in helping them achieve their educational goals. (p. 346)

2.3. Benefits of Technology

A significant portion of the literature relating to multimedia and multitasking is dedicated to the generally negative consequences relating to cognitive outcomes such as memory, task-switching and learning (Ophir, Nass, & Wagner, 2009; Rubenking, 2017; Wood et al., 2012). Yet, there exists a range of research that promotes ICT's myriad benefits within the classroom, such as enhanced collaboration and student motivation (Zheng, Warschauer, Lin, & Chang, 2016), engagement through gamification, where learning objectives are addressed through interactive digital games (da Rocha Seixas, Gomes, & de Melo Filho, 2016), addressing the media needs of students predisposed to near constant digital engagement (Anderson & Rainie, 2012), and the additional support enabled for students with specific learning needs (Istenic Starcic & Bagon, 2014). Effective integration of technology within the learning environment is key to responding to the needs of a generation that greatly differ from those who have gone before them (Howe & Strauss, 2009). Wood et al. (2012, p. 365) declared "there is a consensus that existing and emerging digital technologies have the potential to expand the reach and effectiveness of current educational tools".

The benefits of effective technology integration have the potential to address the needs of students who are predisposed to engage with technology as an extension of themselves, where they interact in a world where the division between real life and online space is greatly diminished (Anderson & Rainie, 2012). Educators' reaction to the current evidence of decreased academic performance and overloaded cognitive strain is often to instinctively remove

ICTs from the classroom as a solution to the perceived problem (Colker, 2017; Henriques–Gomes, 2019). As Taneja, Fiore, and Fischer (2015, p. 142) asserted “banning technology is not a solution since technology could allow for positive learning outcomes when used appropriately”.

In research that surveyed individuals’ use of technology and how their lecturers/teachers viewed the implications of their students slacking in class, Galluch, Long, Bratton, Gee, and Groeber (2009) concluded that removing the devices altogether would not be a practical solution. Rather, they suggested “school administrators must make a decision on whether these technologies are important to class activities, and more formally implement how to minimize damage while still promoting learning” (p. 50).

As educators seek to maintain step with the evolving technological landscape, embracing its place in the classroom instead of deriding it is key, as resistance to its place in society will ultimately be futile. Aagaard (2015a, p. 96) declared that the banning of digital devices from the classroom is “not only impossible, but also highly unwarranted”. Physically removing devices from students is not a guaranteed approach to obtaining focus in the classroom, where focus can so often be elusive in the presence of digital distractions. Students, like adults, have long had the propensity to let their minds wander long before the introduction of technology into their lives. Rosen et al. (2011) outlined neurological research that indicated students will be thinking about their online activity and connectivity even if their device is not within their reach. Rosen et al. (2013, p. 956) suggested that restricting students’ ability to connect to their online worlds can create highly anxious individuals, advising that "out of sight is most definitely not out of mind". It should be noted that emphasis on academic performance as the key outcome can neglect the emotional or social functions of multitasking, where students may be willing to forego academic performance for entertainment, emotional or social gains (David et al., 2015).

2.4. Technological Pessimism

Marx (1994, p. 238) suggested that technological pessimism refers to the "sense of disappointment, anxiety, even menace, that the idea of technology arouses in many people". He contended that it is somewhat paradoxical to have this notion of negativity towards technology, when myriad advancements in medicine, aviation, chemistry, genetics, engineering, and so on have been made thanks to progress in technology. Decades on, his notion of how technology is perceived by those wary of it can be applied to contemporary sentiment. In the 21st century, the aforementioned anxiety can now relate to the advancements in technology which has the capacity to render various skills and professions redundant. There has long been a fear of mechanisation and the industrial class was the result of machines replacing skills and trades that were once performed by the individual. In the digital age, the scope of algorithms and the ability to process increasingly complex tasks continues to render skills, that were once the sole province of mankind, redundant. In his critical appraisal of technology in education, Selwyn (2012a) suggested that the absence of scepticism when evaluating educational technology can lead to the "techno-romantic manner in which most technologies are framed within modern thought" (p. 13). This orthodoxy of optimism is what instils in society a motivation to see technology's overall role as an agent for improving the human condition.

Perilous though its negatives may be, technology's positives far outweigh the prospect of a world without it (Lewis, 2013). This macro perspective can be applied to the microcosm of the classroom, where appropriate and meaningful integration of technology has the capacity to far outweigh the negatives from its absence. Without a pessimistic stance on educational technology, researchers can adopt a righteous stance in its advocacy, without consideration for the issues it presents to society. Selwyn (2012a) suggested that a resistance towards contradictory viewpoints exists, where the core values of educational technology and the orthodoxy of it being a potential force for change are not closely scrutinised. Therefore, a critical stance towards educational technology allows the researcher to address the cultural, historical, economic and political factors that inherently influence the role that the Internet and connected devices play in culture.

2.5. Ubiquitous Technology

Society, beyond the educational environment, is reliant on technology to facilitate a range of processes and interactions that are no longer viable in an offline world. As Castells and Cardoso (2006, p. 6) declared, "technology does not determine society; it *is* society". Matthewman (2011, p. 173) posited that contemporary society has a tendency to overlook digital technology's ubiquitous role in daily life, stating "We do not notice the obvious. Ubiquity creates invisibility…we are only likely to notice our technologies when they stop working as anticipated".

Today's students are increasingly predisposed to engage with their devices, with electronic interruption often becoming an "unpredictable stream of interactions” both educationally and recreationally (Anderson & Rainie, 2012, p. 27). However, research suggests that oscillating between multiple tasks can hinder an individual’s ability to complete a single task effectively and efficiently (McCoy, 2013). Rubinstein et al. (2001) found that multitasking leads to a dramatic increase in processing time and memory errors when learning topics that involved a significant cognitive load. As students are now equipped with an abundance of ICT resources (Brand & Todhunter, 2015), with 99% of 15–17 year olds using the Internet (Australian Bureau of Statistics, 2016), it is imperative to equip them with necessary skills to manage the distractions that come with such connectivity.

Carrier, Cheever, Rosen, Benitez, and Chang (2009, p. 72) stated that “the Net generation do not appear to be getting any better at multitasking than prior generations and seem to be bound by the same mental limitations as other individuals”. These mental limitations can be attributed to Sweller’s theory of cognitive load, where individuals have a limited capacity to complete any two tasks concurrently when the demand on brain processing power is limited (Liu, 2016; Sweller, 2010).

In contrast to most educational resources, digital devices pose a dichotomous situation where they can be both beneficial and detrimental to learning (Sana et al., 2013). Scheiter and Gerjets (2007) asserted that computer-based learning environments (CBLEs) have the capacity to increase the accessibility of complex topics that would otherwise be difficult to comprehend in more traditional learning environments. For adolescents, being able to delineate between their device as a tool for learning and that of recreation poses a significant challenge for the developing mind (Bowe & Wohn, 2015). Their device enables them to play games, communicate with their social networks, and access a range of entertainment offerings, all whilst attempting to focus on learning tasks facilitated by the same device. Educational theory relating to the Habits of Mind (HOM) framework indicate that managing impulsivity is instrumental to the current learning context (Campbell, 2006).

The lure of engaging with technology for non-learning activities requires the development of metacognitive strategies to remain on task in the face of such digital intrusion (Mendoza, Pody, Lee, Kim, & McDonough, 2018). Whereas a traditional mode such as a textbook or worksheet provides a singular and dedicated learning function, a digital device encompasses a raft of options unrelated to learning objectives, such as social networking, entertainment, and gaming. Albeit garnering the label of weapons of mass distraction from some detractors (Gazzaley & Rosen, 2016), it is suggested that teachers should not banish ICT resources from the classroom, as doing so would deprive students of the myriad opportunities available to them as the result of a technologically rich world (Dandolo Partners, 2013; Wood et al., 2012). Instead, teachers need to acknowledge the new challenges precipitated by these devices and adapt their practice to one that recognises that distractions must be addressed before meaningful learning can occur.

2.6. Age of Distraction

The Pew Research Institute, a nonpartisan North American research organisation, conducted a survey of key stakeholders and technology experts to ascertain whether the hyperconnected lives of millennials would result in a net positive or net negative of social and educational outcomes by 2020. The report highlighted the need for vital education reform in areas where students "thirst for instant gratification, settle for quick choices, and lack patience" (Anderson & Rainie, 2012, p. 2). The report determined that this generation of students will both benefit and suffer from a state where being online and immersed in technology is a way of life.

Evidence is needed to provide informed rationale behind technology's implementation in the classroom as it can be met by resistance for those ready to decry the advent of technology and its implications for learning (Fauquet–Alekhine, 2015; Yamamoto, 2007). As Giedd (2012, p. 7) observed, technologies enable adolescents to "...broaden their exposure to ideas, customs, and ways of life". However, what needs to be investigated further is the balance between integration and saturation to assist in determining what approaches a modern teacher can take to ensure that their pedagogy has adapted to students who have a very different style of learning, retaining, and recalling information. A controlled study to assess the impact of multitasking on learning was conducted by Sana et al. (2013). Tertiary students who multitasked scored 11% lower on post-lecture comprehension than peers who had undivided focus on the lecture content. Students were evaluated on application of knowledge using a multiple-choice comprehension test, whilst randomly assigned to varying levels of digital interruption. The study concluded that there was more research required to determine under what conditions would the benefits of technological devices outweigh their detriments (Sana et al., 2013).

2.7. Metacognitive Strategies

For individuals to be aware of the way in which they interact with technology, both within and beyond the learning environment, certain metacognitive strategies need to be engaged. Gurbin (2015, p. 1580) asserted that "as learning is a part of technology adoption, metacognition is essential in facilitating successful technology adoption which is intrinsically a part of learning today". Metacognition is an individual's knowledge of their cognitive abilities and the ability to "consciously and deliberately monitor and regulate one's knowledge, processes and cognitive and affective states" (Hacker, Dunlosky, & Graesser, 1998, p. 11). When it comes to engaging this level of awareness in adolescents, Zimmerman and Schunk (2001) suggested that they must undertake a "self-directive process" (p. 1) to convert their mental abilities into task-related academic skills. In order to achieve this, volition, or "wilful and conscious focus and sustained awareness" is instrumental to progressing goals into actions (Roeser & Peck, 2009, p. 120). Rosen et al. (2011, p. 173) advise that we should be teaching students "metacognitive strategies that focus on when it is appropriate to take a break and when it is important to focus without distractions".

Without the process of actively teaching students such metacognitive strategies, their capacity or inclination to develop such an approach voluntarily may be somewhat limited (Cornoldi, 2010). Metacognitive strategies can have a considerable impact on memory performance, yet factors such as implicit goals, self-regulation, self-efficacy, and effort attribution all determine the success of the individual’s approach (Waters & Schneider, 2010).

2.7.1. Cognitive Load Theory

In an initial study on cognitive load theory (CLT), Chandler and Sweller (1991) observed that students who were required to mentally integrate disparate sources of information were subjected to a heavy extraneous cognitive load. The discussion concluded that there were “long-term advantages of eliminating the need for students to split their attention between multiple sources of mutually referring information” (p. 304).

The breadth and depth of accessible information has increased exponentially since CLT’s inception (Milicevic, 2015), which presents a challenge for students and how they locate, process, and store information in the digital age (Limberg & Sundin, 2006). Sweller (2010) suggested that redundant information could be an impediment to learning and its removal would be a necessary step in improving instructional materials. Sparrow et al. (2011, p. 776) declared that “the Internet has become a primary form of external or transactive memory, where information is stored collectively outside ourselves”. However, managing this vast store of data for later retrieval can put significant strain on an individual’s cognitive load. ICTs may present a significant demand on the cognitive resources required by learners to process new information, which in turn may hinder the construction of new knowledge (Kalyuga, 2009). Jonassen (2004, p. 871) believes that it is critical for instructional design researchers to be aware of “human cognitive architecture” to develop approaches that facilitate long-term retention of information.

Sweller (1988) suggested short-term memory is limited in its capacity to retain simultaneous streams of information. In an initial study on Cognitive Load Theory (CLT), Chandler and Sweller (1991) observed that students who were required to mentally integrate disparate sources of information were subjected to a heavy extraneous cognitive load. The discussion concluded that there were "long-term advantages of eliminating the need for students to split their attention between multiple sources of mutually referring information" (p. 304). Sweller (2010) defines the three types of cognitive load as follows:

1. *Intrinsic:* Occurs during the interaction between the nature of the lesson content and the expertise of the student.
2. *Extraneous:* Caused by factors that are not central to the lesson content, such as delivery methods or activities that divide attention between multiple sources of information, and these should be minimised as much as possible.
3. *Germane:* Enhances learning and results in task resources being devoted to schema acquisition and automation.

The demands placed on cognitive load means that an individual has a limited capacity at any one point to attend to, process and encode a stream of information. Jin and Dabbish (2009) stated:

> When a user switches to a different task because of an interruption, they must load the context of the new task into working memory which can

> be cognitively demanding and time-consuming. The time away from the interrupted task will delay the completion of that task and decay their working memory representation of information in the interrupted task. (p. 1800)

Regardless of how proficient an individual considers themselves at multitasking, there are neural limitations to what they can achieve at any one point. Individuals are only able to perform multiple tasks concurrently when these tasks are automated or rehearsed (Kirschner & Karpinski, 2010). Examples of this include listening to music whilst jogging, talking whilst driving or whistling whilst walking. When behaviours are automated, they present a diminished strain on cognitive load. If both tasks require cognitive control, individuals are not able to parallel process information. Kalyuga and Liu (2015) contended that further theoretical development is needed to ensure that technology within the classroom is used effectively, acknowledging the significant increase in cognitive load that multiple streams of information can present to the learner.

2.7.2. Self-Regulation and Motivation

Research by Kauffman, Zhao, and Yang (2011) found that self-monitoring prompts had a significant impact on how students recalled information during online lessons. They found that students who were prompted during the note-taking process (as opposed to during the study or testing phase) were more motivated to filter information from multiple sources of information throughout the process. The gathered information consequently enabled students to selectively attend to specific cognitive processes and gauge their progress against prescribed performance criteria, adjusting their strategic efforts wherever necessary. Zimmerman (1989) contended that the cultural environment of the school and whether or not there is a restrictive code for classroom conduct may stifle forms of self-regulation. He suggested that the inverse may also be true in alternative schools, where situational constraints are limited and the individual has more agency to regulate their own functioning.

Regardless of the information being communicated to the student, their motivation to attend to it is integral to its effective processing. Bandura and Cervone (1986) suggested that learning goals need to be tangible and often immediate, if not at least foreseeable, for the student. Where outcomes are too distant, motivation can be limited. Awareness of one's own strengths and weaknesses is an important behaviour to teach students, who will be able to use their skills of ongoing self-assessment to develop a range of strategies to address areas where they are cognisant of a deficit in their understanding (Bannister–Tyrrell, Smith, Merrotsy, & Cornish, 2014). As Gurbin (2015) suggested, being self-aware of how technology can influence an individual's capacity to develop meaning and understanding is crucial, noting "whether people are in a natural setting or a more formal, academic environment, metacognition is required for effective technology adoption" (p. 1579). In conjunction with metacognition, self-regulation is instrumental to capitalising on the far-reaching benefits of technology, both within and beyond the school environment. Ormrod and Davis (2004) suggested that self-motivation, the ability to self-evaluate one's own efforts, and the willingness to self-reflect on the effectiveness of one's learning strategies, are all goal related behaviours that relate to self-regulated learners. Without this inclination to be aware of one's own behaviours, the ability to take full ownership over the task and understand how to effectively approach it, will prove a challenging task for the individual who has the propensity to become distracted and stray from their primary objectives.

Deci, Spiegel, Ryan, Koestner, and Kauffman (1982, p. 852) noted "events that pressure people toward specified outcomes, thereby denying them the experience of choice, have repeatedly been shown to undermine intrinsic motivation". Intrinsic motivation for learning, where the student's approach is influenced by their autonomy on the task, their mastery of it, and their perceived relevance of it, are instrumental to their cognitive motivation (Ryan, Connell, & Deci, 1985). Ryan et al. (1985) suggested that increased pressure or control in the classroom could be both detrimental to self-determination and "deleterious to intrinsic motivation" (p. 27). In a comparison between active and passive atmospheres for learning, Benware and Deci (1984) found that students took greater ownership over their learning when they were able to learn with the expectation of using the material rather than simply being tested on it by an external examiner. Additionally, they found that students who were learning without the primary goal of being tested on the content had a greater conceptual understanding of the material. For students participating in this quasi-experimental design, their level of intrinsic motivation and self-determination may have been impeded by the controlled conditions within which the tests were conducted.

2.8. Rate of Technology Advancements

Understanding technology and its implications for teaching and learning is an ever-evolving field. With such rapid development occurring in software, hardware, and bandwidth, education is forever challenged to adapt to the changing pedagogical and technological landscape. This exponential growth is often illustrated by Moore's Law, which suggests that since the mid 20^{th} century, computer processing chips have halved in physical size whilst doubling in power every 24 months (Holt, 2016). This self-fulfilling prophecy is most apparent in enabling computing power to become increasingly affordable, accessible and portable. Ian Goldin, professor of globalisation and development at Oxford University, forecasted that the rapid change with which technology continues to evolve will have a significant impact on the global community:

> The dizzying pace of change in every aspect of life presents us with both the risks and potential rewards of a new renaissance taking place in our modern world. Except, this time, it is the entire world and a population of seven billion who are becoming connected and able both to access and input information that is globally accessible. The pace of advancement is therefore many times faster, and the degree of instability that ensues many times greater (Goldin, as cited in Halloran & Friday, 2018, p. 7).

Such global accessibility has led to ICTs becoming embedded in the education system. However, with inexorable advancements in tools that can be used for learning comes the challenging proposition of determining their pedagogical efficacy. For educators to address the academic needs of students, the implications of ICT continue to be of paramount importance. A tension between advocates and integrators of technology and those who see its place in the classroom as detrimental to learning continues to exist. Craft (2012) suggested that there are two competing perspectives in this digital age, where young people are viewed as either “vulnerable and at risk” or “capable and potent” (p. 1). Determining the benefits that effective integration of technology can have on teaching and learning is important to the debate surrounding technology in the classroom.

The NSW Department of Education and Training (2010, p. 7) contended that there is a need for more research to understand the “technological world of students”. Their report on digital literacies declares that there is a partition between classroom practices and everyday use of technologies, which suggests that students can feel conflicted when the device they are using outside of the classroom needs to be repurposed within the classroom. The challenge, therefore, is to delineate between two diametrically opposed functions offered by the same resource (Dede, 2005). Giedd (2012) suggested further investigation is needed to capitalise on the positive aspects of learning with technology, whilst developing strategies to minimise the negatives. Often it is *the bad* that receives greatest attention in public debate and the saturation of technology within modern society can be derided by those who are not comfortable with its use. The enthusiasm with which adolescents embrace technology can be met with resistance by teachers and parents who were exposed to a predominantly analogue learning environment in their developing years. Erstad et al. (2015) suggested the technological innovations in recent decades have fuelled tensions, with increasing demand on teachers to be "agents of change" (p. 641) in an ever-evolving pedagogical landscape. Research has found that teachers will often use ICTs for basic tasks, yet certain attitudes of resistance preclude them from exploring the greater potential available to them, where technology presents myriad opportunities to evolve their teaching practices (Erstad et al., 2015; Somekh, 2008).

It is incumbent upon policy makers and proponents of classroom ICTs to facilitate capacity building amongst teachers, who require the skills to maintain pace with constant technological change (Davis, Preston, & Sahin, 2009). Kivunja (2015) affirmed that educators, from preparatory through to tertiary, must maintain the fundamentals of 20th century education whilst acknowledging that 21st century tools must be embraced for this new learning paradigm. As schools now look to incorporate ICT throughout the curriculum, and teachers are mandated to integrate a range of digital learning resources, tools and activities into their lessons, the time for resisting technology in the classroom has passed.

2.9. Integrating ICT in the Classroom

The duality of new media and mobile phones is one that brings with it both positives and negatives. Bragazzi and Del Puente (2014) contended that digital devices offer a range of benefits such as the exchange of information and communication, the removal of geographical barriers, and the ability to connect and communicate with a range of actors that were previously inaccessible.

However, with such benefits comes the adverse, with Bragazzi and Del Puente (2014) purporting a list of issues such as the absence of face-to-face interactions and with it the perils of social isolation, economic and financial problems, physical and psychological pathologies, damage related to electromagnetic radiation and, most pertinent to this research, “the fear of not being able to use new technological devices (the so-called techno-stress linked to the technological divide or technological gap)” (p. 156). Whilst their clinical research was based in psychology more broadly, there are parallels with learning to be drawn from the aforementioned geographical barriers and the ability to communicate. This divide can generate resistance in schools where the last two decades have seen global technology investment increase by more than a hundredfold (Bilbao–Osorio, Dutta, & Lanvin, 2013).

The integration of technology into the classroom is now a practice that has been around for several decades (Forman & Pufall, 1988; Papert, 1980), and while its capabilities have dramatically increased since computers first entered the classroom, there are still a range of organisational challenges that its successful implementation face (Laurillard, 2013). Within the classroom, technology integration can vary in the level of implementation and complexity, yet Tondeur, Van Braak, Ertmer, and Ottenbreit-Leftwich (2017) contended that it pertains to any learning experience that is enabled or enhanced by digital tools. Achieving this goal can be a challenge for organisational leaders who can be met with both resistance and conflict between ICT initiators (those making the decisions), and implementers (those having to carry them out in the classroom). Hennessy, Ruthven, and Brindley (2005, p. 158) asserted that "classroom teachers have historically had little say in designing and implementing development plans for using ICT within their schools," which can often lead to disharmony between decision makers and those impacted by such pronouncements. Engaging teachers as part of the dialogue when it comes time to introduce change is critical to successful implementation, where schools can take advantage of the depth of experience required to let the old inform the new (Koksal, 2013). It is imperative for schools to not only provide students with access to technologically rich resources, but to educate them in how to use them appropriately (Brinkworth et al., 2009; Kivunja, 2015; Mutsotso & Abenga, 2010).

Technology plays an integral role in the functioning of a modern school (Aagaard, 2016a; Dede, 2005; Demirbilek & Talan, 2018; Wells et al., 2018) and can be considered tantamount, in developed societies at least, to the plumbing or electricity for day-to-day school functionality. However, for it to operate seamlessly in the background, without a second thought extended to it, it requires the management of complex infrastructure by a team of technical experts. Tondeur, Cooper, and Newhouse (2010, p. 303) highlighted the importance of ICT coordinators, suggesting that they need to be a "formal part in the leadership and decision-making structures of the school". Marcovitz (1998) affirmed that an ICT coordinator can help change schools in positive ways, having the capacity to be an agent for meaningful change (Lai, Trewern, & Pratt, 2002; Strudler, 1995; Watson, 2006).

Beyond the school principal being a key agent for change (Fullan, 1991), accepting that other key personnel within an organisation can contribute to change is essential to fostering innovation (Hopkins, 1994). ICT coordinators are tasked with affecting change in an era where technology has the propensity to advance at a faster rate than that which organisations can maintain pace. Such a role is therefore fraught with pressures and challenges that can often be underestimated by stakeholders who may be involved in the change process, though not fully aware of its technical complexities.

Lai and Pratt (2004) conducted a series of in-depth interviews to study the roles and responsibilities of the ICT coordinator. The research identified a range of obstacles that reduced their capacity as effective leaders within schools, such as lack of recognition and support of their role, as well as a scarcity of professional development and time. Since this study, which declared that a "full-time ICT coordinator is essential if ICT is to be successfully integrated into the school curriculum" (Lai & Pratt, 2004, p. 474), the role has become fundamental to many school leadership teams and can significantly influence the culture of an organisation.

With the rapid rate at which technology advances, the resistance from teachers can be compounded by the fact that fear of change is often regarded as a limiter in teacher performance (Koksal, 2013). Anticipation of an educational revolution has been fuelled by the significant investment from governments around the world, yet teachers who have been determined as working against

ICTs are considered responsible for restricting effective integration (Henderson & Romeo, 2015).

The generational divide between teachers is often cited as one of the key issues relating to how effectively ICTs are introduced into the classroom, with Lisenbee (2016, p. 104) declaring “This gap between students’ expectations and teachers’ use of technology in a classroom creates a disconnect between students and teachers”. Whereas millennial students may see technology as a mere extension of themselves and a tool that extends their abilities to socialise, interact and engage with content (whether for learning or not), a generational gap can widen where teachers see the role of technology as a far more singular modality.

2.9.1. Technology Acceptance Model

Within the research landscape, the Technology Acceptance Model (TAM) has looked at the integration, adoption and acceptance of technology in education (Davis, 1985). The model seeks to identify the potential success of systems, determined by core variables that are informed by motivations such as the perceived ease of use, usefulness and attitudes towards the technology (Scherer, Siddiq, & Tondeur, 2019). The educational potential of devices, which are widely embraced by secondary school students for a range of non-school relating activities, is important to consider when integrating them for learning (Baydas & Yilmaz, 2018). Baydas and Yilmaz (2018, p. 516) asserted that “the mobile/smart phone (with its new advanced features/attributes and functions) is the predominant mobile device for teenagers, provides a challenge for the implementation of mobile learning in formal educational context”.

Within the educational context, laptops and tablets are still one of the primary tools used for learning, as they are more closely associated with productivity. The policies in place can differ considerably from one school to another, so it is often incumbent upon the ICT integrators to adapt to the technology restrictions, or lack thereof, imposed upon them. Yet, Suárez, Specht, Prinsen, Kalz, and Ternier (2018) suggested that there is a lack of practical strategies for teachers who seek to integrate mobile technologies into the classroom. Achieving effective integration of mobile devices, or ICTs more broadly, continues to be noted as problematic in schools, where the distractive qualities can often override the pedagogical benefits (Ott, Magnusson, Weilenmann, & af Segerstad, 2018). The ability to attenuate the distractions that come from these devices is part of being digitally literate in the contemporary classroom.

Venkatesh and Davis (2000) offered a theoretical extension of this model, TAM2, to explain perceived usefulness and intentions with regard to social influence and cognitive instrumental processes. This built upon the previous model to include factors such as job relevance, quality of output, demonstrable results, and perceived ease of use. The extent to which technology integration can be successful is, to a certain extent, reliant on the acceptance of those who are tasked with accessing it for learning. Within the context of the secondary classroom, this pertains to the teachers as facilitators and the students as users. Teo (2011, p. 1) describes this acceptance as a "user's willingness to employ technology for the tasks it is designed to support". Henderson and Romeo (2015) suggested that there are three factors that influence a teacher's propensity to integrate ICTs: their school culture, followed by their confidence using technology and their individual beliefs in technology for teaching. Henderson and Romeo (2015) warned that teachers will struggle to justify the time required to learn new ICT approaches if the final outcome does not provide a significant improvement on a more traditional method.

2.9.2. Digital Literacy

An extensive review of the literature has found a range of ICT interventions or intrusions have been investigated in classroom settings, including mobile phones (Duncan et al., 2012; Fauquet–Alekhine, 2015; Kuznekoff & Titsworth, 2013), tablets (McCoy, 2013; Mueller & Oppenheimer, 2014), laptops (Fried, 2008; Gulek & Demirtas, 2005; Sana et al., 2013; Stephens, 2005), and social media (Gray, Annabell, & Kennedy, 2010; Pempek, Yermolayeva, & Calvert, 2009). As technology advances at a rapid rate, the finding of many of these studies highlight the ongoing challenge to remain relevant to a resource that evolves faster than pedagogical practice. Eshet–Alkalai (2004) deemed digital literacy an essential skill over a decade ago, before the advent of social networking, smartphones and one-to-one laptop programs. Research has revealed that students who are able to focus, attend to and process information are better equipped to apply their knowledge more flexibly to new contexts (Foerde, Knowlton, & Poldrack, 2006).

Several decades since Gilster (1997) coined the term *digital literacy*, its implications have evolved in pedagogical practice. Leu (2000) contended that digital literacy is deictic, in that its definition is temporal and evolves as technology advances. Eshet–Alkalai (2004, p. 93) suggested digital literacy involves far more than the ability to use software or a device, rather it requires a variety of “complex cognitive, motor, sociological, and emotional skills in order to function effectively in digital environments”. The Australian Curriculum stated that students’ ICT capabilities are determined by how they “learn to use technology effectively and appropriately to access, create and communicate information and ideas, solve problems and work collaboratively in all learning areas at school and in their lives beyond school” (Australian Curriculum Assessment and Reporting Authority [ACARA], 2016, p. 1).

Educators must therefore focus on what qualifies as being digitally literate instead of just being literate in one form of hardware, software or resource that may vanish from the educational landscape as quickly as it arrived. In this space, a digitally literate individual is one who has the ability to find, use, and disseminate information with the use of technology. Although the definition of digital literacy is somewhat fluid amongst theorists (Buabeng–Andoh, 2012; Gilster, 1997; Leu, 2000; Ottestad, 2013), having the cognitive capacity to focus and manage attention between media is becoming a valuable currency in learning (Rheingold & Weeks, 2012). Educators must also be conscious of the fact that being born of a certain arbitrary age does not necessarily equip the individual with innate digital literacies. These are skills that still need to be taught as digital natives may be adept at using their devices for recreation, entertainment and socialising (Prensky, 2010), but the skills required for effective learning with technology are not always immediately apparent. With regard to digital literacy, Erstad et al. (2015, p. 643) suggested that it is “central in defining how fluent teachers and students are in using new technologies, both inside and outside of schools, and are understood as cross-curricular competences". Although Chen and Tzeng (2010) found that using the Internet could improve academic performance, Kirschner and Karpinski (2010) believed students may lack the knowledge to determine how authentic, appropriate or accurate the information they find online is. They suggested that simply accessing Google is not the same as using it effectively, citing examples such as students referring to British artist Francis Bacon when attempting to refer to the 16^{th} century natural philosopher, or struggling to distinguish the difference between Martin Luther and Martin Luther King.

Some proponents of raising awareness to the detriments of technology suggested that this 'rewiring' of the brain can have deleterious effects (Greenfield, 2015), where the need to be constantly engaged is impacting the ability to focus. However, Courage et al. (2015) contended that there is a lack of clarity regarding what 'rewiring' actually constitutes in this domain, as some researchers relate the term broadly to learning, whereas for others it can more precisely concern the neural networks and synaptic connections made. In certain cases, the fixation with the screen over more traditional resources can prove a hindrance to the learning process. In research investigating reading comprehension between screen and paper, Mangen et al. (2013) found that reading texts on a screen resulted in poorer comprehension than reading the same material on paper. For teachers charged with maintaining the attention of their audience, this impact on dwindling focus is an increasing concern for educators (Anderson & Rainie, 2012; Dandolo Partners, 2013; Schmid et al., 2014).

Fried (2008) undertook research in the US to support anecdotal evidence from educators who claimed that laptops were detracting from the learning process. Although laptops can increase rates of in-class participation and student motivation (Fitch, 2004; Gulek & Demirtas, 2005; Stephens, 2005), the research revealed laptop use negatively related to several measures of student learning. Fried (2008) concluded that laptops "interfered with students' abilities to pay attention and understand the lecture material" (p. 911). The research established correlations between lower test performance and greater laptop use within lectures. However, causality is more difficult to determine, as students of a lower academic ability might be more inclined to stray from the learning objectives. Fried suggests that using other data relating to students' capabilities and academic performance would attenuate this issue.

Technology within the classroom, for all its perceived detriments and the deleterious effects associated to learning and the retention of information, still has its place in the contemporary classroom (Wood et al., 2012). Witmer (2005) suggested that quality relationships can have a positive impact on student success, noting the importance of cooperation among those involved around the student's needs is essential, declaring "teachers, administrators, and parents are all stakeholders in a child's education" (p. 224). The importance of gathering views from distinctly different perspectives sought to identify where the tension, if any, lay in the partnership among these stakeholders in achieving learning objectives. If a teacher were to be a proponent of technology, seeking ongoing strategies to integrate ICTs into their practice, their efforts could be for nothing if the student returns home to extend their learning and has the merits of said ICTs derided by parents supervising their homework. Conversely, if parents were advocates for this digital approach to be supported in their child's school and found that teachers were not fulfilling the needs of the 21st century learner in this way, frustration could occur. The dynamic among all three parties in the learning process is a deeply complex one based on more than effective pedagogical practice. Witmer (2005, p. 224) suggested that beyond reading, writing and arithmetic, relationships form "the foundations of effective education" and that "teacher-parent and school-home relationships are an integral part of the educational process". Relationships within the classroom are important as the student who connects with their teacher and vice versa will be more likely to achieve improved academic performance (Caine & Caine, 1991). This is because the brain does not separate cognition from emotion, therefore a student will opt to be more actively engaged with content being delivered by someone they have a greater level of emotional connection to (Caine, Caine, McClintic, & Klimek, 2005).

2.9.3. Online Learning

The significant proportion of the literature relates to higher education, where research has been conducted on tertiary students and their interactions with technology for learning. Whilst the learning requirements and abilities of adult students vary from school aged students, the studies conducted can still inform experiment designs within the school classroom. The ability to learn online is considered as one of the most significant developments relating to both the accessibility and democratisation of education in the 21st century (Grossman, 2016). A review by Halloran and Friday (2018) sought to provide education policy makers with an insight into how the universities of 2030 would look.

With regard to how disruptive technologies will shape the way people engage with education, they stated that “demand for learning is shifting to a fundamentally new paradigm” (p. 4).

In the tertiary sector, Halloran and Friday (2018) suggested that demand is outpacing supply when it comes to university students wanting online platforms to facilitate learning. Whilst technology continues to increase access to tertiary level qualifications and short courses for adults, the case for schooling children remains more blended, as opposed to moving entirely online. The tyranny of distance that the Internet erodes has enabled schools and students in remote locations to connect with each other; however, it is yet to offer an alternative that sees the physical classroom and the presence of a teacher replaced. The teacher-student relationship plays a significant role in the motivations of the student and this relational context is one that is not easily replicated online (Hagenauer, Hascher, & Volet, 2015). Some of the key social interactions that are present in the school classroom can be difficult to ascertain when dealing with students online, where physical cues and personal interactions are limited, if not non-existent. This interpersonal relationship in the classroom is critical, where non-verbal cues are key stimuli and the engagement with the teacher is integral to information transmission (Hung, Chiang, Huang, & Lin, 2017).

With predictions of an increasingly digitised learning space, a distinction needs to be made among the social, emotional, and academic needs of the school-aged child compared to tertiary students who have developed greater levels of autonomy and ownership over their learning. With this enhanced space comes the possibility of enhanced engagement, which Newmann (1992, p. 12) defined in the educational context as “psychological investment in and effort directed toward learning, understanding, or mastering the knowledge, skills, or crafts that academic work is intended to promote”.

Game based learning (GBL) continues to develop in education and evidence suggested that it can be beneficial to arousing student interest, motivation and engagement (Wells et al., 2018). Creating activities within the classroom where students are rewarded for academic achievement with quantifiable points to mark their efforts has long existed in teaching (de–Marcos, Garcia–Lopez, & Garcia–Cabot, 2016). The implementation of what Boniecki and Moore (2003, p. 224) described as a ‘token economy’ is not necessarily new to educational settings, yet technology now enables teachers to implement this strategy in a gamified way that reaches their students in a mode that they are both familiar with and interested in. With a range of online learning activities being implemented, it creates rich data sets that can provide teachers with a detailed insight into how students perform on topics, areas or even specific questions. Bydžovská and Popelínský (2014) suggested that the use of effective data mining techniques can enable educators to identify student abilities and subsequently adapt their teaching methods to the needs of the individual.

Laurillard (2013) warned that students should not be solely reliant on a medium that restricts interactivity, such as the natural engagement that comes with inquiry between student and their teacher, asserting that the role of the educator must be robustly defended in a digital age of abundant and easily accessible information. In an increasingly automated and technologically reliant society, there are some who suggested that the teacher is no longer required to communicate the content (Edwards & Cheok, 2018; Frey & Osborne, 2017). Yet, Laurillard (2013) insists that the role of the teacher is now more integral to learning than ever:

> Educationalists must resist the idea that because of new technologies, students can do it for themselves – instead they create an even more critical role for the teacher, who is not simply mediating the knowledge already articulated, but is more deeply involved in scaffolding the way students think and how they develop new skills they will need for the digital literacies. (p. 4)

Whilst the depth of information available to students is like no other time in history, the breadth means that students often don't develop the critical thinking skills to deeply analyse surface level information. This surface level style of learning is one where students memorise facts instead of demonstrate understanding. Their ability to craft arguments can be undermined by their failure to check original sources and a reliance on information provided by others, where they don't apply any critical thinking to the task (Biggs & Tang, 2007).

2.9.4. Handwriting vs. Typing

Debate abounds in educational spheres regarding examination procedures and whether there should be consideration afforded to typing examinations instead of handwriting them (Mogey, Purcell, Paterson, & Burk, 2008; Wollscheid, Sjaastad, & Tømte, 2016). Vincent (2016) observed that students construct the majority of their written responses via the keyboard throughout the course of learning and it is only during formative assessment, such as examinations, where they must revert to a traditional mode and handwrite their response. In her cross-cultural exploration, Vincent (2016) identified a range of motivations for both digital and analogue approaches to coursework:

> Motivations for using paper and pen are influenced by the haptic qualities of reading and writing – the feel and the smell of the paper and the grasp of the pen, the turn of the page, and extend also to the practical usefulness of note-taking and writing in margins while reading. Conversely the use of hypertext and automatic error correction in online writing are making the use of keyboard and screen more compelling. (p. 104)

Dr Sarah Pearsall, of Cambridge University, said "Fifteen or twenty years ago, students routinely wrote by hand several hours a day, but now they write virtually nothing by hand except exams" (Busby, 2017, para. 2). In a series of experiments relating to note-taking strategies and students' subsequent ability to recall information, Bui, Myerson, and Hale (2013) found that students who typed their notes verbatim received immediate benefit from their ability to digitally organise and record key content; however, the shallow encoding of information led their long-term recall of the information to be less effective than peers who had taken organised handwritten notes.

Mueller and Oppenheimer (2014) found that students who typed notes verbatim were not as effective at encoding concepts into long-term memory as students who produced handwritten notes. Their research found that students who had typed notes on their laptops performed worse on tests than those who had hand written, with regard to both factual content and conceptual understanding.

2.9.5. In Class Results: Technology and Comprehension

As many schools move to a Bring Your Own Device (BYOD) model (Ricci, 2015), students are now bringing a range of personal devices into the classroom and the access to tablets and mobile phones presents challenges beyond those of the laptop. With many schools promoting BYOD initiatives, much of the control of the device can be relinquished by schools and consequently enables students the freedom to harness the power of their own device. With their devices free from a range of school implemented network controls, it creates a challenging level of freedom for schools to manage.

Network and Wi-Fi restrictions can be enforced by institutions; however, the ability to subvert any access or safety restrictions is remedied by the student who is able to access networks such as 4G (cellular data that allows wireless Internet access) beyond the jurisdiction of school network control. A school's control over a sanctioned device such as a personal tablet or smartphone also engenders a range of property, privacy and access concerns, where the student may not necessarily be obliged to share the content or behaviour taking place on their device, even though it is occurring within the classroom environment. Therefore, the tension that may arise from BYOD and like initiatives is best addressed through teaching appropriate use, rather than militant control over the individual's online conduct.

Wei, Wang, and Klausner (2012) investigated the impact that texting can have on attention in the classroom, suggesting that it "may undermine learners' attention from classroom instruction and adversely affect the capacity of short-term memory to process the multiple tasks in which students are engaging (texting and learning), leading to negative cognitive learning outcomes" (p. 186). As students are as inclined to communicate with their peers via text as previous generations might have been to whisper at the back of the class or pass a paper note, the challenge presents itself in how to restrict a behaviour that is so integral in the social mores of contemporary adolescent behaviour.

The Australian Institute for Teaching and School Leadership (AITSL), which provides "leadership for the Commonwealth, state and territory governments in promoting excellence in the profession of teaching and school leadership" (Australian Institute for Teaching and School Leadership, 2015, para. 1), advises schools to integrate technology that expands learning opportunities for students. Each educational institution implements their own policies and guidelines for technology use and this variance needs to be considered when addressing the use of technology on a broader scale. Whilst some secondary schools might prohibit the use of mobile devices within the classroom, others might actively encourage its integration and implementation of teaching strategies that enable students to engage with multiple devices (laptop, tablet, smartphone, etc.) within the one lesson. Regardless of the level of technology saturation within the classroom, there is significant evidence relating to its implication for comprehension and academic performance when poorly managed (Demirbilek & Talan, 2018; Lepp et al., 2015; Levine et al., 2007; Sánchez–Martínez & Otero, 2009).

Lepp, Barkley, Sanders, Rebold, and Gates (2013) addressed the disruptive challenges brought by the mobile phone, where the presence of such a device may hinder behaviours "conducive to academic success" (Lepp et al., 2015, p. 1). Students who use their phones habitually can find it difficult to regulate their use during academic endeavours where there is a demand on their attention. A breadth of research has concluded that smartphones can have a detrimental effect on learning activities (Demirbilek & Talan, 2018; Duncan et al., 2012; Jacobsen & Forste, 2011; Lepp et al., 2015); however, as schools and universities embrace BYOD, this once prohibited device is now becoming a sanctioned ICT within some learning environments. Students may struggle to resist the lure of the smartphone in their pocket, regardless of whether it is a prohibited device or not (Lawson & Henderson, 2015; Wood et al., 2012).

Jacobsen and Forste (2011) found that total mobile phone use was a significant negative predictor of Grade Point Average (GPA) amongst American university students. The mobile phone can serve as a trigger for constant, habitual use (Oulasvirta, Rattenbury, Ma, & Raita, 2012), where the motivation to access information is not always aligned with the classroom learning objectives. This inclination to respond rapidly to interrupting incoming messages can result in resumption lag (discussed further in this chapter), where returning to the task at hand is hindered by a loss of focus. Borst et al. (2015) suggested that the longer and more complex an interruption, the higher the resumption costs, "especially if they interrupt the primary task at high workload moments" (p. 2972). The duration of the interruption, the complexity of the interrupting task, and the moment that the interruption occurs, can all contribute to the length of the resumption lag.

Research by Rosen et al. (2011) found that students who opted to respond immediately to incoming messages performed significantly worse than their peers who opted to wait up to five minutes before responding to the interrupting text. They concluded that "we should be teaching our students metacognitive strategies that focus on when it is appropriate to take a break and when it is important to focus without distractions" (Rosen et al., 2011, p. 174). Encouraging students to develop an attitude of responsible use should be considered when developing digital literacy skills, as an inability to manage digital interruptions can be detrimental to sustained focus. Rosen et al. (2011) asserted that "making strategic decisions about technology usage that benefit learning" (p. 75) is a form of metacognition, due to using technology appropriately being elemental to its efficacy. Self-regulation is therefore key to adapting to a space where distractions are constant and the immediate instinct is to attend to tasks that may not complement the learning objectives at hand.

2.9.6. Lesson Concentration and Comprehension

Attention is an integral function of effective learning, with Godwin et al. (2016, p. 141) stating conversely that "inattention or off-task behaviour is a significant problem in educational settings as inattention reduces students' opportunities to learn”. In an educational context, seeking gratification within the classroom can now be superseded by the stream of contact that is coming to the student from beyond the confines of the room. As opposed to an age of mind-wandering or day-dreaming, where the student’s mind drifts to distraction, technology now actively pushes distraction onto the student. As Aagaard (2016a, p. 11) observed, “just as laptops and tablets open up the possibility of bringing the outside world into the classroom, they also constitute a backdoor through which students may occasionally escape”. Whether it be instant messaging, ‘likes’ on their social media stream, or content that is more enticing than the lesson being presented, the adolescent mind is confronted with an overwhelming array of information at any one point in time.

Bailey and Konstan (2006) suggested that distractive tasks, where cognitive resources are reoriented away from the primary task, can lead to increases in learning errors, learning times, annoyance and anxiety. Research indicates that the learner can feel an increase in stress as the result of excessive multitasking, as the time to effectively master material is also increased (Gazzaley & Rosen, 2016, p. 126). It is incumbent upon teachers to be sensitive to the demands on their students’ cognitive load, with Mayer and Moreno (2003) recommending that effective instructional design is dependent on understanding how the human mind works. Rosen (2010, p. 95) suggested that teachers should “develop educational models that allow for appropriate multitasking that improves learning”. Rosen et al. (2013, p. 956) advised that the answer is not to demand that students unitask, as all it will achieve is a “shift from external auditory, visual and tactile distractors to an internal, anxiety-laden need to check in with their electronic worlds”. If teachers do not integrate technology intentionally and meaningfully into the classroom, then Kay and Lauricella (2011, p. 39) warned that students will “engage in a wide range of non-productive laptop behaviours”, such as gaming and social media.

The ability to understand lesson content can be complex in and of itself, with new and unfamiliar information being disseminated and the student being asked to make links between new and possibly abstract concepts. Therefore, attending to unrelated content during a lesson may be too cognitively taxing for students and the result may lead to limited comprehension (Kuznekoff et al., 2015). The number of memory errors and processing time required to learn new topics that involve a significant cognitive load dramatically increase when students are attempting to complete too many tasks concurrently (Kraushaar & Novak, 2010, p. 241). As technological innovations continue to evolve in teaching and learning, teachers must construct activities that encourage more durable knowledge. Students might be engaged and gratified by the introduction of various ICTs into the learning process, but the process of encoding knowledge for later retrieval can be undermined if the ICTs’ implementation is not carefully considered. Kalyuga and Liu (2015, p. 3) suggested “it is not technology itself that matters but how it is used”. If students are attempting to learn while engaged in multitasking behaviour, the result can be the acquisition of less flexible knowledge that cannot be easily recalled and/or applied in new situations (Foerde et al., 2006).

2.9.7. Technology as a Learning Distractor

Research has shown that attempting to either attend to or process more than one task at a time can overload the capacity of the human information processing system (Drews, Pasupathi, & Strayer, 2004; Marois & Ivanoff, 2005; Wood & Cowan, 1995). As multitasking consumes cognitive resources that could be otherwise used for processing primary information, Aagaard (2015b, p. 888) suggested that it is not surprising that media multitasking impairs academic performance. Evidence indicates that the memory of students who engage in computer mediated non-lesson related activities will be significantly compromised (Risko, Buchanan, Medimorec, & Kingstone, 2013).

Even if distraction does not decrease academic performance, it can make it more difficult for newly acquired knowledge to be applied flexibly in new situations where the information needs to be applied to new learning contexts (Foerde et al., 2006). Several studies have identified a negative relationship between the use of social-networking sites and academic performance (Fried, 2008; Kirschner & Karpinski, 2010; Kraushaar & Novak, 2010; Risko et al., 2013; Rosen et al., 2013; Rosen et al., 2011; Sana et al., 2013; Stollak, Vandenberg, Burklund, & Weiss, 2011). This includes: negative relationships between students using their mobile devices in class and students' scores on a multiple-choice test (Kuznekoff et al., 2015), responding to messages during a lesson resulting in significantly fewer notes and significantly diminished quiz scores (Kuznekoff & Titsworth, 2013), hierarchical linear regression indicating Facebook use and texting during class were negatively predictive of overall semester GPA (Junco, 2012), texting while attending lessons impairs academic performance (Dietz & Henrich, 2014), students who allocate greater cognitive resources towards distractive rather than productive online work achieve lower academic performance (Kraushaar & Novak, 2010), a negative relationship between time spent instant messaging and reading comprehension scores and overall reported GPA (Fox, Rosen, & Crawford, 2009), and multitaskers' laptop use posing a significant distraction to participants sitting in their vicinity (Sana et al., 2013).

Junco and Cotten (2012) found that there was a strong, negative relationship between the time spent on Facebook and cumulative GPAs, where engaging in social media use while trying to complete schoolwork may preclude deeper learning due to the strain on their cognitive capacity. Kirschner and Karpinski (2010) found that Facebook users reported a lower GPA and fewer hours of weekly study than non-users. Such negative relationships are not just confined to the United States of America, as populations across Europe and Asia have identified similar trends (Helou & Rahim, 2014; Karpinski, Kirschner, Ozer, Mellott, & Ochwo, 2013). However, evidence from Australia, especially in the secondary school environment, is currently scarce. Judd and Kennedy (2011) called for further research as there is a need to distinguish between activities suited for learning and those that adversely impact the learning process due to ineffective multitasking.

Sana et al. (2013) found that the distraction from a student's laptop within the lecture environment not only impeded the individual's academic performance but had negative implications for neighbouring students who weren't using their own device. When students sat near peers who exhibited less self-control over their distractive technologies, Sana et al. (2013, p. 29) contended that "despite actively trying to learn the material (as evidenced by comprehensive notes, similar in quality to those with a clear view of the lecture), these participants were placed at a disadvantage by the choices of their peers".

Research examining the influence of multitasking with a range of electronic media on the ability to learn from university lectures determined that lower scores were associated with students who were more inclined to multitask, as opposed to those who did not (Wood et al., 2012). Although the majority of studies focus on the tertiary learning environment, similar approaches to learning are pertinent to the structure of the secondary classroom. One of the most considerable differences between the two is that adolescents have a greater inclination to become distracted (Konrad et al., 2013). Another factor to consider is that secondary students are attending lessons compulsorily (a legal requirement in Australian schools), as opposed to voluntarily, such as tertiary students. Secondary school students are also exposed to a breadth of subject areas, where the content and focus of their lessons may hold no intrinsic value or motivation beyond the mere obligation to attend. Research on high school and university students (Rosen et al., 2013) observed that they typically became distracted by social media after less than six minutes of studying.

Lepp et al. (2015) found that the negative relationship between technology use and academic performance could be attributed to the decrease in time afforded to uninterrupted studying and the decreased focus that comes as the result of ongoing technological distraction and interruption. Beyond increased time to complete tasks, Carr (2011) argues that shallow thinking has replaced deep, contemplative thought and analysis. He allegorises the search for information today as jet-skiing across the surface of the ocean compared to diving into the depths to find material. The Internet's propensity to provide surface level information easily and immediately, at the expense of rich content, is often attributed to our decreased ability to remember key details. Known as *transactive memory*, the minutiae of facts and details that organise our daily lives can now be outsourced to the online space, in theory freeing up our brains to remember more vitally important information (Sparrow et al., 2011). They also suggested we were becoming dependent on our computers and the importance of knowing where to find information has superseded the ability of remembering it.

2.10. Problematic use of Devices

There are a range of factors, many external, that present challenges to educators when it comes to effectively integrating technology within the classroom (Courage et al., 2015). As secondary schools in Australia are mandated to integrate ICTs into the curriculum, the presence of technology is unavoidable for the adolescent's education (Dandolo Partners, 2013). To what extent the ICTs are embedded in the learning landscape can vary depending on factors such as accessibility, viability and practicality. Beyond the integration of ICTs themselves, the way in which this occurs is usually solely dependent on the individual teacher in a specific classroom and how they choose to direct their students' learning (Lisenbee, 2016). The discrepancy that can occur here means that students can go from one lesson to another and be either discouraged or encouraged to utilise their technology, depending on the individual beliefs of the teacher in charge and how they perceive ICTs' efficacy in the classroom. Beyond the teacher's individual perceptions, the content of the lesson and the learning objectives will dictate to what extent technology can be used within a specific lesson. For reasons of feasibility and practicality, not every lesson will enlist ICTs to enhance or complement the pedagogical approach.

The manner in which a student approaches learning with the necessary motivation and awareness relates to their psychological wellbeing, which is identified as a key factor contributing to academic success in children (Deighton et al., 2018; Dix, Slee, Lawson, & Keeves, 2012). When considering a young person's psychological wellbeing, how they engage with technology can be considered an increasingly relevant factor in their overall state of mind (Burns, Liacos, & Green, 2014; Heid, 2018). Therefore, teachers must develop an understanding of the often-distinct differences between themselves and their students regarding the relationship that they may have with technology. The term nomophobia, a truncation of no-mobile-phone phobia, is one that has gathered support in literature to define the fear or anxiety that comes from being separated from one's device (King, Guedes, Neto, Guimarães, & Nardi, 2017). Bragazzi and Del Puente (2014) proposed the term be included in the Diagnostic and Statistical Manual of Mental Disorders (DSM), which they describe as the "gold standard for assessing the psychiatric diseases" (p. 155). Researchers at the University of Iowa designed and validated a questionnaire, the NMP-Q, in an attempt to qualify what nomophobia was and how it can be more accurately defined. They stated that “nomophobia is considered a modern age phobia introduced to our lives as a by-product of the interaction between people and mobile information and communication technologies, especially smartphones” (Yildirim & Correia, 2015, p. 130). The anxiety that comes from being offline is something that teachers must be cognisant of, as a challenge in the classroom is one where rules and regulations intervene the very construct of social interaction that the millennial student is accustomed to in contexts beyond the classroom (Anderson & Rainie, 2012; Cowling, 2018; Kuss, 2017). Gazzaley and Rosen (2016) suggested that separating an individual from their device can create levels of anxiety where the distraction of simply thinking about their removed smartphone can be a challenge tantamount to the distraction of it remaining in their pocket.

There is an ever increasing body of literature that supports anecdotal reports relating to the distractive allure of technology and the perpetual stream of notifications that make the smartphone difficult to ignore (Aagaard, 2016b; David et al., 2015; Fauquet–Alekhine, 2015). The abundant social connections that can be carried around in one’s pocket and the onslaught of bottomless content that fuels social media has the capacity to leave the individual dependent on connectivity (Kuss, 2017; Müller et al., 2016). Whether it is the ‘ding’ of an incoming text message or the validation that comes from a pixelated thumbs-up, it can lead to both a positive social stimulus and dopamine influx. Cognitive neuroscience tells us that the dopamine activation that comes from the reward of social engagement and streams of digital validation can lead individuals to be constantly tethered to their device (Kim, Milne, & Bahl, 2018; Milani, 2017). Therefore, it should be no surprise that the separation from such a stream of digital engagement can lead individuals to feel both anxious and stressed. In an experiment that asked participants to complete a range of puzzles, Clayton, Leshner, and Almond (2015) found that individuals who were not permitted to respond to their ringing mobile phone whilst completing their task had elevated blood pressure, a faster heart rate and self-reported feelings of anxiety and unpleasantness. They observed that restricting users from attending to their device "activated their aversive motivational system and also led to a decline in cognitive performance" (Clayton et al., 2015, p. 132). It is emotional reactions like this which have the potential to elicit stress and restrict motivation in students if technology is not integrated and managed effectively.

The majority of criticism directed towards technology has been either moralised or medicalised (Lovink, 2011), with the popular consensus tending to promote the unease surrounding the digital world as it relates to cognitive and neurological development, as well as the causation of changes in social behaviours relating to addiction and empathy (Greenfield, 2015; Turkle, 2017). The concept of Internet addiction has dominated Internet psychology for nearly two decades, yet the criticism of this potential disorder lacked specific focus (Aboujaoude, 2016).

Defining problematic behaviours is challenging when people are increasingly always online, often with purpose or a specific intent that is not necessarily detrimental. This heavy, but normative, Internet use that is so often required in an increasingly online world does not necessarily denote an addiction, so much as a necessity in some instances. In the absence of any broadly accepted classification of Internet addiction, the definition Shaw and Black (2008, p. 353) offer as "excessive or poorly controlled preoccupations, urges or behaviours regarding computer use and Internet access that lead to impairment or distress" can be considered an accurate summation. The debate continues over what can be classified as either excessive or inappropriate use and remains a challenge in classifying the term *Internet addiction.* Starcevic and Aboujaoude (2017, p. 1) suggested that "terminological and conceptual conundrums" abound due to the lack of concordance between varying understandings of the term. Horror stories such as cardiopulmonary deaths in South Korean Internet cafes (Choi, 2007) can influence how frightening a prospect technology addiction can be a for any parent or teacher responsible for mandating a child's use of technology.

News services have reported on multiple individuals who become so preoccupied with online gaming that they begin to neglect basic human needs and, as a result, suffer physiologically. Scenarios such as the couple who allowed their three-month-old daughter to die from malnutrition whilst they dedicated their time to raising a virtual child are harrowing (Epstein & Jung, 2011). As a society regarded at the forefront of connectivity, South Korea often provides fertile ground in researching the challenges presented to those who become dependent, if not addicted, to living a life online (Yang & Kim, 2018). However, it should be noted that such issues are not just confined to Asia. Such sociological behaviour is increasingly endemic of any culture where the population has ready access to the software and hardware necessary to access the Internet (Sigman, 2012). Problematic Internet Use (PIU), Technology Dependence or Pathological use of Electronic Media (PUEM) are all descriptors relating to the compulsive use of the Internet, where the label addiction is not deemed as appropriate terminology. Aboujaoude (2019) contends that Internet addiction is not so much a distinct condition as it is a manifestation of a possible underlying mental disorder.

Considerable controversy exists where theorists are divided on whether using the term *addiction* is appropriate when discussing the dependence or overuse of personal technologies (Müller et al., 2016; Pies, 2009). Debate on whether dependence on the Internet can be directly correlated to conditions such as anxiety, depression or attention deficit disorder continue to permeate the literature (Kim et al., 2018; Kuss, 2017; Markey & Ferguson, 2017; Müller et al., 2016). Directionality, for instance, on whether an individual turns to the Internet because they are depressed, or they are depressed because they are always on the Internet, can be difficult to establish (Istenic Starcic & Bagon, 2014; Kuss, 2017; Markey & Ferguson, 2017; Müller et al., 2016).

As the physical state of technology continues to shift and portable devices become the norm, attributing the perils solely to the Internet can also overlook other ways in which individuals can become dependent on technology. An individual may become addicted to aspects that the Internet enables, such as the delivery service for online activities, for example gambling, gaming, pornography, social media, shopping and so forth. Therefore, gaming platforms, social channels and various electronic media may all fall under such a description of Internet addiction, yet the term Internet in this context may not necessarily be the most accurate (Starcevic & Aboujaoude, 2017). A more accurate designation may be to the specific online activity, as opposed to an umbrella term of the Internet. If an individual was prevented from a certain online activity, it does not necessarily mean that they would consequently seek something completely different online for the mere sake of addressing the absence of their first preference, such as someone prohibited from playing video games would not necessarily address their predilections with online gambling (Pontes, Szabo, & Griffiths, 2015). Such a distinction has led to the DSM being more targeted in their classification about addiction through the inclusion of the word gaming.

Video game addiction, classified as *Internet Gaming Disorder,* was recognised in the DSM as a condition that warrants further clinical research and study (American Psychiatric Association, 2013). Yet, the problematic use of devices transcends gaming when it comes to the addictive properties of interacting with technology. The DSM concedes that their clarification is limited to Internet gaming and does not include social media, online gambling or general use of the Internet (Petry & O'Brien, 2013). This classification of addiction relates specifically to individuals who play games compulsively, to the exclusion of other interests and interactions. Such an addiction has potential psychological consequences which have the capacity to impede an individual's behaviour, such as:

> sacrificing real-life relationships and other pastime activities, sleep, work, education, socializing, and relationships, obsession with gaming and a lack of real-life relationships, lack of attention, aggression and hostility, stress, dysfunctional coping, worse academic achievement, problems with verbal memory, and low well-being and high loneliness. (Kuss, 2013, p. 127)

The definition of Internet Gaming Addiction may not be wholly appropriate for the distractive properties associated with more socially motivated digital tools integrated into the learning process. However, the psychosocial implications associated with gaming and its addictive nature can be paralleled to online consumption beyond video games. An ongoing debate surrounds calls for the inclusion of Internet Addiction Disorder (IAD) into the DSM (Block, 2008; Cash, Rae, Steel, & Winkler, 2012; Pies, 2009), yet its classification as a disease is regarded as controversial due to the absence of controlled studies that could identify the relationship between addiction and compulsive or impulsive behaviours. Terminology such as compulsive or dependent may serve as better descriptors than addiction, where the clinical definition is characterised by the individual's inability to abstain from the behaviour to the detriment of their own condition and their relationships with others (Goodman, 1990). As psychiatry has increasingly made use of neuroscientific evidence to develop an understanding of mental disorders (Kupfer & Regier, 2011), studies have shown that changes in brain activity related to addiction are relevant to regions of the brain involved in neural activity related to learning, such as reward, motivation, memory, and cognitive control (Volkow, Fowler, & Wang, 2003). Thus, the ability to regulate one's behaviour in the face of digital distractions, laden with the alluring properties purposefully designed to promote their addictive properties, is the challenge that students face on a daily basis.

2.11. Accessibility to the Internet

The way in which young Australians consume technology is rapidly evolving, at a pace dictated by the increasing accessibility of devices, data and a propensity to be perpetually online (Australian Bureau of Statistics, 2018; Deloitte, 2017). Statistics explaining Internet, social media and technology use increase yearly, consequently creating data that becomes superseded almost as soon as it is released. As activity increases online, the ways in which they interact with media, entertainment and each other evolves to suit a system where interpersonal connections made online facilitate meaning as much as those created offline (Hodkinson, 2017; Müller et al., 2016).

The results of the Household Use of Information Technology (HUIT) survey gathered by the Australian Bureau of Statistics note that households with access to the Internet has been steadily increasing since 2004, with 97% of homes with children under the age of 15 having access to the Internet (see Figure 1). Houses in metropolitan areas were more likely (88%) to have the Internet compared to those in remote parts of the country (77%). This is in contrast to the turn of the century, where only 56% of homes had access to a computer at home, with only 37% using those computers to access the Internet (Australian Bureau of Statistics, 2000). In contemporary Australian society, access to technology and the Internet is close to universal. Ninety-one percent

(91%) of households use desktop computers or laptops, with 91% also using smartphone devices. Nearly all households (99%) with children under the age of 15 used a mobile device to access to the Internet (Australian Bureau of Statistics, 2018).

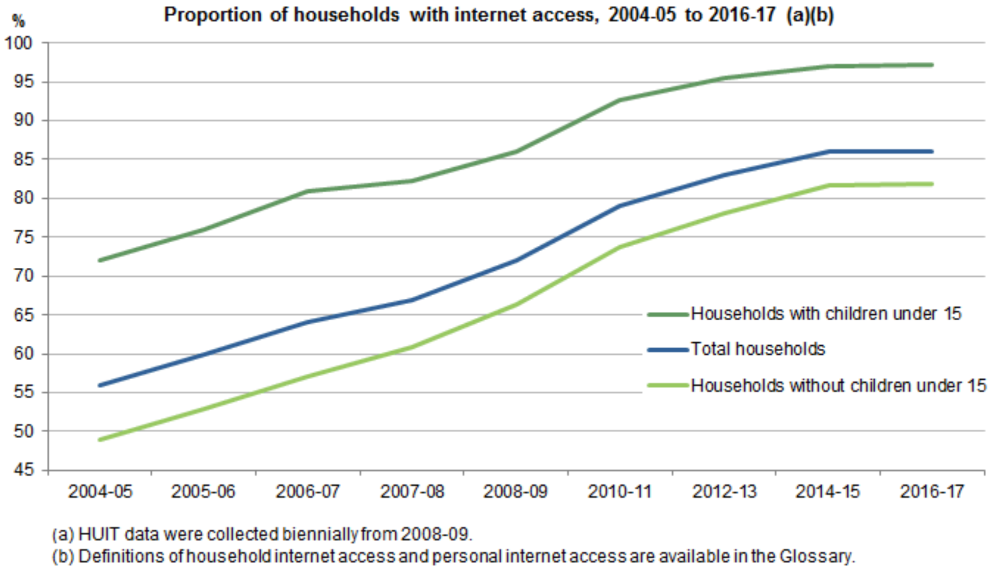

Figure 1. Proportion of households with Internet access, 2004-2005 to 2016-2017, (Australian Bureau of Statistics, 2018)

With such ubiquitous access also comes challenges for Australian households. In 2016-2017, 14% of online households declared that their children (aged 5 to 14) had been exposed to inappropriate content, with 5% stating that their children were subject to online bullying (Australian Bureau of Statistics, 2018). It should be noted that the divide between low and high-income households can have an impact on how readily available a device is for a child to access. Although high income households may have around seven devices per household, at the other end of the scale this is closer to four devices per household. What this means is that students might be prescribed homework and outside of class learning tasks that they are unable to complete if the use of particular devices is shared amongst other members of the same household, consequently limiting their access and ability to address the digital task (Ewing, 2016). Regardless of the specific device in use, whether it be desktop, laptop, smartphone or tablet, this level of constant connectivity enables adolescents to interact and engage with friends, family and peers online.

2.12. Media Consumption

Children can often be resistant to raising the alarm or informing an adult when they are concerned or upset from their online activity due to fear that the adult's instinctual response will be to remove or ban the child from engaging with their device in order to resolve the situation (Hicks, Jennings, Jennings, Berry, & Green, 2018; Hodkinson, 2017). Sexting (sending sexually explicit content to another recipient's device), cyberbullying, contact with strangers online, and negative experiences as the result of social media are all concerns that relate to how teenagers behave in the digital space, often out of the observation or jurisdiction of responsible adults, such as parents and teachers (Office of the eSafety Commissioner, 2018).

Australia is one of the most active nations when it comes to online activity, with 60% of the nation's population regularly using Facebook and 15 million unique visits to YouTube every month (Cowling, 2018). However, there is often a misconception that it is solely young people who are drawn to social media and become dependent on it. Data reveals that of all users of Facebook, 13-17 year-olds are the smallest proportion, at 940,000, compared to 18-25 year-olds (3.5 million), 25-39 year-olds (6.1 million), and 40-55 year-olds (4.1 million) (Cowling, 2018). With regard to gaming, research suggests that males are more predisposed to play video games, with Veltri, Krasnova, Baumann, and Kalayamthanam (2014) observing that males start playing games earlier in life, play more frequently and spend more time playing. There are a range of societal issues that influence this behaviour, where Fox and Tang (2014) suggested the hostile and aggressive nature of this male dominated pastime can lead to a gender imbalance in participation.

Critics posit that young people are leaving Facebook as the platform of choice for social interaction and, as its users grow older, it is no longer a destination for adolescents to congregate online (Deloitte, 2017). With new offerings and applications promoting features that cater towards the millennial, such as Snapchat and Instagram, the diminishing numbers of young people on Facebook does not necessarily denote a decrease in their online activity, merely a shift from where other generations are spending their time online (Sulleyman, 2018). As the democratisation of technology continues to influence the family home, engagement with screen-time is increasingly migrating from the traditional hub that is the family living room, to individual spaces and bedrooms where the individual can curate and cultivate the media and content specific to their interests.

Smartphones and tablet devices enable the individual to direct their entertainment without a sibling vying for the remote or a parent dictating the evening’s viewing schedule (Hodkinson, 2017; Larson, 1995; Livingstone, 2007). The way in which people seek and curate their entertainment highlights an increasing propensity to seek quick, instant gratification and the loss of attention that can come when such gratification is not readily presented. Deloitte's Media Consumer Survey showed that the majority of respondents (77%) will skip an advertisement that precedes a video, half will abandon a short video entirely if the advertisement cannot be skipped, and one in three now use technology to remove these marketing intrusions altogether (Deloitte, 2017).

Overly romanticised ideals of what family time should be are incongruous with the reality of the digital age, with Blackwell, Gardiner, and Schoenebeck (2016, p. 1399) stating "the perception of family time as one for family members to be constantly engaged with each other is unrealistic". Research suggested that managing technology in the home can be a source of tension between parent and child, as both endeavour to navigate the new boundaries that come with living a life online (Blackwell et al., 2016; Boyd, 2014). Blackwell et al. (2016, p. 1390) observed that "many parents feel unknowledgeable and anxious about what their children are doing online" and suggested that many of the rules that are introduced into the home are breached, by both child and parent alike. Blackwell et al. (2016, p. 1391) noted that "conflicts between parents and teens often arise due to differences in expectations and conflicting ideas around social conventions" and this dynamic can be exacerbated by social conventions which exist in an online construct that previous generations did not grow up in.

Establishing trust and involvement between parents and teens can have the power to diminish conflict and discordance between the two (Smetana, Metzger, Gettman, & Campione-Barr, 2006). Therefore, recognising and understanding the social needs of the child can be important in fostering a positive relationship with technology in the home.

Snapchat continues to be a more attractive option for many adolescents, with the impermanence and anonymity of this channel of communication leading many teenagers to preference it over other apps (Cavalcanti, Pinto, Brubaker, & Dombrowski, 2017). Handyside and Ringrose (2017, p. 348) contended that "Snapchat's distinct temporality and user affordances have unfolded in ways viewed as having specific impacts, risks and possibilities presented by digital culture" and it is this perception that can lead parents to be concerned over how the app is used. Interestingly, there is growing evidence that adolescents create dual social media accounts, where one is used ostensibly as a means to distract away from where other content may be shared (McGregor & Li, 2019). Patterson (2016, p. 1) said 'finstas', a portmanteau for fake-Instagrams, are created and curated for a range of reasons:

> Chronicles of debauchery, sexy outfits, best-dinners-ever, hook-ups, breakups, rants, road trips, beach days and everything in between were documented by a plethora of openly and unabashedly flaunted pictures and videos. But as more parents began "friending" and "following" and "posting," so too declined the allure of these channels for teens; the platforms once synonymous with freedom, became constrained by

> oversight. Teenagers faced a choice: quit social media or evolve. They chose evolution... in the form of the Finsta.

This subversive tactic is one way in which adolescents create a digital landscape that they can socialise in without the observation of prying parents and teachers. Teens for generations have opted to conduct their social activities beyond the view of adults and though the predilection for privacy remains the same, the meeting place for socialising has now moved online (Blackwell et al., 2016; Cranor, Durity, Marsh, & Ur, 2014).

The widely reported generational chasm of screen time is not as deep as some commentators might suggest. Teenagers and young adults are certainly considered heavy users of digital technologies, yet older generations are not far behind. The Nielson Global Survey of Generational Attitudes polled over 30,000 individuals from 60 countries throughout Asia-Pacific, Europe, Latin America, the Middle East/Africa and North America. It highlighted how adults are as, if not more, dependent on technology as teenagers (Nielsen, 2015). Whilst there are assumptions often made about younger generations having a significant dependence on their devices, Mayyasi (2015) contended that adults can be equally drawn to the allure of being online:

> One could criticize young people's micro-interactions on Facebook, Instagram, and Snapchat as shallow connections that lack the depth of face-to-face conversations. But adults who check their email constantly may be searching for a similar illusion of productivity—a quick fix of

> feeling productive and important that pales in comparison to 90 minutes of focused work. (para. 4)

Younger generations should be neither maligned nor judged for their predilection to engage with their devices. Often the younger generations can be derided for their high levels of engagement (if not dependence) with technology; however, it should be noted that adults can be just as susceptible to being dependent on their device. The content that different generations engage with may be wildly different, yet their hours of screen time are not so dissimilar. Whereas a teenager might while away the hours on Instagram and Fortnite (a free online multiplayer game), the Generation Y workaholic may be checking their emails all weekend, whilst the Baby Boomer spends their evenings posting to Facebook and playing scrabble online. Scientists and academics have called for any guidelines relating to screen time to be based on evidence, as opposed to moral panic (Davis, 2018).

2.13. Divided Attention vs Multitasking

Multitasking is coordinating a series of parallel tasks by switching between them in a sequential process, as opposed to simultaneously attending to multiple tasks at once (Judd & Kennedy, 2011). This process of neural network switching can be associated with a “decrease in accuracy, often for both tasks, and a time delay compared to doing one task at a time” (Gazzaley & Rosen, 2016, p. 76). Whilst some theorists have argued that digital natives are adept multitaskers (Brown, 2000; Prensky, 2010), others contended that this propulsion to multitask is really just diluting the effectiveness of completing any one singular task (Fernandes & Moscovitch, 2000; Kraushaar & Novak, 2010; Sana et al., 2013). Junco and Cotten (2012) declare that a decade of research has established “clear evidence that human information processing is insufficient for attending to multiple input streams and for performing simultaneous tasks” (p. 506). The debate regarding multitasking questions whether it is simultaneous engagement in various activities or just sequential engagement in multiple tasks.

It is challenging to perform multiple tasks concurrently and still be able to “effectively attend to and encode information associated with each task” (Dzubak, 2008, p. 1). When distinguishing between simultaneous and sequential processing, the performance of one task is likely to be detrimental to the second task (Delbridge, 2002). Kirschner and Karpinski (2010, p. 1237) asserted that there is extensive empirical evidence, not necessarily specific to technology use, that relates to the negative implications of attempting to “simultaneously process different streams of information”. Mistakes are increased and the time taken to achieve learning parity is lengthened by attempting to process information concurrently, instead of sequentially. Depending on the workload, performance can be affected for a range of reasons. As Adler and Benbunan–Fich (2015, p. 432) suggested “At low levels of workload, performance is compromised due to inattention and lack of stimulation, while at high levels, performance also suffers due to the cognitive inability to deal with overload”.

2.13.1. Implications for Multitasking

Lee, Lin, and Robertson (2012) undertook research on tertiary students to determine the implications of media multitasking on cognitive load and attention, which found that digital distractions interfered with knowledge acquisition. They concluded that there were considerable implications for students and educators alike, declaring an ‘unquestionable and urgent’ need for further research to be conducted in order to understand the impact that multitasking has on society. Frequent multitasking has the potential to become self-reinforcing and consequently a habit if individuals are not capable of self-regulating their inclination to multitask (Olson & Fazio, 2001; Wang, Tchernev, & Solloway, 2012).

The pressing challenge of divided attention applies to the classroom environment where there is a high cognitive load placed on adolescents attempting to learn new content. This division of attention can impair the cognitive processes that mediate “the encoding of information into short and longer-term memory” (Judd & Kennedy, 2011, p. 626). As lesson content is often unfamiliar and unrehearsed, the demand on the brain to process streams of information can be high. Learning is maximised when a student is paying attention (Galluch et al., 2009), which is a contest in an age where attention is divided amongst increased modalities within the classroom.

Gazzaley and Rosen (2016, p. 72) stated that sustained attention, or vigilance, is measured by “how well someone maintains consistently high-level performance on a repetitive task over a long period of time”. Sustained attention has been found to be one of the major variables in affecting academic performance (Steinmayr, Ziegler, & Träuble, 2010), with students who are more adept at regulating their attention, emotions, and behaviour earning higher course grades (Duckworth, Tsukayama, & May, 2010) and higher standardised test scores (Duckworth, Tsukayama, & Kirby, 2013; Mischel, Shoda, & Rodriguez, 1989). Conversely, Kraushaar and Novak (2010, p. 248) observed that "students with a greater extent of distractive multitasking compared to productive multitasking exhibit lower academic performance".

2.13.2. Resumption Lag

There is a time cost associated with the rapid changing from one task to another due to the limitations on which the brain can process changing modes of information (Allport & Wylie, 2000). This cognitive juggling can be referred to as *resumption lag*, where switching tasks requires a 'changing of gears' as different parts of the brain and its circuitry can be engaged by different activities (Dzubak, 2008, p. 2). There will always be a time cost involved in an interruption, where the length of the interruption will consequently increase the cost, or lag, in returning to the primary task that was interrupted (Cades, Davis, Trafton, & Monk, 2007; Monk, Trafton, & Boehm–Davis, 2008).

Where an individual is repeatedly interrupted, either of their own making or involuntarily, it stymied the efficiency with which they could complete their primary objective (Judd & Kennedy, 2011; Rosen et al., 2013; Rubinstein et al., 2001). Not only this, but the literature also suggests that the encoding and processing of new material can be diminished when interruptions occur (Borst et al., 2015; Lauber, 2014). The challenge for resisting interruption within the context of the classroom is that the allure of such an interruption may be greater than that of the primary goal, or that the primary goal is no longer rewarding (Payne, Duggan, & Neth, 2007). Foroughi, Werner, McKendrick, Cades, and Boehm–Davis (2016, p. 1481) suggested “individuals who are better able to manage interference are likely to resume tasks more quickly following interruptions compared with those who cannot manage interference as well”. Their research found that individuals with higher working memory capacity (WMC) were able to manage interruptions and consequent resumption lag far more efficiently than those with low WMC.

Interruptions can be either forced, where the individual has no control over its occurrence, or self-initiated, where the distraction or deviation from the primary task is intentionally sought out. Also known as discretionary task interleaving (Payne et al., 2007), sentiments such as boredom or lack of interest in the goal can lead a student to generate their own interruption. An intentional interruption from the primary task is not always necessary to deviate from the work at hand. It may also involve deferring to other technologies to complement the learning process, such as seeking out further information on a website or chatting to a peer online about homework. Regardless of the interruption’s motives, the consequent resumption lag is still an impeding factor.

Jin and Dabbish (2009) listed a range of reasons why an individual might self-interrupt. These include interruptions such as needing a break, recalling another task, a prompt leading the user to begin a new task, adjustment to the environment, an inquiry to retrieve information needed for the task, and a wait that leads an individual to fill downtime until the primary task can be continued. Sometimes it can be the complexity of the task which hinders the individual's ability to resume it, after a deviation (Gould, Brumby, & Cox, 2013).

Yeung (2010) found that in a set of given tasks, the level of difficulty can affect the order in which subjects decide to pursue them, and the extent to which they are interleaved. To address the interruptions faced when working online, researchers Bailey and Iqbal (2008) developed a system that could recognise (to a certain extent) the complexity of the task at hand and withhold incoming notifications on the computer until a natural break in the task was reached. A similar interruption management system was devised by Arroyo and Selker (2011), recognising that the extent to which an individual can successfully complete a task can be hindered by ongoing interruption. With myriad opportunities to seek out interrupting tasks whilst online, the resumption lag can severely hinder the individual's ability to return to the work that they were not intrinsically motivated by in the first place.

2.13.3. Typologies of Interruption

Jin and Dabbish (2009) developed a typology of discretionary task interleaving in order to explain the different ways in which an individual can have their primary task interrupted, specifically to those working on a computer. Their intention was to investigate internal interruptions, as opposed to externally generated interruptions which have been more extensively researched. The following list of interruptions outlines both the type of interruption and both the positive and negative consequences of it occurring:

Adjustment: where the individual seeks to improve their environment in order to improve their productivity. This can directly or indirectly improve the situation, without a change in working context, yet may also lead to stress and frustration if improvements are not achieved.

Break: where the individual seeks out a more desirable task due to their frustration or fatigue with the primary task. This can aid in the enjoyment of the primary task by improving the individual's mood, yet delay or procrastination can occur if they are reluctant to return to the primary task.

Inquiry: where the individual seeks out information that will assist in completing the primary task. This facilitates task completion, yet can be a time-consuming process that can make it difficult to refocus if the information is mentally intensive.

Recollection: where the individual is required to complete an unrelated task whilst performing the primary task. This enables a sense of accomplishment, yet can make it difficult to refocus.

Routine: where a task is performed as part of a habit. The prior experience can streamline the individual's workflow, yet can be disruptive if the routine is more mentally demanding or time consuming than the primary task.

Trigger: where stimuli encountered prompts a new task to be completed. It can enable new ideas to complement the primary task, yet can also hinder the ability to focus if the new idea is time consuming.

Wait: where an unrelated task is sought out to pass time when the continuation of the primary task is blocked. This maximises productivity and use of time, yet can delay the resumption of the primary task if the wait time is over estimated.

2.14. Summary

The literature reviewed in this chapter has predominantly explored the research pertaining to ICT, the brain's capacity to handle multiple streams of information and the consequences that such technology can have on teaching and learning. Whilst the advancements in technology continue to progress at a rapid pace, the understanding of how the individual's brain works, manages cognitive load and handles distractions is more established. Therefore, the strong basis of knowledge provided from a biological, psychological and neuroscientific perspective should enhance understanding in how to effectively manage the use of ICT both in the classroom and beyond. Research continues to investigate the ways in which technology affects the way people function, from a range of perspectives. Social interactions, dependence and reliance on connectivity, data privacy and analytics, and the role that artificial intelligence and virtual reality will have in the future, are all pertinent questions for the digital age. Within this broad construct of technology and its implications is how it will influence the fundamentals of pedagogical practice and education. Further investigation is needed to inform and facilitate effective ICT integration into teaching practices. As the teaching landscape evolves into one where technology is increasingly ubiquitous, a deeper understanding of its acceptance, the motivations for its use, and its benefits for learning, are key. The more that can be understood about ICT in schools and behaviours when learning at home, the better equipped policy makers and educators will be to cater to students who engage with their devices on a daily basis.

Chapter 3: Methodology

3.1. Introduction

The purpose of this chapter is to outline the philosophical assumptions that underpin this research and to introduce the approach and techniques implemented. The chapter defines the scope and limitations of quasi-experimental design and seeks to situate the research amongst existing traditions. The fundamental goal of this research is to develop further understanding around specific phenomena through grounded theory, thematic analysis and the collection of both quantitative and qualitative evidence.

3.2. General Approach

Conrad and Serlin (2005, p. 373) stated that methodology is the "process through which we construct scientific knowledge" where the researcher seeks to describe, explain and justify their chosen research methods. Exploring and understanding phenomena which are educational in nature deals with questions that can be investigated from different conceptions and interpretations of social reality. Consequently, paradigms have purposefully been established to define the criteria according to which one would select and define problems for inquiry.

Thomas Kuhn (1962) states that a paradigm's function is one which groups together a likeminded community of researchers, describing it as "an integrated cluster of substantive concepts, variables and problems attached with corresponding methodological approaches and tools" (p. 33). Beyond this definition, Ahmed, Opoku, and Aziz (2016) identified 29 other interpretations of the term paradigm, observing that where consensus exists it relates to a shared acknowledgement that a paradigm is "a set of beliefs and assumptions about the world" (p. 22).

Within the social sciences, there traditionally has existed the competing paradigms of quantitative and qualitative research. Beaudry and Miller (2016, p. 5) suggested that the philosophical assumptions at the root of these differences relates to "what is knowable, who creates knowledge, and for whom the knowledge is intended to be used". In the absence of an explicit methodology, research can be left open to speculative interpretation, where the reader deciphers the approach by "piecing together clues based on data collection or analysis methods" (Caelli, Ray, & Mill, 2003, p. 5). Research methodologies must not be disparaged in favour of one or another, as the selection of an appropriate methodology pertains to its best fit, rather than it being the best overall. Collis et al. (2003) warned that falling into such a trap, where one research approach is considered superior to another, can lead the researcher to unnecessarily exclude certain philosophical domains. The best fit, with regard to this research, is to use the comprehension test results to inform and give context to the views and values shared during the subsequent semi-structured interviews.

3.3. Mixed Methods Research

A single definition for mixed methods research is, to a certain extent, contentious due to theorists categorising this approach to investigation in various ways. Yet, Tashakkori and Creswell (2007) provided a depiction of the process undertaken for this research, where "the investigator collects and analyses data, integrates the findings, and draws inferences using both qualitative and quantitative approaches or methods in a single study or a program of inquiry" (p. 4). Debate abounds regarding the pairing of two distinctly different approaches to research, with some theorists positing that the quantitative and qualitative approaches are so vastly different in their philosophical and methodological origins as to be incompatible (Ritchie, Lewis, Nicholls, & Ormston, 2013). The pairing of the two approaches enables access to a greater insight into phenomena, where a more singular approach would be unable to provide rich detail and explanation. With regard to this research, the qualitative data seeks to provide an insight into how closely aligned perceptions of technology's effectiveness are with the quantitative data. Whitehead and Elliott (2007, p. 264) suggested that mixed methods provide for more "meaningful, complete and purposeful" research and this research would not be as meaningful if the results from one method did not exist to complement the other. Whilst considering the vastly different ontological and epistemological foundations of both paradigms, there can be value in pairing them to achieve a different type of outcome to one sought by a more singular approach. With regard to combining quantitative with qualitative research, Punch (2013) states:

> Quantitative research brings the strengths of conceptualizing variables, profiling dimensions, tracing trends, and relationships, formalizing comparisons and using large and perhaps representative samples. On the other hand, qualitative research brings the strengths of sensitivity to meaning and to context, local groundedness, the in-depth study of

> smaller samples, and great methodological flexibility which enhances the ability to study process and change. (p. 290)

Ritchie et al. (2013, p. 38) suggested that it can create a unique combination of data, which provides for a "powerful resource to inform and illuminate policy or practice".

This methodology integrates two forms of data that can complement the overall research in the instance where purely quantitative or qualitative data would preclude the research from adequately addressing the research question. Conrad and Serlin (2005) contended that articulating issues in the construction of educational research can be challenging, with quantitative research requiring qualitative processes, such as making judgements, and qualitative studies involving quantitative processes such as counting and the use of descriptive statistics. Within educational research, this can apply to either high-inference, where researchers are interested in being able to make broader generalisations about the data they have collected, or low-inference methods, where the data to be analysed is specific to the population they have sampled. This research seeks to present data that has generalisability beyond the context within which it has been collected. However, Conrad and Serlin (2005) caution that it is important that the methods and subsequent analysis are chosen based on the question at hand, as opposed to the approach most comfortable or convenient for the researcher. Onwuegbuzie and Leech (2005a) note that distinctions exist between quantitative and qualitative researchers, regarding ontology, epistemology, axiology, rhetoric, logic, generalisations, and causal linkages.

This continuum between purists and pragmatists dictates how one views the extent to which qualitative and quantitative research designs can be considered compatible.

Over the past couple of decades, mixed methods research has been established as a third methodological movement (Creswell & Clark, 2007; Tashakkori & Teddlie, 2010b), with prominent authorities identifying a research community with its own "philosophical, theoretical, methodological, analytical and practical foundations and constructs" (Cameron, 2011, p. 96). This third alternative in paradigmatic debates has arisen due to MMR being regarded as a "viable and comprehensive model of inquiry" for researchers in the social and behavioural sciences (Rolf, 2017, p. 45). Creswell and Clark (2007) suggested that a better understanding of research problems can be found by combining quantitative and qualitative approaches.

Tashakkori and Teddlie (2010b) identified three key aspects of MMR that are superior to a single method approach: the ability to answer research questions that other approaches cannot, mixed methods can answer simultaneously confirmatory, and exploratory questions. Secondly, differing viewpoints can be provided due to divergent findings. Thirdly, the breadth and depth can provide stronger inferences to complex social phenomena. This research, which is both quantitative and qualitative in nature has both confirmatory and exploratory questions which align with these assertions.

The method in this research aims to establish the implications of technology on lesson content retention through the analysis of quasi-experimental research data gained from repeated classroom tests. The complexity of the issue requires a methodology that can explore the situation from multiple angles, with Tashakkori and Teddlie (2010a, p. 274) stating that “the multidimensional nature of many, if not most, social and behavioral phenomena is the reason why mixed methods are often required in research addressing those phenomena”. As with previous studies investigating the relationship between technology and learning (Ackerman & Goldsmith, 2011; Duncan et al., 2012; Fernandes & Moscovitch, 2000; Junco & Cotten, 2012; Mueller & Oppenheimer, 2014), gathering quantitative data will be instrumental in identifying any differences between varying levels of ICT implementation and the processing of lesson content. Christensen and Knezek (2008) suggested that experimental researchers attempting to measure specific constructs need to develop their own tests, as opposed to seeking out a pre-existing instrument.

As with any field of research, MMR presents a range of limitations that deserve consideration. Though a possibly obvious caution, Whitehead and Elliott (2007) warned that MMR can be more time consuming and laborious than single design research. This is due to the time management required, whether both methods are collected sequentially or concurrently; resource intensive, where tests, interviews and observations all require separate and considered approaches; and multiple analyses required to interpret the qualitative and quantitative data and ultimately combine these results into something that communicates the understanding of the overall phenomena (Johnson & Onwuegbuzie, 2004).

It is incumbent upon the researcher to justify their combination of methods as a way of gaining a deeper understanding than had they pursued a single approach. Miller and Fredericks (2006) suggested that further justification can be required to defend the researcher's position in the face of more purist researchers who believe that the mixing of methods can lead one paradigm to impact or interfere with the other.

3.4. Paradigms

Research that enlists a mixed methods approach has gathered momentum in educational spheres, with a complementarity between approaches providing a richer understanding of contexts specific to teaching and learning (Conrad & Serlin, 2005). Research has long had differing paradigmatic approaches, where assumptions of knowledge (ontology) and the means of producing it (epistemology) have varied (Bazeley, 2004).

3.4.1. Paradigm Wars

Erupting in the 1980s, the Paradigm Wars were the result of a decline in solely objective quantitative research on teaching (Gage, 1989; Hall, 2012). Research relating to the practice of teaching had, up until that point, been described as "at best, inconclusive, at worst, barren" (Tom, 1984, p. 213). Butcher and Pont's 1968, 1970 and 1973 volumes of research were all experimental (Nisbet, 2005), and Entwistle and Nisbet (1970) allocated a mere three out of 176 pages of their textbook on educational research methods to case studies.

Thus, the shift in the latter part of the 20^{th} century provided a reprieve from the unchallenged acceptance of positivist assumptions. Theorists argued that the scientific nature of inquiry was inadequate in providing a full insight into how teachers should operate within the classroom (Barrow, 2015). The positivistic approach had failed to address the humanistic qualities and attributes that are so integral to the reality of teaching. Critical theorists regarded educational research as a technical exercise that aimed towards efficiency, rationality and objectivity, whilst neglecting the relationship between student and teacher and their connection with social, political and economic constructs (Gage, 1989). The critical opposition of previously ingrained approaches to educational research brought saw the objectivist-quantitative research decline in the late 1980s. Gage (1989) states:

> In schools of education, enrolment declined in courses in tests and measurements, statistics, experimental design, and survey research. Structured classroom observations, achievement tests, attitude inventories, and the use of statistics to estimate the reliability and the interrelationships of such measures virtually disappeared. (p. 6)

This dramatic shift was evident throughout educational research, with funding for objective quantitative researchers decreasing; journal articles on tests of statistical significance, correlation coefficients, and effect sizes diminishing; and memberships of related bodies and foundations plunging (Gage, 1989; Guba & Lincoln, 1994; Waever, 1996). Teachers became instrumental in research on teaching, which can now seem as an obvious inclusion to educational research, yet was often overlooked prior to this philosophical change. Through this change came a realisation that quantitative and qualitative research could be combined and that the “incompatibilists”, who considered the combination as antagonistic, were simply wrong (Howe, 1988, p. 10). Incompatibilists would suggest the conceptions of reality, truth, and the relationship between investigator and the object of investigation are vastly different between the two paradigms. However, Howe (1988) suggested that pairing these methods is epistemologically coherent, to the extent that in some instances, qualitative and quantitative inquiry is inseparable.

In the decades that followed this initial debate, Gage (1989) said educators had developed a yearning to know more about how varying styles of teaching were related to levels of student achievement and attitude. The adversarial nature that erupted between these perspectives was borne out of competing agendas, where disparate disciplines were seeking prominence over their competitors. It was not until researchers in the social sciences realised that cooperation was key to survival, as an absence of it would result in disciplines perishing, that things began to change (Guba & Lincoln, 1994; Salomon, 1991). Regardless of which paradigm a researcher pursues, Shannon–Baker (2016) suggested that critics should be more focused on how the researcher chooses to operationalise their chosen paradigm, stating that to do so “better promotes researchers’ explicit and intentional interaction with their philosophical foundations throughout the design, implementation, and reporting stages of their research” (p. 332).

3.4.2. Interpretivist and Positivist Paradigms

Auguste Comte, regarded as the father of sociology, employed Descartes' epistemology, who viewed the interpretivist rationale as "the most excellent approach to create and generate knowledge and information concerning truth and realism" (Aliyu, Bello, Kasim, & Martin, 2014, p. 83). The positivist ontology considers the world to be external and that objective reality exists independent of the researcher's perspective (Bourdeau, 2015; Grix, 2010). It therefore lends itself to a structured approach where a hypothesis can be developed and tested, employing a rational and logical approach that is impervious to personal perspective or bias (Crowther & Lancaster, 2012).

Critics of positivism declare that attempting to replicate the research methods in natural sciences to social sciences can be inadequate and that an interpretivist approach is more appropriate (Denscombe, 2002; May & Williams, 2002). Nudzor (2009, p. 115) referred to this ongoing conflict in social research, where debate arises between the nature of ontology and competing epistemologies, as "the paradigm wars". In his defence of the positivist paradigm, Schrag (1992, p. 7) concluded that if we are to consider the classroom as our 'research arena' then improved policies should be informed by investigating the differential efficacy of our current practices. The positivist paradigm enables the researcher to prove or disprove a hypothesis by deduction (Mack, 2010), with emphasis on a scientific method that employs experimental design, statistical analysis, and ultimately findings that have generalisability. Adopting this lens aims to generate data to identify relationships between the level of technology implemented and its impact on retaining information for learning, with positivism identifying “causes and relationships demonstrated statistically” (Takona, 2002, p. 301).

3.4.3. Pragmatism

Pragmatism, which is generally regarded as the philosophical associate of MMR, is a paradigm that provides a set of assumptions about knowledge and enquiry that underpins the methodology and distinguishes the approach from purely quantitative approaches which are based on a philosophy of post-positivism and purely qualitative approaches that are based on a philosophy of interpretivism or constructivism (Onwuegbuzie & Leech, 2005b; Rossman & Rallis, 2003). Teddlie and Tashakkori (2003) outlined the primary intent of pragmatism is to “reject the either-or choices and the metaphysical concepts associated with the paradigm wars, and to focus instead on ‘what works’ in getting research questions answered” (p. 291). It has arisen as the result of the paradigm wars, rejecting the forced choice between post-positivism and constructivism (Creswell, Plano Clark, Gutmann, & Hanson, 2003). As this research has a multitude of purposes, a pragmatic approach allows it to address questions that do not reside comfortably within a strictly quantitative or qualitative research design. Shannon–Baker (2016) contended that pragmatism is outcome oriented, where the research determines the meaning of things, characterised by “shared meaning-making in order to create practical solutions to social problems” (p. 322).

3.5. Theoretical Framework

Informational Processing Theory (IPT) views cognitive functioning as analogous to that of a computer (Slate & Charlesworth, 1989), as opposed to behaviourist notions of simply responding to stimuli. IPT is understood through memory and attention processes and seeks to understand how the mind computes sensory information (see Figure 2). Theorists suggest that one must attend to, rehearse and make sense of stimuli if it is to be committed to long-term memory (Ornstein, 2014; Rosenthal & Zimmerman, 2014; Snowman & McCown, 2011).

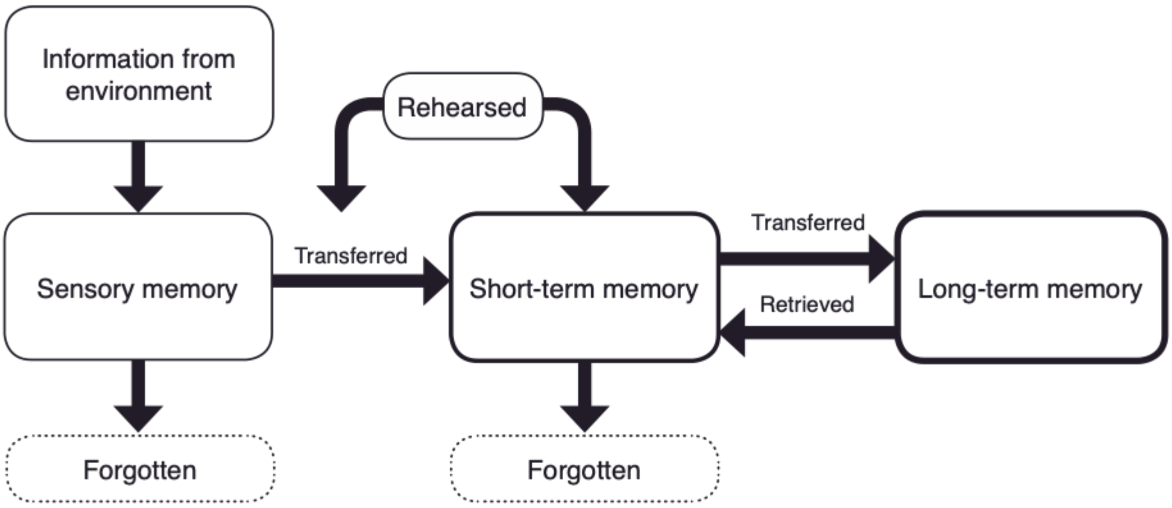

Figure 2. Information Processing Model adapted from Lauber (2014).

If information is not attended to, then it cannot enter the brain's information processing system (Gagné, Yekovich, & Yekovich, 1993), which presents a challenge for adolescents that are attempting to encode a range of concurrent stimuli within the classroom setting, with attention being a "limited mental resource" (Jonassen, 2004, p. 981). Kandarakis and Poulos (2008, p. 112) advised that students must 'selectively focus' on information that is most likely to be significant, amidst the bombardment of sensory stimuli, which can be a challenge in the face of information coming from so many directions. Snowman and McCown (2011, p. 288) state that the IPT approach involves "implementing those conditions that help students effectively transfer information from the 'outside' (a text or lecture, for example) to the 'inside' (the mind)". Kandarakis and Poulos (2008, p. 118) believe that "teachers with a greater understanding of the theory and how it is formed can select learning strategies in order to improve the retention and retrieval of learning".

This theoretical framework aims to develop an understanding of how students process, encode and retrieve information when subjected to varying levels of the quantitative quasi-experiment's independent variable. The science tests were designed to assess students' ability to recall information that was presented to them through a range of videos. Safran and Segal (1996, p. 47) suggested that experiments within this framework are limited due to their scientific approach in laboratory settings, which will be counteracted by this research being conducted within the natural classroom setting to enhance ecological validity.

3.6. Cognitive Theories

In adolescents, the prefrontal cortex is constantly developing and adapting as synapses are perpetually being established (Greenfield, 2015; Konrad et al., 2013). Research relating to the brain suggests that the centre responsible for executive functions, and consequently multitasking, are not fully developed until after puberty (Blakemore & Choudhury, 2006; Dux, Ivanoff, Asplund, & Marois, 2006). This region of the brain serves as the control centre that facilitates goal management and the decision making process (Powell, 2006) and the demands on this region are high as students navigate their way through school and beyond.

During task switching, Foerde et al. (2006) identified a shift in neural activity from the hippocampus, which is responsible for purposeful thought processing and memory to the striatum, which is the brain region associated with more rote or habitual learning. Even if a student is considered to be gifted and talented, an individual's brain still has a limited capacity to process and encode information, with the strain of multitasking resulting in what is described as the *central bottleneck theory* (Borst et al., 2015; Pashler, 1994). This immutable limitation in human information processing suggests that when two tasks require immediate responses, they must be placed in a queue. Research indicated that when there are two cognitive tasks being simultaneously performed, there were decrements in performance in at least one of the tasks (Dux et al., 2006). Resource theory, or capacity theory, offered an alternative to the central bottleneck explanation (Borst et al., 2015; Kahneman, 1973; Lang, 2006). According to resource theory, only when the demands of concurrent tasks exceed available resources, a loss in performance is expected. Resource theory enables parallel processing together with an executive function or cognitive control mechanism to manage the resources (Meyer et al., 2002).

Threaded cognition theory (Salvucci & Taatgen, 2008) suggested that multiple objectives can be maintained as threads. Threads can swap resources as deemed necessary and once a thread has accessed a resource, other threads reliant on perceptual, motor, and declarative cognitive resources must be put on hold until their resources are freed up by the previous thread. This theory suggested that it is possible to undertake multiple tasks concurrently, albeit suffering a performance trade-off in the process. The *motivated cognition model* provides an insight into why it is so challenging to resist distractions when studying. Lang (2006) explained motivation as a strategic activation of appetitive and aversive systems. Whilst the appetitive systems seek to maximise positive affect through new experiences, the aversive system seeks to avoid negative affect. Allocating resources is considered a volitional function, where appetitive activities such as interacting with friends would receive more attention than more aversive activities such as completing homework.

3.6.1. Self-Control and Regulation

Pintrich (2000, p. 453) stated that Self-Regulated Learning (SRL) is "an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behaviour, guided and constrained by their goals and the contextual features in the environment". For students to set meaningful goals for learning, they need to be intrinsically motivated by the content with which they are presented. In the absence of such engagement, the propensity to monitor, regulate and control becomes hindered. In secondary school, the challenge to find this motivation lies in the fact that students must enrol in and participate in a range of subjects, predominantly in their lower senior years, where they may hold no interest for the subject or an intent to pursue it beyond its compulsory stages.

Devolder et al. (2012, p. 3) suggested that "values, interest and affective reactions" can all contribute to the motivational beliefs of the student.

Bandura and Cervone (1986) asserted that self-regulated academic learning behaviour is a combination of self-generated and external sources of influence. Young people are presented with the pressures of school whilst also the need for the social approbation of their peers, which can often result in a conflict between electing to do what is beneficial in a learning environment and what satisfies a broader range of emotional needs. In an analysis of empirical studies, Kalyuga and Liu (2015) highlighted that learning environments with a primary focus on ICTs "might pose a variety of cognitive, metacognitive and self-regulatory demands on learners and most learners might not be able to regulate their learning" (p. 6). Self-control, interchangeable with self-regulation (Baumeister & Alquist, 2009), is the regulation of attentional, behavioural and emotional impulses in the face of temptations that might deviate from more prescient goals. Junco and Cotten (2011, p. 376) observed that whilst students might be aware of the detrimental effects of divided attention towards their academic performance, they "continue to engage in the behaviour". Wang, Tchernev, et al. (2012) declared that the driving force behind multitasking is the emotional rewards gained, even if it proves detrimental to learning.

3.6.2. High Level Self-Regulation

Studies indicate that individuals with a high level of self-regulation can sustain their attention on both assigned learning tasks during class and exert self-control to avoid off-task behaviours, resisting activities such as texting in class

(Wei et al., 2012). Beyond academic achievement and performance, the ability to exercise self-control is a predictor of other key factors such as social competence and forming positive relationships (Eisenberg, Hofer, Sulik, & Spinrad, 2014). Moffitt et al. (2011) conducted research into self-control in childhood which was identified as a predictor of success and well-being in adulthood, including wealth, physical and mental health with effect sizes analogous in size to those of general intelligence or family socioeconomic status.

3.7. Grounded Theory

Grounded theory (GT) having been well established since the 1960s, uses an iterative, inductive process for interpreting data and building theory in the social sciences (Strauss & Corbin, 1997). It provided an outlook that queried whether quantitative methodology was the only valid and unbiased way to determine truths about the world (Mertens, 2014). Yet, GT allows for the incorporation of quantitative data to develop further understanding of what Mills, Durepos, and Wiebe (2010, p. para. 2) described as the "complexity of social life and the change processes inherent in it". Developing a richer understanding of concepts that develop throughout the investigation are key to explaining particular phenomena. Considering phenomena is continually changing, as opposed to being static, the flexibility to build and change throughout the investigation process is key to GT (Corbin & Strauss, 1990). Themes need to be developed to inform analysis, which becomes evident when establishing categories and concepts from the quantitative data collected. Within the context of this research, categories are established from a thematic analysis of the semi-structured interviews conducted with key education stakeholders in teachers, parents and students.

3.8. Triangulation

The metaphor of triangulation derives from navigation, where the use of two known points can be used to locate the position of a third unknown point, thus creating a triangle (Turner & Turner, 2009). Whether the triangulation is investigatory, methodological or theoretical, its purpose is to preclude any possibility of bias in either the data set or methodological approach.

Luttrell (2010) suggested that triangulation provides a better explanation and assessment of generality due to reducing the risk of any chance associations or systematic bias occurring. The purpose of the qualitative measure is to provide an insight that could not be solely achieved by the collection of quantitative data. The convergence model of triangulation design, where data were gathered independently of each other and then brought together, is described by Creswell (1999) as a potentially more effective way of learning information:

> Results from one method can be extended by using another method. The nature of quantitative methods is to focus inquiry on a discrete set of variables to test specific hypotheses or research questions. Alternatively, the nature of qualitative inquiry is to open the study through presenting the large, interconnected complexities of a situation. (p. 460)

Triangulation allows for multiple data sources to be compared and contrasted with each other to build a coherent and cohesive analysis of the data gathered within a research project. Maxwell (2012, p. 654) stated that “educational research desperately needs qualitative approaches and methods if it is to make valid and useful claims about what works”. The quantitative data collected will be supplemented with interviews with participating students, teachers and parents. Griffin (2004, p. 8) suggested that gathering qualitative data can “challenge the researcher’s assumption about specific phenomena”. It is the richness of these responses which can add significantly to the understanding of the social setting being investigated (Kervin, Vialle, Howard, Herrington, & Okely, 2016).

Although Lincoln and Guba (1985) lauded the appropriateness of naturalistic qualitative observation for classroom based research, they concede that it cannot discover cause and effect relationships. Christensen and Knezek (2008) suggested that experimental researchers attempting to measure specific constructs need to develop their own tests, as opposed to seeking out a test or instrument devised by a party unrelated to the specific setting of the intended experiment. As with previous studies investigating the relationship between technology and learning (Ackerman & Goldsmith, 2011; Duncan et al., 2012; Fernandes & Moscovitch, 2000; Junco & Cotten, 2012; Mueller & Oppenheimer, 2014), gathering quantitative data will be instrumental in identifying any differences between varying levels of ICT integration and the processing of lesson content.

3.9. Semi-structured Interviews

Taylor and Bogdan (1984, p. 77) described semi-structured interviews as "repeated face-to-face encounters between the researcher and informants, directed towards understanding informants' perspectives on their lives, experiences or situations as expressed in their own words". In qualitative interviews, there is a continuum between structured and unstructured interviews. Whereas structured interviews are guided by closed questions, similar to that of a questionnaire, unstructured interviews are more akin to observation. Therefore, a semi-structured interview is one which has the flexibility to evolve organically by nature of its flexibility (Newton, 2010). Denscombe (2010) suggested that the semi-structured interview process should be flexible and to let the interviewee progress ideas and elaborate on points of interest. The interviews undertaken in this research allowed participants to deviate from the specific questions and offer a range of opinions that may have not been previously considered by the interviewer.

Denscombe (2010) suggested that a good interviewer is one who is sensitive to the feelings of the participant, attentive to the thread of discussion, tolerant of silences, adept at using prompts to steer the interview where necessary, skilled at probing where more detail is required, able to clarify and confirm the sentiment of the participant's comments, and is openly non-judgmental throughout the process. A semi-structured interview must encourage openness, restrict interruption, and interject with appropriate probing or prompts wherever necessary (Ritchie et al., 2013). This relational interaction between researcher and participant is dependent on a certain level of trust and rapport, as the absence of it has the capacity to restrict a participant's willingness or motivation to respond openly and honestly to the questions posed (Opie & Sikes, 2004).

In the case of these interviews, the sensitivity related to the information that students were required to share regarding their technology habits. As the way in which they interact and engage online was often counterintuitive to the expected, if not prescribed, behaviours of teachers and parents, students may have felt inclined to provide answers that aligned to expectations more than reality (Christensen & James, 2000). This bias was addressed by repeatedly ensuring students that any information they chose to reveal would not be shared with any parties and that the final responses would be anonymised.

Willing participants were involved in an interview process that sought to complement the previously collected quantitative data through recorded verbal expression and expansion upon a range of questions relating to technology use, not only in the classroom, but beyond. Jones (1985) contended that interviews are essential to forming an understanding of a range of perspectives:

> In order to understand other persons' constructions of reality, we would do well to ask them…and to ask them in such a way that they can tell us in their terms (rather than those imposed rigidly and a priori by ourselves) and in a depth which addresses the rich context that is the substance of their meanings. (p. 46)

Interviews are the most prominent means of collecting data in qualitative research, which provides a useful way of forming an understanding around individuals' "perceptions, meanings, definitions of situations and constructions of reality" (Punch, 2013, p. 144). The success of a controlled verbal exchange is dependent on the communication skills of the interviewer and their capacity to extract meaningful responses out of the discussions they generate through their line of questioning. An effective qualitative interview should provide an "undiluted focus on the individual" (Ritchie et al., 2013, p. 36). Without such communicative skills, the process can be severely hindered.

3.10. Within-subjects and Between-subjects

A within-subjects experiment design was initially determined to be the most appropriate approach to the collection and analysis of the data in this research; however, a range of limitations in the quasi-experiment led the final statistical analysis to be between-subjects. These limitations are discussed further in Chapter 5. Although a between-subjects design can have a range of drawbacks due to a relatively small sample size, De Winter and Dodou (2017) warn that it can be 'ethically problematic' to conduct an underpowered experiment, where both the time of participants and any money required is wasted in the process. One drawback worth noting from this quasi-experiment design is possible ordering effects, which is discussed further in this chapter. Ultimately, a between-subjects design was implemented as it was the most appropriate analysis for the data collected. The capacity for variation arising from the video and subsequent tests raised questions about how the data should be analysed. Charness, Gneezy, and Kuhn (2012, p. 1) suggested that "with these types of designs, as long as group assignment is random, causal estimates are obtained by comparing the behavior of those in one experimental condition with the behavior of those in another". Using this approach seeks to prevent interference from any extraneous factors (such as variation in student motivations, time of the day, lesson variation, etc.) as it important to avoid contamination of the data. MacKenzie (2002) noted that a between-subjects design can be more effective in addressing interference, in this case the difference in difficulty between the various tests.

3.11. Quasi-experimental Design

Within educational research, Clark (2005) suggested that values are central, and empirical questions are secondary, to philosophical investigation. Central to this investigation in an applied social science is a quest to "to increase teachers' reliability and to provide a rationale for their training, is a search for what causes people to become educated" (Clark, 2005, p. 289). Quasi-experimental design aims to test causal hypotheses, where a specific intervention, in this case varying levels of technology integration in the classroom, is used as a procedure under varying test conditions (White & Sabarwal, 2014). Through comparison of groups, this research sought to both identify and quantify to what extent the intervention may have affected the participants' performance on the various tests administered.

In many educational contexts, conducting a true experiment is not feasible due to it being difficult to have full experimental control through randomisation treatments (Kervin et al., 2016). The researcher's intransigence, or lack of complete control over the classroom situation, is what differs quasi-experimental design from a true experiment where they have complete mastery over the conditions (Campbell & Stanley, 2015). The rationale of a quasi-experimental design, as is similar to a true experimental design, is to support what would have happened in the absence of a treatment (Cook, Campbell, & Shadish, 2002).

In the context of the class groups, these were assigned by matter of availability and convenience in alignment with the data collection timeline. However, the randomised element was that each class was assigned a varying order of the three procedure conditions for the three different tests. According to Gribbons and Herman (1997), the use of comparative data generated from experimental designs enables the researcher to interpret the information with confidence that their observed outcomes are the result of their targeted interventions, instead of being attributed to another extraneous variable or event.

3.12. Validity

Conrad and Serlin (2005, p. 455) stated that "the impact of different measure properties and the appropriateness of measures are at the core of validity of interpretations of all educational research". Within quantitative research, validity relates to how dependable, consistent and replicable the design is over time, instruments or groups (Cohen, Manion, & Morrison, 2013). Due to the nature of the quasi-experimental design, this could be replicated in a range of environments to extend to a broader population. Invalid inferences can be made in research by concluding that a treatment has an effect, when it does not, and is the result of an error in 'statistical decision theory' (Hedges & Rhoads, 2010, p. 1). Therefore, Hedges and Rhoads (2010) contended that any educational research must be conscious of how this is addressed in order to make valid assumptions based on the quantities observed. The power, or sensitivity, of the test describes to what extent any significant differences will be evident in the collected data (Burns, 1997). Drawing causal inferences from quasi-experimental studies can be problematic, with Cohen et al. (2013) warning that it can be tempting to assume that correlations by default can mean causation. Therefore, it is important to be cognisant of all conditions which may relate to the overall outcome.

Morrison and van der Werf (2016) suggested that finding causality in educational research is akin to seeking the 'holy grail', an elusive process where problems are not only ontological or epistemological, but procedural. Cohen et al. (2013, p. 62) noted that "any cause or intervention is embedded in a web of other causes, contexts, conditions, circumstances and effects, and these can exert a mediating and altering influence between the cause and its effect". They contended that researchers in education are not merely concerned with what works, but indeed how and why it works. The rationale behind this is to enable policy makers and theorists to make accurate predictions about what will happen if particular interventions are introduced into a process. Any attempts at claiming causation in experimental studies are derived from the application of theory rather than the statistical tools utilised to analyse the collected data (Morrison, 2012). Although any attempt in educational research of highlighting causation can be potentially beneficial to furthering the understanding of the field, a significant amount of caveats relating to what could be classified as causation is usually required (Phillips, 2005; Sammons, 1995).

3.13. Order Effects

Order effects have required consideration in the analysis of the quantitative data. Such effects occur when there are confounding influences within an experiment where subjects are exposed to multiple conditions (McBurney & White, 2009). A change can occur in a subject's performance, depending where in the process they are exposed to a particular condition. This quasi-experiment required the four classes to be exposed to the three procedures in varying orders, to eliminate the possibility of the lesson content influencing the test results. This enabled the three different tests to be administered under the three different procedural conditions, yet negated any option to control for potential order effects. The statistical influence of these order effects is discussed further in Chapter 6.

3.14. Summary

The reliability of this research is facilitated through the provision of a triangulated perspective, wherein participants (parents and teachers) who have the capacity to either motivate or dissuade the focus population of students in their educational goals are integral to the learning process. The pragmatic approach facilitates a belief that theories can be both "contextual and generalizable by analysing them for 'transferability' to another situation" (Shannon–Baker, 2016, p. 325). In qualitative research, transferability addresses the possible local and external connections that the data gathered can reveal about a particular phenomenon (Given, 2008). The phenomenon in this research is technology and how it affects learning, both from an objective viewpoint gained through data, and that of perceptions gained from key educational stakeholders. The complementarity of this mixed methods paradigm has been designed to provide an insight into the interaction between these stakeholders and the technology that education is increasingly reliant on in the digital age. Lincoln and Guba (1985) contended that no single item of information should ever be afforded serious consideration unless it can be triangulated. The qualitative measure of semi-structured interviews enhances the quantitative data that has provided a statistical perspective on how technology actually influences the classroom environment and the individual's capacity to retain and retrieve information.

Chapter 4: Mixed Methods Research

4.1. Introduction

The purpose of this chapter is to outline the context of the conducted research and how it relates to the research questions, as well as the rationale for using a mixed methods approach. Ethical considerations relating to the scale, participating schools, test participants (quantitative), and interview participants (qualitative) are discussed.

4.2. Context

This research was conducted at two single-sex independent Catholic schools in metropolitan Melbourne, Australia. Both schools are non-selective in their student entry procedures. One of the most common methods of participant selection in educational research, and much of the social sciences, is convenience sampling (Kervin et al., 2016). The participants were from schools selected as a convenience sample due to the accessibility provided to the researcher throughout the entire process. Also known as accidental or opportunity sampling, Bhattacherjee (2012, p. 69) defined convenience sampling as a "technique in which a sample is drawn from that part of the population that is close to hand, readily available, or convenient". Whilst using a readily available population to sample for research aids convenience, access, consent and insider knowledge, the researcher must be cognisant of the disadvantages that can come with such convenience sampling, including having a vested interest in the results, bias and subjectivity (Punch, 2013).

The researcher was a teacher at School A and School B is the affiliated sister school, hence the participants were part of a convenience sample. The sample aims to provide a representation of a broader population of like students.

All students in participating Year 10 science classes were provided with an information sheet (see Appendix A**)** and a subsequent assent sheet (see Appendix B and Appendix C) to confirm their participation in the research. Two students out of 87 at School A and 40 students out of 92 at School B declined to participate in the research. As the naturalistic quasi-experiment was devised to be integrated into the science curriculum, these students still participated in the lessons and subsequent tests. However, their data were omitted from any subsequent analysis.

4.3. Participating Schools

School A is a boys' school, with over 2,000 male students of between 4 and 18 years of age, spread out over three campuses, is a member of the Associated Public Schools of Victoria (APS) and the IBSC (International Boys School Coalition).

School B is a girls' school, with over 700 female students of between 4 and 18 years of age. It is a member of the Junior School Heads Association of Australia, the Association of Heads of Independent Schools of Australia (AHISA), and an international network of like schools.

4.4. Demographics

Both School A and School B were Catholic schools in Melbourne. Whilst there is evidence from the US (Portes & MacLeod, 1996) and UK (Levačić & Vignoles, 2002) relating to how the type of school can affect educational outcomes, the research is more limited in Australia. However, research has found that students attending private schools were significantly more inclined to complete their secondary education and to achieve higher scores at the conclusion of their schooling (Pianta & Ansari, 2018).

The Index of Community Socio-Educational Advantage (ICSEA) is a quantitative measurement constructed by the Australian Curriculum Assessment and Reporting Authority [ACARA] (2014) which aims to index the "the average level of educational advantage of the school's student population relative to those of other schools" (p. 2). The purpose of this index is to allow people to determine socio-demographic factors that influence educational advantage, when comparing like schools and their National Assessment Program – Literacy and Numeracy (NAPLAN) results.

Factors such as the school's geographical location, family backgrounds, and the proportion of Indigenous students within the school's enrolment, all need to be considered when addressing the educational advantage or disadvantage of a school. On a scale with a median of 1,000 and a standard deviation of 100, schools around 500 on the index represent extremely educationally disadvantaged backgrounds, whereas schools around 1,300 represent student with very educationally advantaged backgrounds. School A's ICSEA index was 1183, and School B’s ICSEA index was 1179 (Australian Curriculum Assessment and Reporting Authority [ACARA], 2017).

Beyond race, ethnicity, and gender differences relating to academic performance (Strenze, 2007), Berger and Archer (2016) declared that socioeconomic status can impact student goals. They found that students who were completing senior school, not because of their motivation but more because of legal compulsion, had significantly lower academic achievement goals. Although debate has existed for decades regarding how socioeconomic status directly impacts student performance and achievement (Berger & Archer, 2015; Ginsburg & Bronstein, 1993; Strenze, 2007), Rothman (2003) contended that the ever-evolving Australian demographic and the subsequent educational landscape requires ongoing review of socioeconomic status, as it is a factor that can influence academic performance. When socioeconomic status is used to measure children’s school achievement, it relates to the status of the family or parent of the child (Considine & Zappalà, 2002), which takes into account their achievements in education, employment and occupational status, and income and wealth. With regard to educational outcomes, Considine and Zappalà (2002) observed that students from low socioeconomic status households are more likely to exhibit lower levels of literacy, numeracy and comprehension, lower retention rates, lower participation rates in tertiary education, higher levels of problematic school behaviour, lower likelihood to study specialised maths and science subjects, higher likelihood to have difficulties with their studies and display negative attitudes to school, and be less likely to transition from school to the labour market.

It should be noted that limitations relating to the generalisability of socio-economic, academic ability, and cultural differences need to be considered when cogitating the participant sample as a representation of a broader population of students. In this instance, all participants were students at Catholic schools in Melbourne, Australia.

4.5. Ethical Considerations

This research obtained approvals from the Human Ethics Research Committee (HERC) at the University of New England (see Appendix D) and received agreement in writing from School A and School B to become involved in the data collection (see Appendix E and Appendix F), both deidentified for the purposes of non-disclosure. There were a range of ethical considerations that needed to be factored into the data collection process, primarily due to the majority of participants being school children. Einarsdóttir (2007) noted that ethical matters take on significant importance when children are involved, with informed consent, access, relationships, confidentiality, and protection all requiring considerable sensitivity throughout the process. The researcher was not the classroom teacher for any of the students involved throughout the process, notwithstanding having taught some of the students from School A in the previous year. The wording for the students' information sheets were made more accessible and in language that clearly communicated the research process to them. As all students were minors (a person under the age of 18), they were provided with an assent form and their parents with a consent form. Both students and parents were provided the opportunity to nominate their willingness to participate in subsequent interviews. Only those instances where both parent and child consented for follow up interviews were contacted.

Where a student consented to be interviewed, but their parent did not wish to participate in the research, the student was omitted from the qualitative data collection.

When interviewing children about their online behaviours, it is also advised that they should be treated as active participants in the process, rather than mere respondents (Lobe, Livingstone, Olafsson, & Simões, 2008; Ólafsson, Livingstone, & Haddon, 2013). If resistance from the child interviewee is evident, due to the intrusion on their private world, the subsequent results will not be indicative of their true lived experience (Cohen et al., 2013). The susceptibility to suggestion, linguistic skills in development, and a blurred concept between fiction and reality, are all factors that bring critics to the process of interviewing children (Einarsdóttir, 2007; Schetky, 1997; Warren & McGough, 1996). Until only relatively recently, research on children used to be through observation and testing. Now child subjects have become more active participants in the process, with researchers utilising children's direct responses and input due to it being regarded as valuable first-hand information to understanding phenomena (Hill, 2006). It is suggested that this participatory climate, where the child's voice is valued "has been fortified by the UN Convention on the Rights of the Child, especially Article 12, which affirms children's entitlement to express their views on matters affecting them" (Hill, 2006, p. 71).

Anonymity was a primary concern for many students, who presented a range of queries to their classroom teachers as to how the data collected was going to be used. Some resistance and discomfort relating to the collection of their test data for non-school purposes resulted in students declining to participate in the research. Conrad and Serlin (2005) contended that the act of providing a consent form, in what would otherwise be a naturalistic environment, can create worry in participants who might assume that such a form and subsequent information sheet is provided to protect them from something. Both information sheets and subsequent communication from the participating classroom teachers outlined that the data collection was strictly anonymised, yet feedback from the classroom teachers highlighted that the concerns over this were unable to be assuaged for some students.

All interview participants, before recording commenced, were reassured that their contribution to the qualitative data collection would be anonymised and any information they chose to reveal would not in any way be shared with other members of the school community. Addressing the potential for participant bias, where the interviewee constructs a response that they believe will present them in the best light, was a primary concern for the interview process, specifically for the student participants. Although participants were assured of their anonymity in the research process, the fact that data collection involved face to face interviews with a member of their school community, as opposed to a disseminated questionnaire that facilitated totally anonymity, is a factor worth noting. The rationale regarding this reassurance was to ensure that students were comfortable in providing honest and accurate responses to questions, where their answers may not have necessarily been aligned with the behaviour deemed acceptable within the expectations and class conduct prescribed by their respective schools.

For the purpose of their own curriculum, participant teachers retained the completed test data for their own assessment purposes. Both the quantitative test data and qualitative data in the form of audio recordings and subsequent transcripts were stored in a secured cloud server, with only the researcher having access to the digital assets.

4.6. Summary

This chapter looked at how the research questions were operationalised with regard to the schools and respective participants. Year 10 science was selected as it is a subject that is a core (mandatory) subject at this year level and, as previously stated, requiring factual responses that recalled content from the videos presented. Therefore, all students within the year level at both School A and School B were enrolled in this subject, whether it was their personal preference or not. The ability to excel within the specific subject area may have been driven by the student's interest in the topic or course in general. Students who were undertaking science because of its compulsory nature, as opposed to electing to study it, may not have been as motivated as peers who were more invested in the course. Future considerations to address this would be to conduct a similar quasi-experimental design with students in an elective unit of science to determine whether their motivation for the course influences their outcomes.

Chapter 5: Quantitative Method

5.1. Introduction

The purpose of this chapter is to outline the process undertaken for the quantitative analysis and how the data were collected. It explains the rationale for the quasi-experimental design and the consequent procedure, including recruitment of participants and subsequent limitations.

5.2. Science Test

Research questions 1 and 2 are quantitative in nature. The quasi-experiment design involved tests that sought to gather data to respond to address the questions relating to how technology affects lesson content retention and under which treatment do students retain lesson content most effectively. The data gathering was designed to be naturalistic in its implementation to ensure that minimal disruption to both the content and conduct of the classroom environment occurred throughout the quantitative data collection phase. The purpose of embedding a test into the curriculum was to ensure that students would approach the test with the same level of academic rigour and motivation that they would any other task within their course of learning. This, however, does not suggest that a test, by default, engenders a level of academic rigour in all students. The design aimed to provide conditions that were neither foreign nor distracting to the overall process, hence avoiding the possibility of any additional confounding variables relating to student motivation and understanding. The length of a lesson for both schools was a 45 minute period, which allowed sufficient time for the teacher to conduct standard administrative tasks (such as roll taking), provide introduction and instruction regarding the task, playing of the video, and administering the subsequent test.

With regard to positionality, Punch (2013) contended that the researcher always approaches the investigation from a particular position, with their perspective framing the analysis and representation of the data. Science tests were developed in consultation with school curriculum leaders to ensure that their content was as naturalistic and embedded into the course structure as possible.

The first phase of the research involved three tests which were devised solely by the science teachers. The only instruction from the researcher was that questions on the tests should require objective answers (e.g., 'what particle can be used to predict the properties of elements?') and not be open to interpretation to ensure a consistent marking rubric. School A developed three tests to integrate into their science curriculum, with a corresponding YouTube video:

1. How to speak 'Chemistrian',
   www.youtube.com/watch?v=mlRhLicNo8Q
2. Balancing Equations
   www.youtube.com/watch?v=RnGu3xO2h74
3. Precipitation
   www.youtube.com/watch?v=IIu16dy3ThI&t=43s

School B developed three tests that addressed different content to School A. As the content of these tests differed between schools, it limited any opportunity to make comparisons between School A and School B. The rationale for the different content was to ensure that the tests coincided naturalistically with their respective science courses being taught:

1. Periodic Table
   www.youtube.com/watch?v=ywvzPxBCarM
2. Ionic and Covalent Bonding
   www.youtube.com/watch?v=VSc491HLzDo
3. Hydrocarbon
   www.youtube.com/watch?v=b2jPBviM7jI

The questions were approved by each school's head of science to confirm that all questions were of commensurate difficulty, length and of objective nature to address the consistency in marking. The difficulty of the tests pertained to recalling key information communicated in the videos, as opposed to deeper analysis or comprehension of concepts beyond the video content. The tests were then modified by the researcher to have a consistent layout and presentation format to ensure uniformity across all tests. These were printed, organised, and then provided to the individual classroom teachers for dissemination (see Appendix G-I).

Each class at both School A and School B completed their respective three tests in the same order. Classes were randomly assigned to three different orders of procedure. Classes were pre-determined by way of timetabling and school administration processes, as opposed to allocating students to new class groups for the sole purpose of the quasi-experiment. The three procedures applied to the classroom conditions related to how students were permitted to take notes during the screening of the video content on which they would be tested immediately after. The procedures applied varying levels of distractibility in the form of access to technology. Whilst pen and paper offered limited scope in its capacity to distract (Vincent, 2016), it was the open access to devices that sought to identify whether students would have their ability to focus impacted by dividing their attention across multiple streams of information (Craik et al., 1996).

Procedure A required students to take notes using solely pen and paper, whilst the teacher actively circulated and monitored conduct within the classroom. Students were then permitted to refer to their paper notes whilst undertaking the test.

Procedure B required students to take notes on their digital device whilst the teacher actively circulated and monitored conduct within the classroom. Students were then permitted to refer to their digital device whilst undertaking the test.

Procedure C allowed students to take notes on their digital device whilst the teacher remained stationary at the front of the classroom and did not monitor students' activity on their devices. Students were free to use their devices for whatever purpose they saw fit during this time. Students were then permitted to refer to their digital device whilst undertaking the test.

The order in which the procedures were administered varied between class.

Table 1 and

Table 2 depict the order that each class completed the three procedures in.

Table 1.
School A Class Order and Procedure Administration

Ordering	How to speak 'Chemistrian'	Balancing Equations	Precipitation
Class 1	A	B	C
Class 2	C	B	A
Class 3	A	C	B
Class 4	B	A	C

Table 2.
School B Class Order and Procedure Administration

Ordering	Periodic Table	Ionic Covalent Bonding	Hydrocarbon
Class 1	A	B	C
Class 2	C	B	A
Class 3	C	A	B
Class 4	B	A	C

Tests were administered to all students in paper form, with between 10 and 14 questions relating to the video content they had just observed. The purpose of the various procedures was to determine whether enabling students to work with their devices, either moderated or unmoderated/unsupervised by the teacher, had the potential to affect their retention of the lesson content. Tests were then marked to provide a total score and once the classroom teacher had completed their marking, the sheets were returned to the researcher to input data into a spreadsheet for later statistical analysis.

The aforementioned three procedures were administered to four classes of students, with each class being randomly assigned a different order of procedure method. Although there are six possible orderings of three procedures (A, B, C; A, C, B; B, A, C; B, C, A; C, A, B; and C, B, A), due to administrative limitations, only four classes were available and thus only four such orderings (A, B, C; C, B, A; A, C, B; and B, A, C) were able to be administered.

5.3. Test Participants

Participant students were members of classes within the Year 10 Science curriculum (approximately 15 and 16 years of age). Classes of students were selected based on the viability of the tests being implemented within the allocated time frame and with willing participant teachers to execute the test conditions. Classes at School A and School B were not academically streamed and consisted of students of mixed ability. All Year 10 science students who participated were completing this subject as part of a compulsory subject allocation, eliminating any motivational bias that may have occurred from students choosing this subject as an optional elective. At School A and School B, students across four separate classes respectively (see Table 3) participated in three science lessons that were integrated into their standard science curriculum, with a standard lesson duration of 45 minutes.

Table 3.
Test Participants

Class (Group)	School A	School B
1	22	24
2	23	22
3	20	23
4	22	23
Total (*N*)	87	92

5.4. Quasi-Experiment Procedure

The quantitative method in this research aimed to establish the implications of technology on lesson content retention through the analysis of quasi-experimental research data gained from repeated classroom tests. Teachers were provided with an information sheet that outlined the format of the quasi-experiment design and how it should be conducted within the lesson (see Appendix N). These lessons were, on average, separated by a fortnight within the third term of the 2017 academic year. At the commencement of the lesson, after class administration and explanation about the impending lesson and how it was to be conducted was completed (approximately 5 minutes), a video sourced by the teacher who wrote the related test, was played to the class as a whole.

Within the context of this research, distractibility can be in the form of all online content that does not specifically pertain to the learning objective at hand. The distraction, therefore, may differ from one student to another. As will be identified further in the qualitative data, some students were more inclined to become distracted by social media and engaging with peers online, whilst others had a propensity to deviate from tasks by watching non-educational videos or playing games. This quasi-experimental design did not have the capacity to quantify specific distractions or determine which non-educational activity was most prevalent on individual devices.

5.5. Video Delivery

Students were played a video which was specifically nominated by the science teacher who devised the corresponding test. Each video, three for each school, went for 12-15 minutes in duration. The video was played once in full, with no pausing or interruption throughout. Once the video had concluded, students were asked to complete the test within 15 minutes. During the lesson, test conditions meant that students were not able to view the video again or seek further clarification or assistance from either their peers or classroom teacher. The academic benefits of YouTube and digital video delivery services, such as ClickView and Vimeo, continue to garner support from educational theorists (Fleck, Beckman, Sterns, & Hussey, 2014; June, Yaacob, & Kheng, 2014). Apart from utilising a video to ensure the consistency of content delivery across all classes at each school respectively, exposing students to readily accessible online videos is no longer an unfamiliar concept in the contemporary classroom. Educators can now defer to online content to communicate otherwise complex ideas, or to depict content generated by others as a mechanism to save time, elicit interest or capitalise on the repeatability and pacing that comes with a video.

The purpose of the content being delivered via a freely accessible resource such as YouTube was to ensure that all students were exposed to precisely the same content. The integration of YouTube into lessons can have a range of engaging and motivational benefits for the student (Fleck et al., 2014). June et al. (2014, p. 64) found that students considered YouTube videos for learning "stimulating, relevant, and managed to attract their attention". However, Drew (2018) noted that teachers must be conscious of what they are trying to achieve with the integration of online video content to their lessons. Within the context of this quasi-experiment, it was simply to present information for later recall. Were the lesson to be delivered by the individual classroom teacher, factors such as teacher/student relationship and receptiveness (Modi, 2015), quality of content delivery and teacher competence (Prasertcharoensuk, Somprach, & Ngang, 2015), and classroom conditions pertaining to the time of the school day or week (Pope, 2016), would have all been factors requiring further consideration in the analysis of results. The videos also controlled for time and pacing, to ensure consistency was achieved across all conditions. Videos ranged between 12 and 15 minutes in length across the six different videos at the two schools.

5.6. Limitations

Following the collection of data, it was determined that the initially proposed analysis would need to be reconsidered. The variance between videos and subsequent tests proved to be a limitation that needed to be addressed, with a between-subjects analysis nominated as a more appropriate method of interpreting the data due to its reliability and robustness, over that of a within-subjects approach (Charness et al., 2012). In a within-subjects design, all participants complete all procedures, with the procedure factor being the only thing which is changed between each treatment. In this study, the procedure, or the levels of the independent variable, were the conditions of *no ICT use*, *moderated ICT use* and *unmoderated ICT use*. The dependent variable was the quality of the participants' retention of the video content viewed, determined by a subsequent test. However, the video used for each procedure and the test used to measure retention of the video content were also changed for each treatment. The consequence of this was that variability in the dependent variable could arise due to variation in the procedure, the video or the test. It should also be noted that the conditions of moderated and unmoderated technology did not specifically determine which distractions were most prevalent, such as the use of social media, gaming, etc. Further quasi-experiments of this nature could seek to monitor more closely the specific content that students access whilst under these test conditions.

5.7. Summary

This chapter presented the details of the quantitative method and how the quasi-experimental design was conducted at School A and School B. Justification was provided in relation to the nature of these tests being within the science curriculum. It detailed the procedure undertaken and an explanation of the videos used to deliver content pertaining to the in-class tests. The collection of these test results consequently provided the data necessary for statistical analysis to address the previously stated research questions.

Chapter 6: Quantitative Analysis

6.1. Introduction

The purpose of this chapter is to outline the statistical processes that were undertaken to analyse the quantitative data and subsequent analysis. It provides justification for the use of specific statistical procedures and relevant software to achieve these outcomes.

6.2. Procedures

In this quasi-experimental design, there were three procedures of note-taking, with varying levels of ICT use. *Procedure A (no ICT use)* involved students viewing the lesson content, delivered by video, and taking notes using the traditional method of paper and pen, whilst the teacher circulated the room to maintain classroom conduct and behaviour. Under this condition, students were not permitted to deviate from the task at hand. *Procedure B (moderated ICT use)* allowed students to take notes on their own devices; however, students' use of their ICT was monitored by the circulating teacher. This was to ensure that students were accessing their device, but were not permitted to access any applications or content that did not pertain to notetaking during the lesson. Accountability to this instruction was upheld by the teacher's enforcement and circulation throughout the classroom. *Procedure C (unmoderated ICT use)* enabled students to use their devices for whatever process they deemed appropriate. Under this condition, students were able to deviate from the task at hand, should they wish. Limitations regarding this condition are discussed further in this chapter. The teacher provided no other instruction on how to take notes or use their device appropriately and remained static at the front of the classroom. From the position in which the teacher sat, they were unable to monitor the activity of the students on their devices. It was incumbent upon the individual student to exercise self-regulation strategies if they were to attenuate the digital distractions now made available to them (Ackerman & Goldsmith, 2011; Eisenberg et al., 2014).

The tests devised by the school's respective science departments were to test the individual student's ability to recall content presented in the video relating to subject matter that they had not previously rehearsed or been exposed to. All tests were completed on paper, ranging in 10-14 questions in length and were marked by the individual classroom teacher. The content of the questions related specifically to the material students had been exposed to just prior to undertaking the test, in standard classroom test conditions. The data analysed is sourced from the numerical grade that students achieved on these tests.

The purpose of this statistical analysis is to enable one to draw inferences in the presence of randomness that can occur in the data collected, with Hedges and Rhoads (2010) noting that in most educational research, the sample will be derived from a complex design. With regard to this quasi-experimental design, the intent is to measure under which procedure students perform best on their administered tests. Conrad and Serlin (2005) suggested that two key methodological challenges that occur when designing such research are determining measurable effects on assessment performances and whether the quality and content of instruction reliably influences these results. As the instruction is controlled by way of preselected video content, this confounding variable has been eliminated.

6.3. School A: Analysis

Each video and subsequent test at School A was analysed to determine under which procedure students performed best. The following elaborates on the results from each test.

Speaking Chemistrian

The Speaking Chemistrian cycle of testing used the video available at www.youtube.com/watch?v=mlRhLicNo8Q, which was 10 minutes 42 seconds in length. The test, which comprised 14 items, is shown in Appendix G. Table 4 summarises the descriptive statistics for the Speaking Chemistrian test grouped by procedure, while Figure 3 shows the corresponding box plot.

Table 4.
Descriptive Statistics for Speaking Chemistrian Grouped by Procedure

Procedure	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
A	36	7.33	2.928	.488	1	13
B	20	8.20	4.561	1.020	0	14
C	21	7.90	3.590	.783	0	13
Total	77	7.71	3.561	.406	0	14

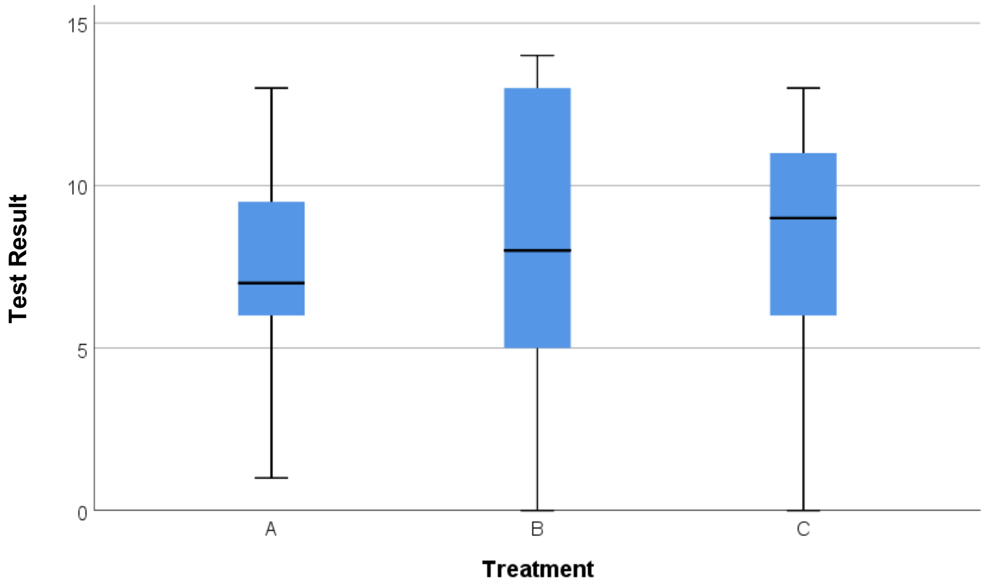

Figure 3. Box plot for Speaking Chemistrian grouped by Procedure

The range of results for participants completing Procedure B (i.e., moderated ICT), demonstrated a substantially larger range of scores within the second and third quartiles. The data distribution failed Levene's test ($F(2,74) = 3.559, p = 0.033$) for homogeneity of variance, so the non-parametric Kruskal-Wallis *H*-test was used to test for significant differences between the groups. No statistically significant difference was identified ($H(2) = 0.871, p = 0.647$), indicating that participant performance was comparable, irrespective of their use of ICT, or whether it was moderated or not.

Precipitation

The Precipitation cycle of testing used the video available at www.youtube.com/watch?v=IIu16dy3ThI&t=43s, which was 11 minutes 20 seconds in length. The test, which comprised 13 items, is shown in Appendix H. Table 5 summarises the descriptive statistics for the associated comprehension test grouped by procedure, while Figure 4 shows the corresponding box plot.

Table 5.

Descriptive Statistics for Precipitation Grouped by Procedure

Procedure	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
A	18	4.89	2.374	.559	1	8
B	20	4.60	3.251	.727	0	10
C	39	5.28	2.964	.475	0	12
Total	77	5.01	2.895	.330	0	12

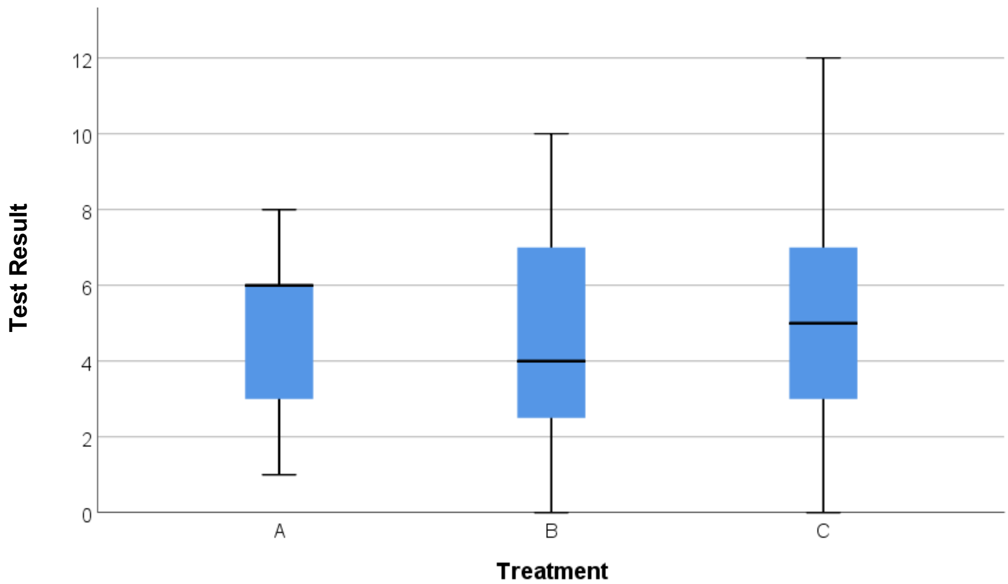

Figure 4. Box plot for precipitation grouped by procedure

The data distribution failed Levene's test ($F(2,74) = 4.881, p = 0.010$), for homogeneity of variance, so the non-parametric Kruskal-Wallis *H*-test was used to test for significant differences between the groups. No statistically significant difference was identified ($H(2) = 0.745, p = 0.689$), indicating that participant performance on the Balancing Equations test was comparable, irrespective of the use of ICT, or whether the ICT use was moderated or not.

Balancing Equations

The Balancing Equations cycle of testing used the video available at www.youtube.com/watch?v=RnGu3xO2h74, which was 14 minutes 27 seconds in length. The test, which comprised 13 items, is shown in Appendix I. Table 6 summarises the descriptive statistics for the associated test grouped by Procedure, while Figure 5 shows the corresponding box plot.

Table 6.

Descriptive statistics for Balancing Equations grouped by Procedure

Procedure	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
A	18	8.06	3.977	.937	0	13
B	41	7.56	3.147	.491	1	13
C	18	6.72	4.156	.980	1	11
Total	77	7.48	3.582	.408	0	13

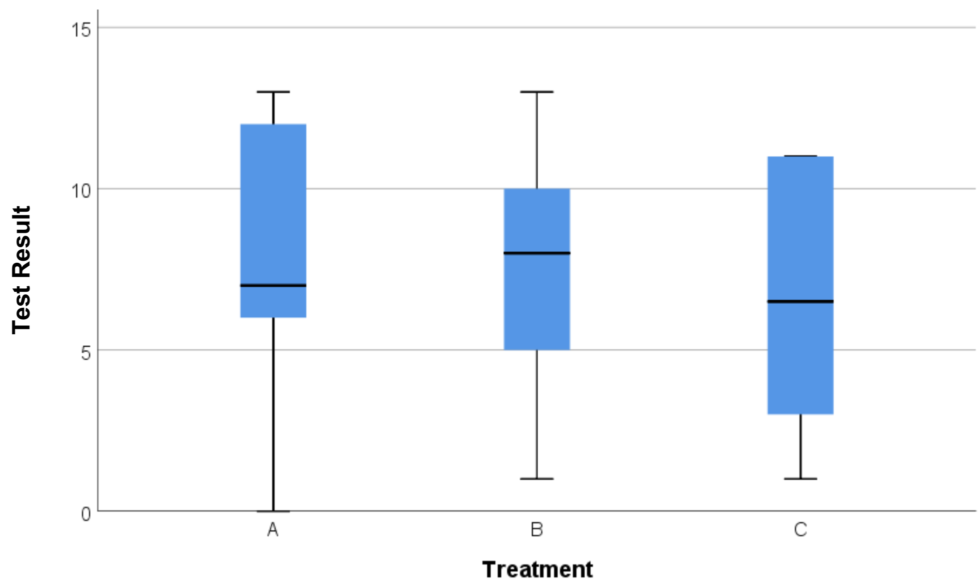

Figure 5. Box plot for Balancing Equations grouped by procedure

The data distribution satisfied Levene's test ($F(2,74) = 0.731, p = 0.485$), indicating homogeneity of variance. The associated one-way ANOVA, using procedure as the grouping variable and the result on the test as the dependent variable, indicated no significant difference ($F(2, 74) = 0.382, p = 0.684$), indicating that participant performance on the Precipitation test was comparable, irrespective of the use of ICT, or whether the ICT use was moderated or not.

6.4. School B: Analysis

Each video and subsequent test at School B was analysed to determine under which procedure students performed best. The following elaborates on the results from each test.

The final quantitative data collected from School B was limited in what insight it provided. A range of omissions in the data presented difficulties for analysis, where students were either absent on days that the tests were administered or did not provide assent for their data to be used. However, it is advised that research should not ignore instances where the data obtained does not necessarily support the researcher's hypothesis (Seale, 1999; Silverman, 2006). The data are also subjected to experimenter bias, with Burns (1997) highlighting that all researchers come to their investigation with "attitudes, values, needs and motives" (p. 149) that they must be conscious of to avoid contaminating their results. He contended that a wide divergence in opinion and beliefs can create a subjective interpretation of the data. Within the context of these findings, the researcher needed to ensure that their interpretation of the data was not contaminated by previously held assumptions or motivations to support pre-established views. Therefore, the researcher needed to maintain vigilance in how their role may affect the data collection and remedy, wherever possible, the aforementioned experimenter bias. This was addressed by being completely removed from the quantitative procedure, from the generation of the test, its administration, through to the collection of academic results for later data analysis using IBM SPSS 25. The Statistical Package for the Social Sciences, or SPSS, is software used for statistical analysis of data.

The design for the data collection at School B was the same as that used at School A, namely four classes involving three different procedures. Due to the curriculum being addressed in the school at the time, different videos and associated tests were used. Unfortunately, there was a lack of return of the consent forms and there was substantial missing data.
Table 7 summarises the number of valid responses.

Table 7.

School B number of responses for all Procedures

Video	**Procedure A**			**Procedure B**			**Procedure C**		
	n	$\bar{X}$	s	n	$\bar{X}$	s	n	$\bar{X}$	s
Periodic Table	22	6.59	1.79	20	5.95	1.76	6	8.17	1.33
Ionic and Covalent Bonding	6	9.00	0.89	9	9	0.71	34	6.91	1.94
Hydrocarbons	18	8.28	1.84	17	8.97	1.35	7	9.71	0.49

The groups with a sample size less than 10, and which are much smaller than other groups, demonstrate a consistently higher mean and much smaller standard deviation, and therefore, variance, than the other groups. The small number of participants in these groups also raised questions about the power of any statistical analysis in which they were used. Therefore, the only quantitative testing completed was for the Periodic Table and Hydrocarbon videos and using only Procedures A and B.

The Periodic Table cycle of testing used the video available at www.youtube.com/watch?v=ywvzPxBCarM, which was 11 minutes 22 seconds in length. The test, which comprised 10 items, is shown in Appendix J. An independent samples *t*-test was conducted to test for differences between Procedures A and B. Levene's test established equality of variance ($F = 0.285, p = 0.596$) and no statistically significant difference was identified ($t = 1.168, d = 40, p = 0.250$). The data distribution is shown in Figure 6.

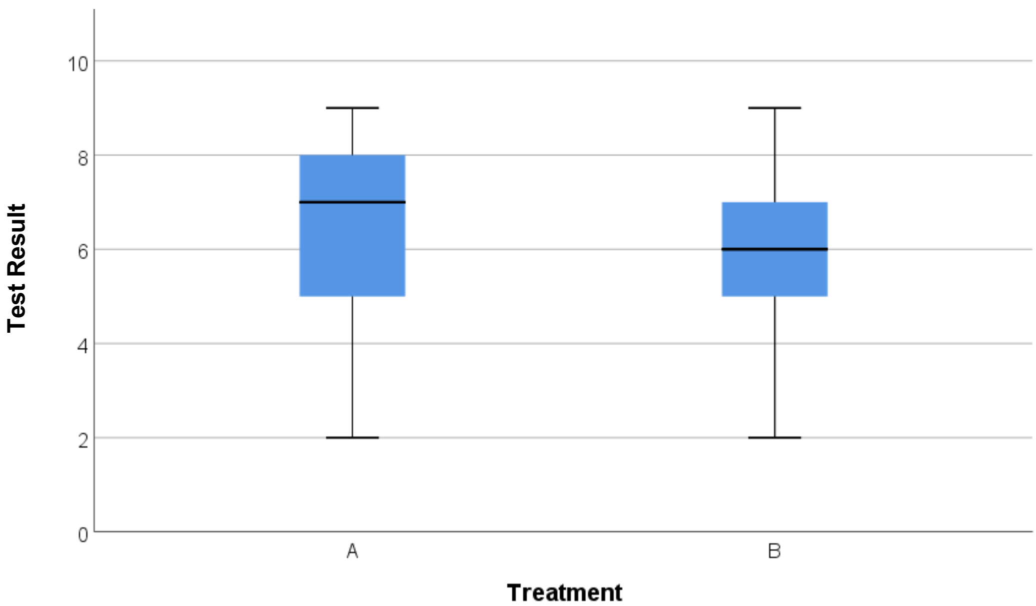

Figure 6. Periodic table result distributions for Procedures A and B

The Hydrocarbon cycle of testing used the video available at www.youtube.com/watch?v=b2jPBviM7jI, with the video being 11 minutes 57 seconds in length. The test for the video comprised 10 items and is shown in Appendix K. An independent samples t-test was conducted to test for differences between Procedures A and B. Levene's test established equality of variance ($F = 1.447, p = 0.238$) and, again, no statistically significant difference was identified between the group means ($t = -1.263, d = 33, p = 0.216$). Figure 7 shows the data distributions for the Hydrocarbon cycle of testing for Procedures A and B.

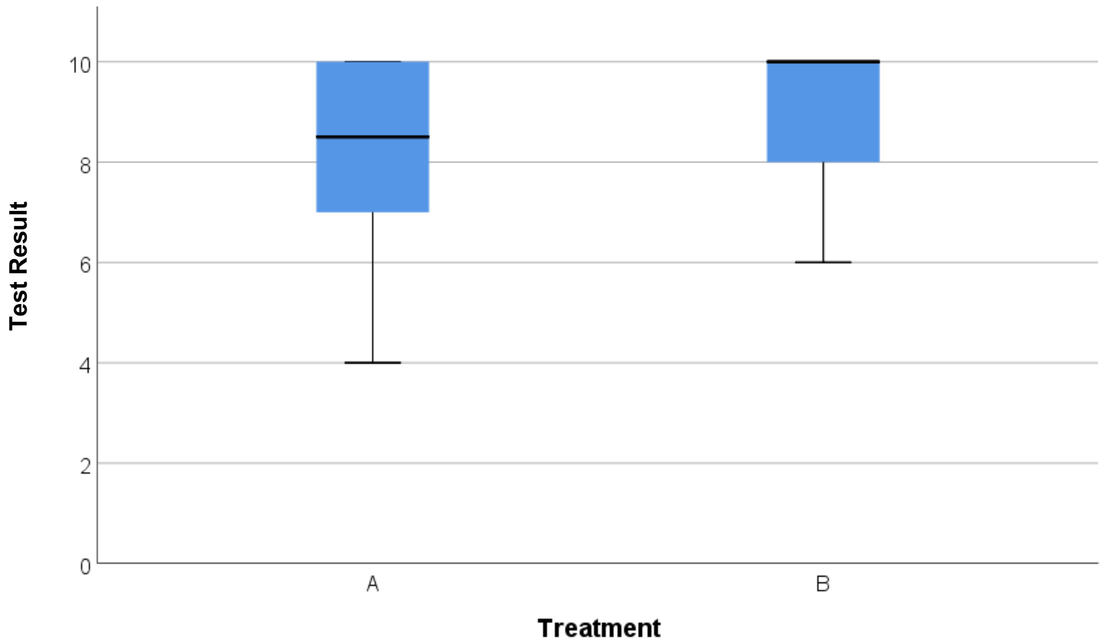

Figure 7. Hydrocarbon test results grouped for Procedures A and B

6.5. Summary

This chapter presented the statistical analysis that was performed to interpret the data gathered from the quasi-experiment design. School A and School B have been analysed independently of each other and the results, although not entirely comparable between males and females, does provide some insight into how students performed differently at both schools. Making any comparison between gender and the ability to self-regulate ICT use and attenuate distraction in the classroom may be difficult to draw from the collected quantitative data; however, the qualitative interviews provide a richer insight into how individuals perceive the efficacy of the technology they are using on a daily basis. These insights are expanded upon in Chapter 8.

Chapter 7: Qualitative Method

7.1. Introduction

The purpose of this chapter is to outline the analytical processes that were undertaken to analyse the qualitative data and how it addressed Research Questions 1 and 2. It outlines the questions asked of individuals categorised into three stakeholder groups (teachers, parents, and students) and how these responses were collected. It provides justification for the use of specific analytical procedures and relevant software to achieve these outcomes. Maxwell (2012, p. 654) stated that “educational research desperately needs qualitative approaches and methods if it is to make valid and useful claims about what works”. The quantitative data collected was supplemented with interviews with participating teachers, parents, and students. Griffin (2004, p. 8) suggested that gathering qualitative data can “challenge the researcher’s assumption about specific phenomena”.

7.2. Interview Questions

Research questions 3 to 5 are qualitative in nature and sought to identify how parents, teachers and students perceived the efficacy of technology for learning. Questions relating to the efficacy of technology within the classroom and at home were generated to form the overarching theme of the semi-structured interview process (see Appendix L-N). The guiding rationale behind the questions was the applicability to all three groups of participants: parents, teachers, and students. The purpose of this was to allow for comparison of responses between the three groups, where varying perspectives on the one issue were established. Due to the semi-structured nature of the interview process, additional improvised questions were introduced to the discussion, as deemed appropriate throughout the course of the interview. This allowed for a richer level of complexity and insight into comments made in response to the pre-planned questions. Ritchie et al. (2013) suggested that quotations gained from the interview process can provide an insight into the language relating to a particular phenomenon, the meanings attached to it, and a rich portrayal of how complex phenomena is viewed by the participants.

Participants were interviewed within their respective schools, in a private space with only the researcher and interviewee present in the room. In the context of this research, the researcher was a teacher at School A, thus neutrality was sought by enlisting participants who were not current students of the teacher. Participants were provided with the questions in advance of their allocated interview time via email. This was to ensure that participants were comfortable with what they were going to be asked, and allowed time to formulate ideas that they would be able to elaborate on during the recording. They were subsequently provided with a printed version of the questions prior to the recording. Participants were invited to voice any queries or discuss any concerns regarding the interview questions and overall process before the recording began. Participants were reminded that pseudonyms would be used in all dissemination of results. The questions asked of the teachers, parents, and students were similar in content and theme, yet differed slightly in how they managed technology for the purposes of education. The primary focus of questions for all groups of participants focused on how the student used ICTs for learning. The semi-structured research questions were as follows (reproduced for the reader's convenience):

Questions for Students

1. How useful do you believe technology is to learning in the classroom?
2. What do you see as the main benefits of using technology for learning?
3. What do you see as the main detractors of using technology for learning?
4. How do you manage the distraction that comes from your technology in the classroom?
5. How do you manage the distraction that comes from other's technology in the classroom?
6. How do you feel when you are separated or prohibited from using your devices?
7. How do you manage the distraction that comes from technology when working at home?

Questions for Teachers

1. How useful do you believe technology is to learning in the classroom?
2. What do you see as the main benefits of using technology for learning?
3. What do you see as the main detractors of using technology for learning?
4. How do you manage the distraction that comes from students' technology in the classroom?
5. How do you monitor/restrict/control how students are using their technology within the classroom?

6. How do students react when separated or prohibited from using their devices?
7. How do you advise students manage the distraction that comes from technology when working at home?

Questions for Parents

1. How useful do you believe technology is to learning in the classroom?
2. What do you see as the main benefits of using technology for learning?
3. What do you see as the main detractors of using technology for learning?
4. How do you manage the distraction that comes from your child's technology at home?
5. How do you think your own technology use influences your child?
6. How does your child respond when their use of technology is restricted?
7. How do you determine when your child is using technology for learning or recreation?

7.3. Thematic Analysis

The analysis and interpretation of qualitative responses is a process of decontextualisation and then recontextualisation, where data is first separated from its original context and then coded to assign meaning and connection with overarching themes (Starks & Brown Trinidad, 2007). Thematic analysis utilises a systematic approach to identify themes, classify data and seek to organise commonalities, disparities and overarching patterns that explain cultural meaning (Mills et al., 2010). The process was inductive due to there being no pre-existing codebook, therefore the researcher had to identify themes, or clusters of meaning (Creswell & Clark, 2007), grounded in the data.

The coding in NVivo was three tiered, with participants initially assigned categories of teacher, parent or student. From there, their answers were coded to identify any responses within the transcript that pertained to the semi-structured interview questions. Within these, supporting themes that related to the overarching research (attention, retention, distraction, focus, benefits, negatives) were identified. The recurring themes identified through the coding process informed the overall structure of the qualitative analysis.

Starks and Brown Trinidad (2007, p. 1376) suggested that “by the end of the story the reader should feel that she has vicariously experienced the phenomenon under study and should be able to envision…coming to similar conclusions about what it means”. Within the context of this research, the insights provided by the three key stakeholders sought to inform the reader of learned experiences and to identify where opinions are both agreed upon or in opposition.

7.4. Interview Participants

All teachers, parents, and students who were associated with the quantitative quasi-experiment were invited to participate in the interview process, with interviews ranging from 10 to 20 minutes in duration (see Table 8).

Table 8.

Qualitative Interview Participants

Category	School A	School B
Teachers (*n* 5)	3	2
Parents (*n* 5)	3	2

Students (*n* 13)	8	6
Total (*N* 24)	14	10

These semi-structured interviews provided the opportunity for individuals to respond to open-ended questions, whilst also encouraging a certain level of freedom to expand upon areas of interest or take the conversation in unplanned directions. With regard to the structure of the interview process, Morison, Moir, and Kwansa (2000, p. 115) suggested that it is worth noting "whether the interview is structured, semi-structured or unstructured, it is contended that the interviewer is never totally in control, inaccessible or unaffected by the actions and responses of the young person".

Parents were sent home a letter (see Appendix O) inviting voluntary participation in the interview process. Parents who responded with an affirmative response to participate in subsequent interviews were consequently registered and were cross referenced with students from School A (23 out of 87) and School B (21 out of 92) who provided assent to also be interviewed. The rationale was to interview parents who had children also willing to participate in the interview process, to best triangulate perspectives. Three teachers from School A (out of the four who participated in executing the quantitative measure), and both participating teachers from School B consented to being interviewed.

7.5. Validity

In order to maximise the validity of the interview process, the researcher should look to minimise the interference that can come with bias.

Characteristics of both the interviewer and interviewee can all influence bias in qualitative data collection (Cohen et al., 2013). Personal beliefs, attitudes, and expectations of both the researcher and participants are factors that contribute to the overall outcome of the interview process, with Denscombe (1995) regarding interviewer neutrality as being akin to a fantasy. Unlike the collection of quantitative data, which has the ability to remove the interpersonal and relational factors from the process, the success of interviews relies heavily on the interaction between involved parties. Lee (1993) contended that undertaking research on sensitive topics can raise difficult methodological and technical problems, therefore it has been important to ensure that the sensitive nature of any matters discussed in the interview process have been handled both ethically and responsibly.

7.6. Summary

The semi-structured interview process, as outlined, seeks to elicit a rich and detailed qualitative perspective on how the key stakeholders (teachers, parents and students) perceive the efficacy of ICT for educational purposes. It is noted that this process is not without its limitations. In both instances where students were being interviewed, such limitations were countered with reassurance prior to the interview recording that all comments were to remain anonymous and any insights or anecdotes shared would not then be relayed to any other authoritative parties within the school, or elsewhere. As Denscombe (2010) advised, the tone of the interview process should be one of neutrality and passivity, where the researcher's role is to "listen and learn" (p. 180), as opposed to preach or influence.

Chapter 8: Qualitative Analysis

8.1. Introduction

The purpose of this chapter is to examine the data gathered from the qualitative research and how it addressed Research Questions 3 to 5. Semi-structured interviews were conducted at two single-sex schools in metropolitan Melbourne where the opinions of teachers, parents, and students were sought to provide an insight into the perceived efficacy of technology for learning.

8.2. Method

In total, 24 interviews were conducted, which resulted in close to five hours of recordings, equating to approximately 52,000 transcribed words. The average length of interview was 12 minutes 14 seconds; however, the majority of parents and teachers interviewed spoke for almost twice as long as the students. Audio files were transcribed as separate text files and then collated for analysis within the appropriate software. The transcripts were imported into Nvivo for coding and subsequent thematic analysis and categorisation. This software package is used to code, categorise, and classify qualitative data and identify themes and recurring attributes in text. The interviews were categorised into perspectives of the three key stakeholder groups (teachers, parents, and students), and then recurring themes were subsequently organised under these groups.

8.3. Participant Coding

Table 9 outlines the coding procedure undertaken to anonymise and label the interview participants, where *X* denotes the individual. For example, the three teachers at School A are referred to as AT1, AT2 and AT3 respectively, whilst teachers at School B as BT1, BT2 and BT3. Parents were “P” and students “S”.

Table 9.

Participant Coding for Anonymisation

Stakeholder	School A	School B
Teacher	AT*X*	BT*X*
Parent	AP*X*	BP*X*
Student	AS*X*	BS*X*

8.4. Teacher Perspectives

The following themes relate to the efficacy of technology and its role in education, as perceived by three teachers at School A (AT1, AT2 and AT3) and 2 teachers at School B (BT1 and BT2). AT1 and BT1 were both science faculty leaders at their respective schools, whereas the other participants were classroom teachers.

8.4.1. Relationships and Partnerships

BT1 noted that there was a definite level of resistance from parents when it came to how the school and individual teachers managed the integration of technology. BT2 said that although she has not personally been met with parental resistance, she has many friends with children in early secondary years who will be arriving home with an iPad or laptop, much to the vexation of their parents. Whilst teachers endeavour to create tasks and activities that utilise ICT in their lessons, often it can present a level of friction when these students then need to continue on using their technology in the home environment, where the educational benefits of using technology might not be as readily apparent to parents. She said, “I think some parents are a little bit in the dark as to how they can monitor what the students are doing at home”. BT2 believed that parents could strive to introduce a range of strategies at home such as turning the Wi-Fi off at a certain time, yet children are increasingly savvy at ways of subverting restrictions, both in and out of school. BT1 felt that the challenge created by students who were perpetually online is one that needed constant review, citing issues that it can present:

> I have known the boys who spend all their night gaming and are dead in the morning, they come to school and sleep all day and they’re back online at night time and the parents are very hamstrung as to know what to do.

AT2 suggested that teachers, regardless of the tools at their disposal, should always be focused on how to maximise student learning outcomes, stating “we’re always looking at ways that we can ensure they learn as much as they can, as efficiently as they can, but not necessarily as quickly. Efficiently means without distraction”. This requires identifying what is necessary and essential, and what is just peripheral noise, and is a pragmatic message he reiterates to parents.

8.4.2. Teacher Perceived Benefits

AT1, as head of science, was a big advocate for ICTs in the classroom and beyond. He said that he loved being able to make a lesson so “multi-modal”, valuing it as a strategy to engage a wide variety of learning styles within the one room, stating “it adds variety to the lesson, you can increase engagement, I would struggle without it". As a proponent of technology integration and its myriad benefits for learning, AT1 stated that it's "hard to imagine" teaching a lesson without it. He used established forms of educational ICTs such as spreadsheets, graphs and word processing software to take notes and disseminate information digitally. Yet, it is the depth of resources offered by the Internet, videos available on sites such as YouTube, and the gamification of learning enabled by sites such as Kahoot! (an online interactive quiz platform), that all contributed to a more enhanced digital learning landscape. AT1 noted that many of his colleagues would use Kahoot! As one of their teaching tools, with the online platform enabling teachers to create personalised quizzes that students can respond to in real time, in a competitive context, and received formative and instant feedback in what Paredes and Chung (2012, p. 34) described as a 'social learning' situation.

For all its pedagogical benefits, AT1 conceded that not every lesson could be equally as engaging and entertaining. He felt that the fight against distraction is one that could never be fully won, and whilst he tried his best to engage all students, there was a curriculum to be taught that might not necessarily resonate with all in his classes. He considered his voice to be one of many that are now competing for student attention. BT1 considered technology to be useful for conveying complex concepts, where visualisations can enhance students' understanding. He found visualisations, models and simulations as useful tools to convey information that would be otherwise impossible without access to ICTs, saying "I think it gives you a much better understanding". Beyond classroom teaching, he found the analytics made available by certain software (such as Education Perfect) a useful way to track and quantify student learning. BT1 contended that making content available to students online not only enables them to work at their own pace, but also provided content to students who needed to extend themselves further. AT2 was a vocal proponent for the ways in which technology could enhance the classroom, but only if it was meaningful and with intended outcomes. He cautioned that using technology without purpose may not necessarily be a bad thing, but that it was just not an educational advantage.

BT2 said of all the technology initiatives she had attempted to introduce over recent years, it is rare that she had then needed to revert to more traditional methods due to ICT failing her, declaring "on the whole, most things that we've implemented, we haven't gone back from". She used the interactive whiteboard to present diagrams and drawings and enjoyed having instant access to resources such as Google Images to provide visual context to her teaching. BT2 said that it is at the teacher's peril to rely solely on technology to facilitate a lesson, as its propensity to fail at crucial points is a risk that can leave the educator at the front of an attentive class without a backup plan. She was grateful for her years of teaching experience prior to the integration of ICT into daily school life, saying "I've had lots of years of teaching in the old days where I've got a few things that I can just suddenly think of off the top of my head". In the face of such issues as Wi-Fi not working or power outages, she advised "you always need to have a Plan B".

8.4.3. Cultural Resistance to Technological Change

As the Head of Faculty, AT1 oversaw the curriculum for all science subjects from Year 7 through to the Year 12 in Victorian Certificate of Education (VCE). Within his faculty were the key disciplines of biology, chemistry and physics, with other smaller fields such as forensics and mechatronics providing a range of areas for students to explore. Whilst many of the science teachers within this faculty were advocates for technology integration, AT1 conceded that any new tool would always be met with a certain level of resistance. He pointed specifically to the introduction of an online portal, where coursework could be disseminated, and formative and summative assessments were recorded for teacher, parent and student access. Several of the parents interviewed considered such analytics as a significant benefit of technology in schools, though AT1 recalled its introduction being met with “huge resistance” by colleagues, saying “they just didn’t want to know about it. All they saw in front of them was work”. He recounted it as being a considerable amount of work to gain the support of teachers within his faculty:

> I had to sell it to them that yes, it is work, but once our units are on there and we’ve got these courses built and there’s resources available, we’ve got this electronic shopfront to the kids. Then I got great traction with staff, but it took a lot of work and it was a lot of show and tell first to get them to that point. I had to get them over that hurdle. Having said that, the younger staff understand, and they were quicker to adapt. Now, they could see it straight away. It was the older staff, some of the more entrenched staff, that were resistant.

BT2 was a teacher with several decades experience, contended that learning how to use new ICTs was hampered by the time available to upskill. However, she found a range of benefits to her teaching and sought to integrate a range of strategies to enhance her practice with technology, stating that it was "enormously useful". This positive approach ultimately contributed to her motivation and she outlined how she enjoyed "trying new things" in her lessons with technology. AT2 also regarded ICTs as useful when enlisted for appropriate purposes but considers that its functions may be limited, declaring that it was a good source of information, but this didn't necessarily enhance the gaining of knowledge.

It should be noted that particular generations were not necessarily responsible for resistance to technological change; however, it is particular mindsets or motivations which were not confined to any specific generation within the teaching profession. The generational divide was not only one that occurred between students and teachers, but within the teaching staff itself. BT1, who declared his age of 54, said "I think anybody who is 50 and over may actually struggle with that whole type of teaching".

At the other end of the teaching experience spectrum to AT2 is AT3, who was in his second year of teaching, albeit relatively new to the classroom, his sentiments regarding the benefits and detriments of ICTs for learning were similar to that of someone who was teaching before he was born.

AT3 believed that technology was beneficial, but to a "finite extent". Beyond it being a rich and detailed resource for information, the ability to visualise learning is something that AT3 believed could enhance understanding in his classroom. Instant feedback provided by online quizzes is one way that he integrated technology to both engage and motivate students to learn. However, he acknowledged that with its benefits came a range of negatives that demanded the teacher regularly monitored the way in which students were using their devices. He described his role of continuously patrolling the classroom and standing behind students as an unfortunate but necessary "prison warden" approach, where students needed to be under constant supervision to ensure that they remained on task when using ICTs. This element of distrust can often be fractious to the teacher-student rapport, yet AT3 contended that it is currently the most logical solution to control the natural response of students to divert their attention to more enticing options on their device.

8.4.4. Perceived Negatives

The variance in teachers' approaches to whether they encouraged the use of the student's device or outright banned its presence from the classroom was often a point of contention amongst students at School B, who observed a lack of consistency from teacher to teacher. With specific application to course content, BT1 asserted that the traditional method of pen and paper was still the more logical solution. With regard to teaching chemistry, he believed developing the skills to write and solve chemical equations manually was crucial. As this was the context under which examinations were completed, he considered it important to teach students how to solve problems without the use of technology.

BT2 declared that School B had a range of ICT policies in place, yet conceded that her colleagues all implemented or adhered to it in their own way. She noted that some teachers might allow students to listen to music, yet if she prohibited it, the precedent set by a fellow colleague may create friction between the students and the more vigilant teacher. BT2 suggested that "we need to keep constantly having a new set of policies that we all try and achieve". The recurring theme amongst all teachers interviewed, from both School A and School B, was that students would always be resistant to any policy that separated them from their personal device, even if the rationale behind said policy was for their academic wellbeing. However, teachers and students alike were in concord that whatever the policy might be, its consistent implementation made classroom management easier for all.

Within the classroom, AT1 contended that the student needs to be constantly monitored to ensure that they were not using their device for non-school related activities. In reality, however, he conceded that this is neither possible nor a logical approach to classroom management. AT1 said that the battle they were constantly "fighting against" was students who wanted to be connected at all times to their personal devices.

AT1 observed that his students were "easily distracted by their device". He specified Year 10, the cohort age that participated in this quantitative quasi-experiment, as a problematic year level when it came to managing technology in the classroom. Year 10 is the last year where science is a compulsory subject for all students, which contributed to a significant variance in student motivation. He considered it a struggle “on a daily basis” for students who have decided they will not be pursuing science, yet still must make it through the year. This placed him in a more adversarial position at times, where he needed to take a more authoritarian approach to maintain the focus and engagement of his students.

AT1 accepted that his sentiment may appear to be encouraging stereotypes yet wondered whether it was boys’ natural propensity to be distracted, and when parents lamented to him that they can’t get their sons to focus, he often felt the same way when trying to teach them. BT1 also believed that there is a turning point around the Year 10 mark. He said that there is a strong emphasis on integrating ICT in Years 7 to 10; however, this shifted towards more traditional methods as students approached their final years of secondary schooling. He equated this to the strong focus in Year 11 and 12 on examination preparation, which was still completed without any technology, as handwriting skills were still essential to the examination process.

8.4.5. Teacher Integration

AT1 believed that all teachers approached technology integration in their own way, and with this came a range of classroom procedures and expectations implemented by the individual. In his own classroom, he required all laptops to be closed whenever he was delivering direct instruction. If laptops were required whilst he was actively teaching, he would make sure to physically roam around the room and observe how many students would scramble to swipe away whatever inappropriate content was on their screen before it fell into their teacher’s view. AT1 conceded that teaching from the back of the classroom is a strategy that has its benefits but may also be unfair to the diligent student up the front who doesn't need to be so closely monitored from behind.

AT2 was a veteran teacher of boys who had seen the school he worked at change dramatically over four decades. However, the fundamental goals of filing students through a timetabled day, with the primary purpose of disseminating information to students who will be asked to recall said information at a later date and have their attainment quantified with tests, had remained much the same. AT2 contended that technology was just another "reference source", akin to how students once upon a time would access the library for materials and information to support their learning. However, he believed that having access to more information did not necessarily suggest that it was a solution to what he described as a "learning crisis". The crisis AT2 referred to was the multitude of distractions posed by technology that he believed were impediments to understanding the lesson content he was delivering, stating "the distraction comes in the fact that technology provides other sources of distraction, whether it be for amusement's sake or simply to provide music, games or simply for students who access the news". BT1 contended that girls may not be as predisposed to gaming as boys, suggesting that their distraction came more from videos and social media engagement. Although students were encouraged to take ownership of their own learning, AT2 suggested that it was incumbent upon the classroom teacher to institute rules and strategies where the individual adolescent might not have the ability to self-regulate their own behaviour with technology. His approach is one where he would immediately tell students to put their devices away when he entered the room, and they may only return to them when invited to do so. AT2 rationalised his approach by saying that it minimised the time wasted on monitoring and controlling distractions.

Generational divides can often dictate the level of resistance or understanding that individuals come to technology with (Kim et al., 2018; Van Volkom et al., 2014), and BT1, who is 54 years old, reflected on how his own position has been no different:

> I didn't have a childhood that was associated with technology and so I had to move through with it and evolve with it. I could imagine that parents of younger generations would have a bit more of an idea because they have gone through it themselves.

BT1 had taught science for several decades and lead the science faculty at School B. He purported a range of benefits to using ICT within the classroom. The ability to use animations or videos to help students "visualise" certain aspects of the curriculum is something he considered to be valuable, as it provided a "much better understanding" compared to any content delivered in the absence of such digital alternatives. Beyond the multimedia offerings enabled by ICTs, BT1 contended that platforms that enhanced assessment and feedback procedures were also a useful component of technology in the classroom. He was able to access software online that provided insights into how regularly students were checking content. He noted that the additional learning materials provided to students through online portals were usually frequented most by those who were striving to excel in a particular subject. As a learning leader, he did not mandate his teachers to integrate ICTs into their teaching programs; however, he did acknowledge that there was a lack of consistency and uptake from teacher to teacher. In his role, he was tasked with organising over a decade's worth of files that had accumulated over the years, from a range of different teachers. He observed how searching through this digital repository of resources (including assessment tools, documents, animations, videos, links, diagrams, etc.) reflected a broad range of ways in which teachers had created resources and used ICT in a variety of ways. As his school moved to a new platform, his challenge was to determine what digital content was relevant and what could be removed from contemporary teaching practices, just in the same way that traditional resources such as textbooks and tools are periodically phased out from the curriculum. BT1 said it is a matter of "picking through" all the content out there to determine what might actually be of educational benefit and he considered it a challenge for all teachers to identify where technology is either a hindrance or a help.

As far as the management of technology and the potential distraction it brings his students, he observes that by Year 10, the majority of his students have developed a mature approach towards their devices and can exhibit an ability to eliminate distractions and focus on their work. He classified the way that students interacted with technology as "age specific" and that the younger years had greater difficulty in managing their screen time effectively. With regard to specific hardware use, BT1 said that his school had gone through an "evolution, not revolution" where iPads were once prescribed, yet now students were reverting to more conventional laptops over tablet devices, due to their processing power and capacity to run a broader range of educational applications. Yet "balance" is what BT1 denoted as key to any program that asked students to bring their own device. He said that he can do just about everything on his smartphone yet acknowledges that with smartphones came all of the non-school related apps that interrupted the students' focus.

8.4.6. Classroom Control

AT2 said that whether he walked around the room or not, some students would always be off task. Prior to the introduction of devices in the classroom, this was still a classroom management issue for teachers. The only difference now was the allure of content beyond that of the textbook or exercise book was far more enticing than it once was. AT3 said that screen monitoring software is a worthy consideration for classroom management, in order to hold students on their devices to account. However, he suggested that fostering an ability to self-regulate was still critical in an age where technology was embedded into the learning process. He found this atmosphere of "distrust" an ongoing battle, where he had to intervene to stop his students following their "natural instinct" to become distracted by their devices.

This ongoing battle, or tension, between adult and child, was one that was highlighted by multiple participants. AT1 admitted "it's hard to police because sometimes it can be hard to know whether they're on task or not. I think that's what I find the biggest challenge, the constant not knowing if that kid is on task or not". He did not go to the extent of confiscating laptops or tablets, yet took a far harder line when it came to mobile phones in the classroom, saying “if I see a phone, bang it’s gone. I don’t allow phones, not for a split second”.

AT1 suggested that positive strategies could address the distraction that came from devices, such as his faculty’s “teach me again” initiative. This is where teachers had begun to make short (two to three minute) videos of complex content that the students could view in their own time and at their own pace. AT1 was a proponent of the school’s learning management system (LMS), which provided an online portal to disseminate lesson content to students and parents. Therefore, for the student who may have become distracted whilst the content was originally being taught, the opportunity to revisit key learning details in their own time was considered truly beneficial. AT1 was proud to report that he had been “getting incredibly positive feedback from the boys on how useful that’s been, particularly from the weaker boys”. He recounted students emphatically praising these video lessons, with one saying, “they’re great because you can play it over and over again until you get it”. AT1 noted that some students admit to “zoning out” during a lesson, so they appreciated the opportunity to revisit content at their own pace.

The word “battle” recurred from a range of teachers and parents, outlining the ongoing tension they faced when it came to managing technology for learning. BT2 allowed the use of devices within her classroom but conceded that they could be a hindrance. She said “by the time they’ve chosen their playlist to listen to and checked their emails and maybe looked up few YouTube clips or something…it’s a constant battle to return them to task”. She explained that she found the ongoing management “time consuming and it takes away from the flow of the lesson”. When BT2 made attempts to control the use of devices within her classroom, she was often met with resistance from her students, stating “if I say shut that screen, it’s actually slanted down to about a thirty-degree angle and it can easily be just lifted up a little, but the phones are on their lap”. Her understanding of School B’s policy is that phones should be turned off or on silent, yet conceded that this is close to impossible to police unless a ringing phone gave the game away. BT2 noted that resistance often came from students who cited other teachers’ technology rules and the inconsistency from one to the next created a point of tension. She felt that “a bit more of school policy” would alleviate the ongoing discrepancies for both student and teacher alike.

8.4.7. Digital Literacy

A recurring theme identified by teachers was establishing what it meant to be digitally literate in the contemporary classroom. Often an adolescent’s capacity to adapt to changing technologies for recreation, with both hardware and software, was not commensurate with how they used ICTs for educational purposes. Therefore, a child who is adept at a particular video game or spends significant time curating their social media did not necessarily have skills developed through these platforms that automatically translated to learning purposes. Beyond the basic functions and essential procedures that required understanding, AT3 suggested that teaching students skills and strategies to manage the distractive allure of their device was key to digital literacy.

When asked about the explicit teaching of digital literacy, AT1 contended that part of teaching in an age where personal devices are ubiquitous was the skill of self-regulation. BT1 was in agreeance when asked whether there should be programs introduced into schools to address the ability to focus and self-regulate. He felt that a student's ability to focus was "age specific" and that there was a discernible shift in how his female students were able to self-regulate, depending on their maturity. BT2 endeavoured to educate her students in how to best manage their devices, wanting them to "to regulate the use and try to keep their minds on one thing at a time in particular and the value of that". AT1 acknowledged that it could be difficult to teach strategies that might seem as "obvious", but even outlining how to turn off notifications and close irrelevant content sometimes needed to be explicitly taught. AT1 was not without empathy when it came to the students' need for digital connectivity, declaring "my personal opinion is they feel their day is richer with it turned on and that's what we fight against".

8.4.8. Quasi-experiment Reflection

Regarding the quantitative quasi-experiment, AT1 found it an elucidating process to understand how much content can be contained within such a short video. He stated, "when these videos are being used as a teaching tool, it's important that the teacher using them has really taken the time to dissect the video piece by piece". The quasi-experiment made him consider his own teaching practice, which often was to refer students to a YouTube video without closely evaluating the amount of content covered within the short clip. Upon reflection, he observed flaws in this approach, noting how many students would need to see a video four to five times before they were able to adequately process the content delivered at full speed. He said “it’s definitely made me think carefully about the way we use those videos and how much content they deliver and how important it is to clarify that content and not just say – here’s the video, good luck with that”.

AT1 said that it was challenging to create three videos for the quasi-experiment that were equitable in content and difficulty. He also noted that the level of engagement from some students may have hindered their academic approach to the quasi-experiment, observing “I think some boys weren’t convinced about the test being part of their course and therefore possibly treated the task with less genuine engagement than they probably needed to take on”. AT1 believed that some students felt that the data collection were an “imposition on normal learning” and it was a challenge to create a fully naturalistic quasi-experiment in the face of the multitude of paperwork and consent forms that preceded the actual quasi-experiment. AT1 considered students with accomplished handwriting skills, specific to fast note-taking, were at a distinct advantage during the quantitative quasi-experiment. Conversely, when the quasi-experiment allowed for notes to be typed, those who were more proficient with the keyboard were then at an advantage. He suggested that the speed of note-taking may have had some impact on students’ test results.

BT1 expressed surprise regarding the resistance that the quasi-experiment was met with at School B, regardless of him communicating the rationale, the assurances of anonymisation, and promoting the benefits that the research would have. He said that all present students completed the tests, yet the difficulty came in retrieving the consent and assent forms from students who were concerned about how their data would be used. BT2 observed a "negative vibe" from many of her students who were hesitant to return their assent forms, noting considerable resistance in her two classes. She also noted that had the quasi-experiment been for a longer period of time, the data may have revealed greater challenges in staying on task, yet found that her students were able to apply themselves adequately within the quasi-experiment's constraints. Veteran educator AT2 believed that student participants would have been capable with the pen and paper condition, irrespective of the teacher's presence or surveillance during the task, observing "it was fairly clear to me that they were more comfortable with pen and paper".

8.5. Parent Perspectives

The following themes relate to the efficacy of technology and its role in education, as perceived by four parents of students at School A (AP1, AP2, AP3 and AP4) and one participant who was a parent of students at both School A and School B (BP1).

8.5.1. Perceived Benefits

AP4 was emphatic in how valuable she found technology and its role in education, asserting that she was most certainly not "anti-technology" and considered its accessibility to have immense benefits. She compared her own experience as a student several decades prior to that of her son, reflecting on the access to a relatively broad range of resources and how she would be able to look up information via indexes with tools such as a microfiche (thin photographic film that preserves books, newspapers, magazines on a negative in a condensed format). Now her son could use advanced search techniques on the Internet to pinpoint precise information that enabled a depth of information to be accessed that was previously impossible.

AP4 believed that technology not only enabled, but encouraged, students to revisit content that they required further clarification on. This self-paced learning was facilitated by students retrieving media content that could be accessed and replayed without the teacher having to reiterate the information. Enabling the individual to return to complex concepts in a lesson was something that AP4 saw as a meaningful benefit for her children's learning. She contended that the onus for creating this content was on the classroom teacher, as not all students would learn what they were teaching at the same pace.

AP2 also considered technology to be "amazing" in the way it opened up a wealth of information to her children. She considered the interactivity, enhanced presentations with 3D models and animations, and increasingly powerful digital devices all positive ways in which children could be engaged, especially for more visual learners. AP1's views were similar, noting that it had a role to play, as long as it was being used to "access the right information" and that the onus should be on teachers to show the students how to achieve this. By educating students in how to identify reliable sources of information from a young age, she contended that it would be a skill that would help them navigate the seemingly endless trove of information available online.

At School B, BP1's understanding of technology's role in the classroom was less enthusiastic. As a mother of three, she declared that her children all obtain varying results, so it was difficult to attribute the benefits or detriments to ICT integration. She conceded that her son's ability to type his work, in lieu of his poor handwriting, was a tangible benefit. Yet, she acknowledged that this may not necessarily be a long-term benefit, with formal examinations requiring handwriting skills for the foreseeable future. She had observed the challenge her son faced, where he often could verbally communicate complex concepts, yet would struggle to translate that into handwriting. Therefore, technology provided him with a voice that otherwise would be restricted by more traditional writing methods, with BP1 saying it can be a "physical thing holding students back".

Regarding the role of classroom technologies, AP3 was at the other end of the spectrum on parental perspectives, declaring "I don't think it's useful, not the way they're currently using it". She acknowledged the great capabilities of technology, yet considered it more a distractor than a positive if its mere function was to replace books. As someone that used technology throughout her own working day, she was all too aware of the attention economy (Crogan & Kinsley, 2012) that her children could easily fall prey to. She said she believed that her children were susceptible to distraction and straying from the task at hand from the moment they opened their laptop or turned to their device. Beyond the novelty of technology, BP1 contended that its integration must be both purposeful and meaningful if it is not to become just another distraction. She argued that the power of technology should enhance differentiated learning, where the individual can take ownership of their own learning and use technology to help pace them through content at a different rate to peers that may advance at different speeds.

When an individual used technology in specific ways, BP1 believed that the power of analytics and assessment should enable learning deficits to be identified in ways that a teacher may never be able to isolate on their own. She said it should "be able to pick up things that teachers simply couldn't…where a child is making the same mistake, but the teacher can't constantly watch that child over and over". BP1 considered the online portal, where her son's academic results were published, as a useful digital tool to keep parents informed with ongoing feedback and data points, beyond the feedback reports. She did note, however, that her son was usually honest and upfront about his grades, so the portal primarily acted as a supplement to information her son readily disclosed.

8.5.2. Perceived Negatives

Amongst parental opinion, a range of concerns regarding technology and the challenges it presented for their children, both at school and at home were identified. Parents varied in their own use of technology and the role it played in their own lives, which possibly contributed to how beneficial they saw its place in the lives of their children.

AP3 described the "incessant need to multitask" as the most notable hindrance that technology had on her children's learning. She felt the way that applications were designed to divide attention and distract was a serious issue and she encouraged her children to eliminate distractions if they were undertaking schoolwork. Empathising with the challenge that this presented for the classroom teacher, she perceived managing technology and teenagers en masse as a “lost battle”. This was a turn of phrase that recurred from the perspectives of teachers, parents and students alike. AP4 explained this “lost battle”, saying:

> I guess I’ve assumed the school doesn’t allow them to do other things but how on earth do you monitor it? I know the phones have to be in the lockers, but I don’t know how many people actually do that.

AP3 felt that her children’s own perceptions of their ability to multitask was misguided and she was cognisant of evidence that suggested that multitasking was not an inherent skill of the digital native. She regarded the constant need for “instant gratification” as detrimental to their focus and saw why they might struggle to remain on task in a classroom filled with technology. AP3 felt there was an urgent need for greater education and awareness relating to the challenges that came with ubiquitous technology and the role it plays in children’s lives, stating “I think kids need to see the impact of what multitasking really is because they just have this invincible attitude that they can do it all and they just don’t get it”. Her concerns also encompassed other implications, such as sleep and social behaviour, which she believed her sons would take more notice of if there were “more voices” involved in the conversation.

AP1 declared that it was challenging as a parent to know when her children were using their device for schoolwork, and when it was for entertainment. She felt that the ability to switch from one task to another so rapidly would often dilute the efficacy of the task at hand. She found that the Internet's ubiquitous nature and constant connectivity made it "hard to get off" once online, as there was so much to draw one into the online world. The reliance on the Internet to answer all questions was a concern raised, where AP1 believed that delving into a deeper level of critical thinking could be hindered by finding easy answers online.

BP1 was adamant technology brought with it a range of challenges that could be detrimental to learning. Her main concern, as was a recurring theme amongst interviewed teachers, parents and students, was distraction. Not only could a student be running multiple programs at a time, but she believed the notifications that came with this could significantly hinder her children's ability to focus. In solidarity with teachers, she admitted that she didn't know how someone at the front of the classroom could compete with a room full of teenagers who were engaged with devices that presented such distractions, outlining her concern "the addictive nature of technology bothers me because I feel like that detracts from their learning, as well outside of times where they're not focused on homework, specifically where they could be doing something really creative".

8.5.3. Technology in the Home and Parental Guidance

There was a considerable amount of variation in the way parents managed their children's technology in the home. Whereas some would operate on a foundation of trust, other households implemented more specific rules in the home and expectations placed upon their children. Throughout the interview process, parents discussed a range of ways in which trust was established in the home and how with increased trust came more freedom for their child to use their technology freely, on the assumption it would be done so responsibly.

AP1 conceded how difficult it must be for her son to use the same device for both education and recreation and to know when was appropriate to switch between the two modes. She said that as parents it’s “hard to know” when their child was learning or gaming, unless they were under direct supervision. BP1 considered her children’s reliance on technology as an ongoing point of conflict, describing it as “a constant war”. She said that she has “quite strict rules at home” and explains what is enforced:

> We have no technology Monday to Thursday other than for homework. That’s the rule. That’s not actually what happens but there’s no TV, there’s no PS4 either Monday to Thursday. And people who do do it, I don’t know how they fit it in because their week is so full as it is. The older they get, the more that becomes loose, but as a general rule that’s it. I’ve also got a technology box that I just recently bought so phones are taken downstairs and are off by 9 o’clock at the latest. They’re downstairs, the kids sleep upstairs. I’ve got a box now that I can actually lock the devices into because I was finding they were slithering down.

BP1 admitted that her strict technology rules are both the product of being reactive and trying to be proactive in the ever-evolving technological landscape. She acknowledged that her approach may be stricter than others, conceding “I do find that a lot of other kids do tend to have freer rein with their phone than my kids do at home”. Her control was relinquished when her children stayed with other families and she attributed the challenges at home to the different approaches they’re subjected to outside of the home, stating:

> You can have one set of rules, the school has one set of rules, but then if other people within the community or within their social network are not supporting those rules then it becomes that contradicting situation. I think that’s why the kids keep pushing the boundaries, because there’s not that consistency being met by the whole community.

She considered that coming from a teaching background had encouraged her to keep abreast of articles and commentary on how to parent and educate in the digital age. Although she did not consider her children to be necessarily rebellious or defiant, she conceded that the allure of their devices could often override the expectations she tried to enforce.

BP1 had looked to adapt these boundaries to the needs of each of her children, noting that with her eldest in Year 10, it was about having a conversation and hoping that a level of maturity could influence her daughter’s ability to moderate her technology use. Ultimately, she considered it to be about balance and, pragmatically, she felt that if balance could not be achieved, then her intervention is warranted, declaring:

> There's a time for play, there's a time for rest, there's a time for work and working it out herself as to when those times are. I'm happy to leave her to work it out but if I see that that's not happening, I'm not going to be paying the school fees that I'm paying here to have that time just wasted.

As a mother of two teenage boys, AP1 insisted upon "downtime" as an essential part of her sons' routine. She believed that they needed time to decompress upon arriving home from school, where the intense and frenetic nature of that environment can begin to drain the individual if they're not given opportunities to "get back into home mode". Many conversations with child psychologists led AP1 to this approach, as she acknowledged that bombarding her children with responsibility immediately upon their return home sent the wrong message. She imparted her advice, saying:

> Don't hassle too much, I think sometimes parents can pick the wrong fights with kids. Battering them as soon as they walk in the door does not work as they need to have technology, which is part of their world and I would never stop them because I know when they talk about Instagram and YouTube, it's their way of talking about things on trend. It's not only seeing what's happening on technology but knowing that the information is actually very social.

At certain times, AP1 actively encouraged her sons to engage with their technology so that they could “get it out of their system” before attending to their homework. AP1 believed maintaining an open dialogue in her family around technology and the issues it presents was key. With more contentious topics such as online pornography, she argued that it is better to talk about it than to “push it under the table” as knowing her children’s perspective or gauging their level of understanding over these complex topics helped inform her parenting. She believed that simply assuming schools would cover all these issues could lead to gaps. Conveniently, though not intentionally, the Wi-Fi didn’t reach her sons’ bedrooms, which AP1 found advantageous at homework time. She dispelled the often made comparison to the television entering the home and changing the family dynamic. With this “complex technology”, AP1 observed that there was so much more that people could do with it, so it required “a rule book and a strong basis of what it is and how to manage it”. She acknowledged that her children’s generation had a very different entertainment diet to that of her own childhood. Reflecting on her son’s use of screen time at home, she conceded that “the way they relax with technology is not what we used to do and we do it too, we’re learning quick, but they are the masters”.

A recurring theme regarding homework between various parents was centralising where their children completed their work, ensuring that it was in a common area under the passive supervision of the parent. Due to an acknowledgement that their children would struggle to self-regulate if left literally to their own devices, the need to have their children work where they could be seen was an important strategy. AP1 used to use an app that monitored screen time and blocked access to specific sites, yet has since relaxed her control over such particulars at home. She had abandoned the software after noticing that the increased maturity in her sons brought with it a greater capacity to self-regulate. Therefore, imposing such restrictions was no longer a necessary, or appropriate, approach in her home.

AP4 said that a recent move to a new home meant that her children had convenient desk spaces in their rooms to complete homework without direct supervision. Yet, an inability to exercise adequate self-regulation without supervision had led to her children once again working at the family dining table to ensure they remained on task. She conceded that it was not well received, but insisted that all technology remained downstairs overnight as a necessary measure at home. AP4 reflected upon how different her son was when his smartphone was taken away on a recent family holiday. She observed that otherwise "he would have his phone attached to his body 24 hours a day". After an initial point of friction, her son became more present and engaged with his family on holiday. Of her son, she said "I think he has very little capacity to self-regulate and it's just so addictive" and outlined her rationale for the confiscation as an intervention necessary to control his use. AP4 also discussed a range of perils presented by technology with her son, such as pornography and what is and isn't appropriate to post to social media, believing open conversation to be instrumental to effectively managing technology in the home.

AP3 said that having a household with five children presented space and noise issues that led to certain concessions being made. She too was an advocate for a trust-based approach, saying that having all her children working in the same family space wouldn't be feasible, so therefore had to trust that they could work independently in their own bedrooms without direct supervision.

AP2's approach also varied between her sons. She observed that her youngest had not yet developed an interest in his smartphone or the need to use it heavily. However, she would confiscate her older son's smartphone during homework time to ensure he remained on task. Additionally, she would not allow phones in the bedroom overnight as they would need to be left to charge in the kitchen. As this had been the household rule from the beginning, AP2 noted that she had been met with minimal resistance from her children. She considered her sons to be both mature and responsible and consequently did not feel compelled to take such drastic measures as turning off the Wi-Fi.

Parents shared a variety of challenges with how to manage technology within their own households. Factors such as having children at different life stages and levels of maturity, children who interacted with technology in vastly different ways, and how to model appropriate use, were all points of contention. With regard to modelling appropriate use, some parents found this more difficult than others. AP2 declared that she was not a particularly avid user of technology and so the barrier between her and her children was trying to understand how they could possibly spend so much time fixated on their

screens. She said that banning smartphones at the dinner table was an important rule which also applied to her husband and his smartphone.
AP2 said that she was connected with her son on Facebook as an "invisible friend", which enabled her to monitor his online activity to a certain extent. BP1 admitted to taking a more invasive approach to monitoring her children's social media accounts:

> They know that they can have a spot check any time, but I've also got their account passwords and I've got both their Instagram accounts on my phone. But they don't put anything on Instagram anymore, it's all Snapchat now which is a lot harder to monitor.

BP1's extreme approach to monitoring her children's behaviour brought with it a range of technical difficulties, especially with Snapchat, which did not retain exchanges between two accounts unless messages were purposively saved. She conceded that the ephemeral nature of the platform forced her to relinquish some control over how her children used their devices, yet tries her best to monitor its use. She would undertake "spot checks" where she would ask her children to unlock their phones and allow her to look through the content on their personal devices. She was vehemently opposed to the disappearing content, saying "Snapchat really bothers me because you can't just go through and see what they've been doing".

AP3 adapted her expectations from her older son to her younger son, having learnt a range of approaches throughout his early teenage years. She contended that the management of technology in the home did not necessarily lend itself to blanket rules, as much of how her children interacted with their devices was "personality based". One of her sons was much more game oriented, whilst the other spent his time on social media. Therefore, the conversations she had with each of her sons was sensitive to their individual behaviours and digital diets. With her eldest, she reflected upon how strict she was up until he reached Year 10, and how this was an ongoing source of conflict within the home. She felt that a "history of addictive behaviour" in her family lead her to not only being vigilant, but perhaps too restrictive on her son, acknowledging that she had to relinquish a certain level of control for trust and responsible use to be established.

8.5.4. Parents Modelling Behaviour

BP1 felt that modelling responsible behaviour at home was challenging with both parents working in the technology industry. She considered setting an appropriate example as important, yet in reality it did not happen. Of her partner she said "he's a terrible role model as he's on his phone permanently. He's on the phone from six o'clock in the morning and through till late at night, through dinner time and I think we're all guilty of bad phone use". AP4 was not a heavy phone user, nor was her husband, so found modelling behaviour at home to be quite manageable. She did insist upon no phones at meal times, which her entire family managed to adhere to, stating that "I hate the way it interferes with things like that".

AP3 maintained rules around the tenet of respect, which included no phones after school, at the dinner table, and notably in the car. She considered the car as a space where she could converse with her children and felt that they can be missed opportunities to engage with her children if their heads are in their screens. Between her and her husband, they endeavoured to use their own technology in a similar way to what they would expect of their children. AP3 said “we’re trying to role model the right behaviour because they all go more on what you do than what you say to do”.

BP1 acknowledged that trying to learn with technology would present inevitable challenges that did not exist with more traditional learning materials such as books. Whereas a book was in a static state of information, the screen of the smartphone, tablet or laptop could be filled with a multitude of content unrelated to the task at hand. She conceded that the allure of technology was not just one that permeated the world of the adolescent, but was far more widespread to other generations. Indeed, modelling appropriate behaviour presented a challenge for some parents who were just as susceptible to the addictive nature of their own technology.

8.5.5. Partnership with School

Parents found that conversations around technology use and the enforcement of rules at home were most effective when supported by the school’s approach to devices.

BP1 said that the physical restrictions of handwriting were a concern she held for her youngest son who was due to enter secondary school. Of her son, she said “their mind is actually working brilliantly” yet felt that his incredibly poor handwriting would restrict his ability to communicate his true understanding of concepts. She was cognisant of the fact that he would need to develop his handwriting to adequately address the demands of examinations, which were largely done by more traditional methods. She observed that students with learning difficulties faced a range of challenges in the classroom, highlighting how a one-size-fits-all approach to ICT integration may benefit some, whilst being detrimental to others.

AP3 was pleased when her son's school changed their BYOD (bring your own device) policy away from the iPad, citing it as "the best decision they've made". She felt that the tablet device was oriented more towards gaming, which made it difficult for her son to delineate between schoolwork and recreation. Although the tablet may have offered affordability, portability and convenience, AP3 found her son always had to access a computer if he was working on more substantial assignments. She considered that technology had the potential to be a "massive missed opportunity" by schools if they did not adequately consider how to implement it effectively into lessons. With schools quick to mandate technology use and constantly striving to appear innovative with emerging digital devices, AP3 believed that there needed to be more evidence, as well as conversations between school and home, to address the gaps in understanding ICT's role in education.

BP1 was a unique interview participant in that she had a son at School A and a daughter at School B. This provided her with the ability to compare and contrast the approaches that the different schools took to technology management and policy. With regard to the communication between school and home, she considered it to be a valuable part of the education relationship, as this was information that informed the way she managed her children's devices at home. BP1 found it a significant challenge in the home to deal with children who attended different schools and were consequently subjected to notably different technology policies. She considered the relaxed nature of her daughter's school contrasted considerably to that of her son's school, where the use of technology was closely monitored and disciplinary sanctions were consistently enforced for those who failed to meet expectations.

AP1 found a seminar facilitated by her son's school to be a useful way to develop understanding from her children's perspective. As opposed to viewing technology as a dangerous or harmful tool to adolescent development, starting an open and honest conversation about the trials and tribulations of the digital age was far more beneficial to her parenting. AP1 considered empowering young people to engage with technology in a mature and responsible way was important. With regard to the school's responsibility, she didn't think an explicit "rule book" was necessary, but if a school was to mandate the use of technology, it should come with "clear parameters with what it can do and how it can be useful". AP2 felt that her son's school approached responsible use really well, regarding the ICT contract that students were required to commit to as a "really good framework for things we might have to talk about" and it enabled parents to steer discussions that are supported by the school's own policy on technology use. She suggested that her son found some of the expectations "unrealistic" and attributed it to those who wrote the policy having distinctly different technology diets to that of the children it was enforced upon.

BP1 found the approach of her daughter's school as a point of conflict at home, as it was considerably different to that of her son's school. She felt that the lack of consistency had the propensity to lead individuals to "keep pushing boundaries", as the boundaries could often be blurred when policy was not uniformly enforced. Whether it was the expectations that different teachers placed on their students, or even when her children visited friends' homes, each new scenario created different guidelines on what constituted appropriate technology use.

AP4 believed that more answers were needed in a world where technology permeated daily life. She said that it was a concern for her children and a topic that was regularly discussed with other parents who were always looking for the most appropriate strategy to manage their children's digital diet:

> I think that everybody's latched onto the technology and think you have to go forward with it…I think this research is fantastic and that it absolutely needs to be done because everyone has adopted all this technology without knowing what the adverse consequences are.

8.6. Student Perspectives

The following themes relate to the efficacy of technology and its role in education, as perceived by seven male students at School A (AS1, AS2, AS3, AS4, AS5, AS6 and AS7) and six female students at School B (BS1, BS2, BS3, BS4, BS5 and BS6). All students were between 15-16 years of age and had completed all three tests as part of the quantitative quasi-experiment.

8.6.1. Classroom Use

BS5 admitted that the school policy advised students should not use their smartphones in class; however, due to the individual teacher's leniency and personal discretion, this policy was usually not strictly enforced. AS6 said that something as simple as how actively the teacher moved around the classroom would determine what level of productivity the overall classroom would be operating at. As many of the student participants conceded, their ability to self-regulate and eliminate distractions was one of their greatest challenges. Therefore, if a teacher remained static at their desk, whilst row after row of laptop screens faced away from the teacher's vision, students were more inclined to deviate from the learning objectives due to their behaviour being unmoderated by the teacher. AS6 suggested that for focus to be maintained, the teacher would need to be "constantly active" in patrolling the classroom. Yet, for the teacher on patrol, constantly roaming around to observe what students were doing could undermine the level of trust that is considered to be so crucial to the teacher/student relationship (Lee, 2007). Regardless of the teacher's propensity to roam, AS6 outlined that their efforts may be in vain, due to the swiftness with which a student can swipe their device to present a screen that, for all intents and purposes, makes the student appear to be working productively.

As soon as a teacher had moved on to another area of the room, a swift swipe by the student would return them to whatever activity they were engaged in prior to the teacher's patrol. Some teachers took a more militant, or zero tolerance, approach to technology in the classroom. This meant that students were not to access their devices and must rely on more traditional methods such as pen and paper resources. In such a class, even if the student did not find themselves either disengaged or unmotivated by the lesson, they did not have the option to mentally escape the room via their device.

BS1 considered technology as a useful tool to get work completed more efficiently, pragmatically stating "in the classroom, it gets things done a lot quicker. It's quite easy to use, you just pick it up and whip it out". She conceded that without technology she would be far more disorganised, whereas her device enabled her to access all her learning materials efficiently and without the fear of having lost a worksheet or leaving something at home, lest she leave her iPad behind.

8.7. Motivation

The tests within the quantitative measure related specifically to the science curriculum and the degree to which students were intrinsically motivated by the content of the curriculum, and more specifically the tests conducted, may have implications for the research. Students may have struggled to perform on the three tests, regardless of the levels of technology integration, due to an absence of intrinsic motivation to focus on the content being delivered. As the classroom conditions for all three tests was tightly controlled to eliminate confounding variables as much as possible, this level of firmly managed classroom conditions may have impacted students' levels of motivation. Although secondary school students should be familiar with test conditions as par for the course in the formative assessment schedule of learning, the preamble to these tests (consent forms, information sheets, briefing, etc) may have framed their perception of how their test results would be used beyond that as an assessment tool for the reporting and feedback of their classroom teacher.

8.7.1. Self-Regulation

Managing the distractive qualities of ICT presented one of the most prevalent issues for students. The way in which students approached this concern was wide-ranging, with a variety of strategies being enlisted to aid in the onerous task of self-regulation.

AS3 stated that the easiest way to delineate between using his devices for school and then recreation was to see his laptop and his mobile phone as separate entities with separate functions. Whereas his laptop was a device used throughout the school day for note-taking, research, communicating with teachers and peers, his mobile phone was never a tool enlisted in the learning process. As he kept his mobile phone off his person and secured in a locker at all times whilst at school, he was able to eliminate the distraction that came from a relentless barrage of inwards communication. Storing his smartphone in his locker was a conscious decision as he was self-aware to the extent that having his smartphone in his pocket, whilst in class, would be a temptation too challenging to resist. When at home, he would ensure that his smartphone was in another room, or not within reach, as he completed his homework. This would once again eliminate the allure of checking a device that would deviate his focus from the learning objectives at hand. The separation between devices for different purposes was an effective strategy to maintain focus and then reward oneself after a school task had been completed with other applications such as gaming and social media, which were less accessible on his laptop. As he progressed through to senior years of secondary school, he acknowledged that such strategies would become increasingly vital to his academic success, stating:

> I think with the increased workload, I'd probably want more breaks, but if I keep the same approach…with removing my phone and stuff to be able to still concentrate, I feel like I would still be able to manage it.

Some students, who do not separate the purpose of their device from education to recreation, found it a significant challenge to eliminate distractions. BS6 said that the most difficult place to focus on her work was at home. This was because, as opposed to school where social media as blocked, at home she had unrestricted access and free reign to access the sites and content that had been prohibited throughout the school day. She said that she needed to enlist the help of others at home to ensure her focus could be both enforced and maintained during periods of study.

> At home obviously it's not blocked so that's what I find the biggest distraction and especially at exam time I find…even if it's ten minutes I'll just check it and then I'm there for an hour on my phone and I don't even notice it. I haven't really figured out a way to get myself to stop doing that. I'll try and like throw it over the side of the room to

eliminate it, but I've got my mum to take it off me sometimes until I finish studying.

8.7.2. Notifications

Many students declared a range of personal concerns encountered when they became separated from their device. Whether their smartphone was confiscated by a teacher or parent, or simply because school policy restricted the use of a personal device during class time, students encountered multiple circumstances where they were prohibited from using their technology.

AS2 said that whenever his smartphone was confiscated he felt "bare, like I don't have anything to do". He admitted that even if he took the approach of leaving his smartphone in another room whilst working at home, he would still be thinking about it and could usually last no longer than half an hour before checking to see what he may have missed during his brief digital hiatus. AS4 shared a similar sentiment, where he attempted to turn off all notifications, yet sometimes just couldn't deal with the feeling of being so disconnected. He believed he was capable of going without his smartphone for three hours, yet still considered it an imposition, if not a violation of his personal rights, if someone attempted to confiscate his device.

BS2 said that social media, games, or "anything you can get notifications from" became a distraction in class. She usually took her smartphone to class; however, would usually have it turned off and stored in her pencil case. She saw this as the most effective way to eliminate the bombardment of notifications that she would otherwise receive if she were to leave her personal device turned on. AS5 said that he could go the entire school day without checking notifications on his smartphone, yet sometimes would check up on things at recess or lunch if there was something happening in particular that required his attention.

BS5 had the prospect of distraction from apps such as Snapchat and Instagram removed by the simple fact that her smartphone phone did not have the capability to run these apps. Her *dumb phone*, a phrase that had been used to describe the inverse of a smartphone (Heid, 2018), where the tech capabilities are significantly diminished, prevented her from engaging with social media on her device. She considered this to be an advantage whilst at school, as it meant there was no risk of distraction from her smartphone phone; however, outside of school she saw the lack of functionality in her smartphone phone as a social disadvantage.

AS2 took specific steps to try and avoid notifications when using his device. For this reason, he used a separate Internet browser for school than he did for recreation. This was due to the fact that opening Google Chrome at school would enable Facebook notifications and so forth, which proved hard to ignore. If, however, he used Safari (another web browser) at school, he could proceed with his work uninterrupted by such pop-ups. He said that his iPad, iPhone and Mac laptop were all linked, which meant that any notifications that came through to his tablet and smartphone would also interrupt his laptop work. Therefore, he needed to make a conscious decision to shut down some of his portable devices to limit what notifications could interrupt his workflow. This required him to put his smartphone into airplane mode and to shut down his iPad temporarily.

8.7.3. Organisation and Note-Taking

Pragmatically, AS1 found that using technology enabled him to produce neater work, which helped him decipher his notes in the long-term. He considered the school's online portal to be useful, to a certain extent, but found accessing it could lead to distractions that pen and paper did not offer. AS1 felt at ease with his teacher's management of technology in the classroom and said he felt no resistance or frustration towards moments when teachers would ask the class to put away their technology (laptops and tablets) altogether, conceding "they have their reasons". AS5 found the online portal to be a convenient way to access all the files he needed. The portal's success was dependent on his teachers being active portal users themselves, as they were the ones obligated to populate the pages with learning content. BS4 regarded School B's online portal as a useful resource for students who were away and needed to catch up on lesson content. Conversely, BS1 found her own use of technology in the classroom to be more beneficial than whatever the teacher tried to implement, contending that it wouldn't be any different for her if teachers reverted to more traditional teaching practices. BS1 lauded the practicality offered by being able to store all her work in one online location, regarding her tablet as "easy to carry…with everything on it" compared to if all of her notes were in hard copy. She found its place in the classroom as convenient and said that it helped her stay organised and well equipped with digital resources. This was a shared sentiment from other students who appreciated accessibility abled content that could otherwise be lost if in hard copy. BS5 found the convenience and ease of research, compared to having to “go off to the library”, as one of the most significant benefits of having access to her own device.

8.7.4. Specific Software

AS2 said that technology enabled him to produce work in certain subject areas that otherwise would be significantly more laborious by traditional means. Referring specifically to Google Sketchup, a widely available computer aided design (CAD) program, he felt that he could produce architectural designs that were superior to his hand drawn attempts.

AS2 raised a unique concern that was not voiced by any other participants, regarding his perception on negative aspects of ICTs for learning. He said that submitting assignments digitally meant it was easier for teachers, with a variety of software, to identify where plagiarism had occurred. Whether this was speaking from experience or prior behaviour was not expanded upon.

AS7 considered ICT integration to have a range of benefits in school, saying of videos and documentaries “I find that really helpful for explaining concepts instead of just reading and writing all the time. So, it’s good to bring out another way of taking information in”. He considered the interactivity a crucial element to understanding concepts that would otherwise be more opaque in the context of a traditional textbook. He also found that videos were a useful way to return to key points in his notes for clarification and the speed with which he was able to skip through them enabled him to swiftly locate the information he needed to review. BS5 said that the interactivity from presentations and games made lessons more engaging and that different teaching methods and resources throughout the day kept her engaged. AS3 felt that technology was useful in some subjects, yet was "useless" in others like English, contending that "it's useful for different areas of learning". In English, where he was strongly encouraged to develop his handwriting skills, he posited that typing his essays would not adequately prepare him for examination conditions. He considered the individual teacher's aptitude to be a key determinant in how useful it was in the class, and that this varied significantly throughout his standard school day.

Some of the students from School B held a more pragmatic perspective, with BS2 feeling that the role of technology integration was only as strong as the Wi-Fi, and without it, any initiatives simply could not work. BS4 considered technology to be a hindrance when it did not work or there were complications with the software or hardware. She was cognisant of technology's propensity to fail at inconvenient times, noting that it could be difficult to stay on task if the teacher at the front was having difficulty with the ICT, whereas had they just presented content from an analogue resource such as their textbook, it "wouldn't crash". BS1 said that her device's battery life was often a concern, as without sufficient charge, she lost access to a considerable repository of her learning materials. Similarly, BS1 took a more functional approach to her reflection on the challenges that technology presented, stating that "battery life was a concern" throughout the school day. BS1 found that the lighting impacted her sleep, as often she would want to do work in the evening, but conceded that late night screen time could negatively impact her sleep (Akacem, Wright, & LeBourgeois, 2018).

BS2 felt that introducing interactivity such as Kahoot!, an online quiz style game where the teacher creates the content, helped maintain her focus and engagement. She said "it enhances it a bit more and I personally understand it a bit better". BS3 and BS4 both felt that technology enhanced their ability to research topics and BS3 said she would really struggle if this were taken away. She considered Kahoot! and the gamification of learning to be an effective way of engaging the class as a whole. BS4 considered PowerPoint presentations a handy way for teachers to present information, as well as for students to complete research assignments.

8.7.5. Mediating Distractions

With regard to the negative aspects of technology in the classroom, AS1 found a range of apps (such as sports news and games) to be an ongoing distraction. Due to their notifications that could pop-up at random intervals, their propensity to take him off task was an ongoing challenge he faced. He noted that some of the content he would access at home was blocked on the school network, which precluded him by default from accessing certain sites. Even though School A published a firm policy on prohibiting mobile devices within the classroom, AS1 admitted that his would often be in his pocket. Mentally, he felt more at ease with ready access to his smartphone, even if he kept it off during class time. Unlike some students who struggled to ignore the steady stream of notifications in their pocket, AS1 said "I don't use my phone as regularly as others". BS5 found that her teachers were increasingly relaxed about the presence of smartphones in the classroom, and although they were not actively endorsed learning devices, most teachers tolerated them. Turning smartphones off was a recurring tactic that students said they implemented to avoid distraction. As opposed to turning the smartphone to silent or refraining from checking notifications, AS4 said that he turned everything off and would return to it later. AS5, also in contravention of the school policy, would keep his smartphone in his pocket during class time. He felt he could ignore the vibrating notifications during lessons but said that it would become more challenging on days when there was "more going on" within the context of his social life. AS7 felt that technology offered the opportunity to "get off topic and zone out" in class and that it took considerable willpower at times to remain focused. If he felt that he had a strong understanding of what his teacher was talking about already, or the content was not challenging him, he would seek other means of engagement in class via his laptop.

AS7 said that he understood why teachers would instruct the class to put their devices away but admitted that he found it "frustrating" when moments arose where he would have liked to have been able to type notes, but the teacher had enforced a blanket ban on use. He attributed this to a "trust issue" and observed that the strict approach was often precipitated by the most distracted students, yet resulted in even the most diligent students having their access to technology restricted. Many students used their devices to listen to music when studying; however, earphones were usually prohibited in the classroom. Interestingly, some students noted that using earphones to listen music, whilst in class, was an effective way to eliminate other distractions. BS3 brought her smartphone to class but would rather turn it to silent than completely off, as she still wanted to be able to have the occasional glance under the desk at what notifications were coming in. She reflected that she used to struggle far more with self-regulation, having only recently been given a smartphone, but found she had improved in managing its use over time.

BS1 said that the level of difficulty relating to the tasks in class would determine whether she would seek out distraction from her tablet device. She said that if it was reading from the textbook, or something that was not challenging, she would likely be engaged in online chat with her classmates and then sought clarification on the reading content later. BS5 observed that the mere design of the laptop screen, which was usually perpendicular to the desk, compared to a tablet which could lay flat, meant it was more difficult for teachers to see what students were doing on their laptop screens. Her main distractions in class came from "texting friends, going on other websites and playing games". BS5 acknowledge that texting was prohibited, but outlined ways to subvert this rule, such as the practice of using one's smartphone from within their pencil case or behind their laptop screen, which also provided a barrier between their hands and the teacher's view. However, she said that the capabilities of her "dumb phone" precluded her from engaging in too much off-task behaviour, as her device did not support the apps that many of her friends had access to. BS6 used the same tactic to avoid the gaze of her teacher's view, stating that it was easy to pretend she was working, whilst really being on her phone. She noted that some teachers were wiser to these subversive behaviours than others, which could often be eliminated by the teacher positioning themselves at the back of the room, so that they could observe the activity on students' screens, as opposed to just the back of them. As was a recurring theme from all participants, the intrusion of push notifications, where messages are received without being actively sought, proved challenging for most. BS2 said “it can be very distracting if you get notifications during class, because you’ll then want to go on and see what it is”. BS3 was able to avoid most distractions during class due to removing the majority of social and gaming apps from her iPad, which was her primary device for schoolwork, saying “I used to play on games more last year, but now I like to focus more in class”.

AS4 said that if he sees non-lesson related content on the screen of a student nearby, it will more than likely “suck” him in, as it will be more enticing than whatever content the teacher is delivering. He said that he endeavoured to stay on task for half an hour or so, though admitted that the off-task behaviour of others could easily lead him astray. BS6 encountered the same difficulties in her classroom, where neighbouring screens could be a considerable distraction. AS6 said that the screens of peers were certainly a potential distraction when attempting to focus on the lesson content, yet he also added that their capacity to intrude upon and interrupt the flow of lesson content occurred when the teacher became preoccupied with managing students’ focus. When a teacher interrupted their own lesson delivery to discipline individual students or address a situation that had arisen due to a device being used improperly, it could prove to be frustrating for the students who did actually want to engage with the lesson content.

This sentiment of distraction coming from peers’ devices was a recurring theme for both boys and girls. BS2 admitted that her attention would divert to other screens whenever she was “not as engaged in a lesson or not as interested in what [she is] doing". BS3 reflected that games used to be a distraction, yet she had grown out of them somewhat. The recurring sentiment was that games were often a last resort in the pursuit of distraction and were enlisted when more preferable options such as social media and videos were blocked. BS6 said that she did not use her laptop for social media at all, as her smartphone was the outlet for all the applications she needed to interact with her friends.

Smartphones were a greater concern for students than their laptops. Although laptops offered them distractions such as YouTube videos, Facebook Messenger, and gaming, their real lives as teenagers were conducted via their smartphones. As BS6 suggested, the smartphone was the hub of interaction for her and her peers, as apps such as Snapchat and Instagram could not be accessed via her laptop.

She said that she would play games only because she had "nothing better to do" and this would often be the case when the student had explained that they had become disengaged with the lesson content being delivered. BS5 said that "boredom" would usually be what led her to stray towards distraction in class, where she looked for things to occupy her mind beyond what the lesson content was offering. BS6 conceded that her main portals of entertainment (social media, etc.) are blocked whilst at school, so would resort to gaming. However, this was never a pastime she engaged with outside of school, where she could access platforms such as Snapchat and Instagram. If the student found they were their mind-wandering and tuning out from what was being taught, their lack of intrinsic motivation led them to seek alternative sources for entertainment and engagement (Risko et al., 2013). BS5 observed that students would play games depending on "how much we like the class in particular".

The freedom to game, however, could be stifled by the individual teacher's approach to students using their devices within the classroom. BS5 said that it varied, depending on who their teacher was, "some of the teachers won't let you have your laptop lid open when we don't need it open whereas others don't care". As the policy at School B was not uniformly implemented, this could result in students moving from one lesson to another and facing different rules and restrictions with regard to how they used their technology.

8.7.6. Distraction from Peers

Regardless of the measures that AS2 endeavoured to implement in order to eliminate distraction from his own device, he conceded that peers within his peripheral vision were an added level of difficulty that impeded his focus on the lesson content. If someone sat in front of him had content such as a video or game that were not related to the lesson, he would need to try harder to ignore their behaviour. Sometimes this would result in him physically moving to another desk to avoid the distraction. AS3 said that even if he was exhibiting self-control and was attempting to focus on the learning objectives at hand, the mere presence of a peer's screen who was off-task could be a distraction in the classroom. BS3 said she would get distracted "on occasion" if peers around her were on interesting videos but would be able to ignore their screens, for the most part, if she was in a subject she enjoyed. AS4 accepted that every student had mastered the ability to instantly flick from non-school related content to a word document whenever a teacher was approaching their screen. He admitted that he had ways to subvert any possible confiscations in class and that he was "too quick" for his teachers to catch him using his smartphone. Tactics such as leaning his smartphone up against his laptop screen, so that it appeared he was being productive from the view of the teacher facing him, enabled him to get away with using his smartphone in class. He felt he was able to ignore such distractions if the teacher was motivating him to learn. However, if he was disengaged or fatigued, then he would prefer to watch a peer's screen than listen to the teacher at the front of the room. BS1 also found it easy to switch between content to always present to the teacher at least an appearance of productivity. She felt that the vigilance of the teacher varied from class to class; however, on the most part there was an assumed trust from the teacher that the student was attending to their work and could exhibit self-control. She admitted that if she could see off-task behaviour from her peers, she would feel more inclined to do the same to ensure that she was not missing out on the fun.

AS7 found that his smartphone was no cause for any distraction whilst in class and although he kept the device physically in his pocket, it was always turned off during lessons. AS5 recounted that he would often find it difficult to eliminate distraction from peers in his class, saying he was better at attending to private work, yet struggled sometimes during class activities to remain fully focused. He admitted that a significant factor contributing to his ability to focus was the level of motivation he felt for the specific lesson he was in.

In critiquing herself and her peers' use of technology, BS1 considered personality type and academic discipline to be determinants of how well distraction was managed, saying “some people prioritise their schoolwork over social media, but overall it’s just really hard”. BS4 acknowledged that she had no specific strategies for managing distractions in class beyond “ignoring it” wherever she could. She admitted that she would definitely be distracted if someone in front of her was playing a game. BS5 found she had very little interest in the activity happening on classmates’ screens, as without sound or understanding of what they were doing, it did not offer much in the way of distraction, unless they were specifically doing something to get her attention.

8.7.7. Preference for Handwriting

Some of the students said that their preference was to type out schoolwork, yet would adhere to whatever their teacher prescribed. Often teachers would mandate that an assignment had to be completed by hand as an exercise, not only in addressing a specific part of the curriculum, but also in an attempt to develop their handwriting ability. AS2 felt that going through the process of handwriting his notes was faster than his ability to type and also enabled better recall. He noted that the expectations of the teacher varied from subject to subject, with some mandating that work be completed by hand and others accepting assignments that had been typed. AS4 felt that typing increased his efficiency as he was far quicker with the keyboard than he was with the pen. Interestingly, he shared that he would then take his typed notes from lessons and convert them into handwriting later on. He said “in this exam period, I’ve typed up the notes from the PowerPoint and the textbook and then after, I print them and then handwrite them out”. This was his strategy to improve his memorisation and understanding of the content he may have simply typed verbatim without any critical thinking applied. Anecdotally, he considered that the subjects where technology was heavily integrated was where he performed most poorly, whereas in science and maths, where technology was not as prominent, was where he would perform best. AS5 reflected on his earlier attempts to produce all his notes digitally, but found it was far too easy to become distracted if he had access to the Internet whilst attempting to study. He said "I tried earlier in the year typing, but I feel like it just didn't work, I couldn't remember it as well". He found the physical act of having something in his hand that was not digital, in this case a pen, enabled him to eliminate distractions that came from typing. AS7 found that the pace with which lesson content was being delivered would often determine whether he handwrote his notes or not. As he could type faster than handwrite, he would focus on getting all of the content transcribed and then would be able to go back and edit accordingly when it came time to review his notes. He found having digital versions of his notes enabled him to share content with his peers and vice versa. BS4 considered it to be an even split between the subjects where she either typed or hand wrote her notes.

AS3 would type his notes out during class in preparation for examinations, yet would then handwrite his own typed notes as a self-imposed exercise that he believed helped him memorise the content, stating that it made it "easy to process". AS5 took a similar approach when he was attempting to encode information into his long-term memory. However, he opted to write out his notes by hand predominantly because it meant he could put his technology aside and be confident that his analogue materials would not provide any distraction during times of study. Indeed, the effectiveness of his approach may be more than just anecdotal and is supported in the literature. BS6 took a similar approach to AS3, stating “during exams I usually write stuff down if I’m writing notes because I feel like I remember it more than if I’m just typing it”. She stated that she could type faster than she could handwrite her notes, yet the slowing down of the process by handwriting her notes was an effective study technique. AS7 enjoyed the convenience of his typed notes, as he could go back and edit details and use them as a searchable reference point when it came time to revise for upcoming exams. With regard to handwriting notes and processing content in a traditional way, BS3 said “I think it helps me learn and process words”. She also was more comfortable with traditional means of note-taking, having only just recently received a laptop.

8.7.8. Managing Technology at Home

It proved a slightly more challenging environment at home for AS1, where there was not always someone in the room to enforce the appropriate use that was encouraged in the classroom. One of the most difficult circumstances arose from certain media channels serving a dual purpose of both socialising and attending to school related objectives. His smartphone would be switched on once he left school, as it was when there was the most activity on social media and across group chats. Facebook Messenger would be used to contact friends socially, yet also was his preferred method of sharing notes or discussing homework with his peers online. Approaching the penultimate year of school, AS5 accepted that he would have to distance himself from his phone in order to focus. His parents would, on the most part, trust his use of technology. There were occasional moments where he admitted that his parents would take his smartphone due to it becoming too much of an interference. Upon reflection he said that he “felt a bit annoyed, but I can understand why they do it”. He found that debate would arise about his smartphone use when it was taken away in circumstances where he was actually using it for schoolwork.

One such challenge was the use of Facebook Messenger, which would often be used to share school related content between friends. AS1 admitted that the use of email was close to redundant and was certainly not his preferred method of communicating with fellow students about assessments and the like. BS1 noted that her parents had tried to enforce a “hand-in” time for her devices at 9 pm, but that due to logical reasons, it had not been strictly adhered to, as much of her school work was completed on her iPad. BS2 used group chats for various subjects and there was one for people in her year level, which was a channel to share schoolwork on, even though not one officially sanctioned or established by her school. When asked whether she used social media for schoolwork, BS5 said “definitely, we will ask questions, send photos and help each other work things out”. She felt that using Messenger was the most effective means of communication with her classmates, outside of school time, as it was reliable to think that most schoolmates would be online at some point whilst doing their homework. BS3 was the only student to refer to Snapchat for learning, which she said was a handy way to share a question or a photograph of work to a large group and receive instantaneous responses.

AS4 said that his strategies for self-regulation would fluctuate throughout the year, often dictated by the level of workload and whether examinations were imminent or not. AS5 said that his approach differed, depending on how important the work was and he would turn his smartphone off sometimes, but acknowledged that this habit was not as consistent as he would like it to be. AS4 felt that his parents trusted his maturity and academic discipline without the need to enforce any sanctions at home, so would be left to create his own rules on how to best manage his smartphone when completing homework. To remedy the distraction, he declared that he would give his phone to his parents for the whole night to ensure that the decision was literally and physically out of his hands. At home, AS7 also physically removed his smartphone from his study space and used his laptop for homework. As permitted by his parents, he would sometimes check in with social media on his smartphone during study breaks and then abandon his device when he returned to homework. He said that if he was working on something that he was not motivated by, the inclination to constantly turn to his smartphone would significantly slow down his ability to complete the task at hand.

With her pragmatic appraisal of technology, BS1 said that connectivity was one of the barriers between her and distraction. She said that her “limited data plan” meant that she had to be judicious in when she accessed the Internet and what for, whereas the access to Wi-Fi at home provided her with unlimited access. At home she found it a far greater challenge and said “I find myself getting distracted to the point where mum has to take my phone off me”. BS4 said that her “own self-discipline” of turning off her cellular data whilst at school was an effective way to limit incoming content whilst still enabling her to use some smartphone features such as listening to music and taking photos. BS1 admitted to feeling anxious about what she was missing out on whenever she did not have access to her smartphone but acknowledged that she could achieve a "greater point of concentration where you just focus on your work". With the rapid pace with which conversations would progress between social groups who were constantly connected, she felt concern that she would be left behind if she was not in conversations or how her friends would perceive her if she was not replying instantaneously.

BS2 attributed her challenges with technology at home to the lack of structure or set times enforced around homework. Her parents did not allow her to have her devices with her overnight in her bedroom and provided "advice" when she was allocating too much time to her social media. BS3 was given free rein with her technology at home, stating that her parents afforded her "full trust" since gifting her the smartphone at Christmas. She said that she would "put the phone on the other side of the room until I got things done", as this was a strategy to stem the flow of incoming messages that were often difficult to resist, "especially during exam time". However, she conceded that 45 minutes was about the threshold she could manage before going over to check her smartphone again. BS4 set herself timeframes to work technology free so that she could then return to her device between homework breaks after reaching certain goals. With regard to accessing her devices at home, she said "my parents are very trusting of me, so we don't really have any rules". She recalled that they have tried to enforce rules upon her and her sister in the past, but they had not been maintained, attributing some of this to the fact that her parents cannot adhere to expectations of self-regulation themselves.

The benefits BS5 stated of her low-tech mobile phone preventing distractions at school had the inverse effect at home, where she felt like her absence from much of the online activity of her peers left her at a social disadvantage. At home, BS5 considered it to be far more challenging to regulate her behaviour as there were "no time limits, no rules for when I need to stop". She could still access social media from her tablet, yet the process was more convoluted than if she just had access to a smartphone.

8.7.9. Senior Study Strategies

As AS1 entered his final years of secondary schooling, he admitted that he would need to take a more disciplined approach to how he used his devices. One measure would be for him to delineate between his iPhone and his iPad, by removing all recreational content from his iPad so that he associated that specific device with schoolwork. AS5 kept a clear delineation between his two devices, associating his laptop with schoolwork and his smartphone with recreation. In a similar fashion, AS7 considered his laptop as a device solely for school purposes. He said that it was more difficult to be interrupted by notifications for social media on his laptop (unless they are actively sought out), so he considered it easier to avoid the interruptions that are more prolific on his smartphone. As AS2 approached the end of school, he envisaged the challenges that would come from technology, affirming that there was a significant increase in workload during the senior years, where he would need to be more cognisant of how he eliminated distractions.

AS5 had no games on his laptop, which had been a "conscious decision" to eliminate the distractions they brought. BS1 said that during exam periods, she would revert to traditional resources and that “it was a lot easier to have no electronics and just worksheets”. BS2 also turned her smartphone off whenever she needed to study, which was something she was more diligent with around examination periods. She also would go to the extent of deleting apps off her smartphone if she knew that they would distract her, even though she considered it to be “annoying, because you want to see what’s going on”. BS5 took a similar measure of removing, or blocking notifications, from her favourite apps during exam study periods. She admitted to not taking this approach all the time, as she felt it to be an inconvenience. Her alternative to checking social media, when the apps were removed from her smartphone, was to check the family computer. However, she noted that it would be more difficult to waste time online when the rest of her family could see what she was doing.

BS1 declared controlling distractions to be much harder than what some might appreciate, but acknowledged that she could perform better if she wasn’t hindered by these distractions. As she approached the end of secondary school, she said she’d need to eliminate much of her social media but would need her mum to help her as she conceded that she lacked the “will power” to do it on her own. BS3 expressed a similar need to put the control of her smartphone literally in her mum’s hands, where she could then return it on possibly an hourly basis during study breaks.

8.7.10. Advice from Others

AS2 contended that no one had ever explicitly taught him strategies to moderate his technology use, declaring “it’s up to me”. AS5 said that teachers had provided the standard and expected advice throughout his schooling about how to manage technology, yet felt that sometimes the advice would be coming from adults who interacted with technology in a fundamentally different way to teenagers. Regardless of this generational divide, he conceded "if we all listened to what they were saying, we'd probably do a lot better". AS7 felt that he has had to navigate his own way through what defines "appropriate use" during secondary school and it has been a matter of trying to work out what strategies best suit him, as opposed to any external advice or guidance.

BS1 felt that greater awareness needed to be generated to help young people understand the challenges of social media, which was the recurring distractor from both boys and girls throughout the interviews. She said "I think people need to realise that social media isn't as important as we make it out to be". BS2 considered a need for advice to be shared, even if she would then adapt certain tips to suit her own approach to technology. She felt that any advice regarding technology would be better coming from a young person, as they were more likely to know what teenagers were thinking. BS3 felt that older people offering advice did not understand what teenagers "have to go through" but said that she would benefit from someone who could offer "ways or strategies to help us get less distracted…but the individual should know their boundaries".

BS5 felt that the advice that adults provided on a regular basis became repetitive, stating "we've had the same thing every time someone comes in, so it's really just up to us to put those things into effect and self-discipline". BS6 admitted that teenagers will say "they don't know what they're talking about, they're old". However, she still thinks it would be useful to have people come in to provide guidelines and techniques to manage technology and the distractions it presents, both in and outside the classroom. She affirmed that banning it would not be as effective as teaching appropriate use and how to find a level of balance.

8.8. Summary

This chapter presented the qualitative interviews under thematic headings that sought to identify the key issues identified by parents, teachers, and students. When asked about the perceived efficacy of technology for learning, the participating stakeholders held differing views, which may be attributed to a range of factors. Personal competence and confidence with technology, a willingness to be adaptive to changes with ICT, the ability to self-regulate, and the academic aptitudes and motivations pertaining to the learning environment, were all highlighted as issues relating to individual perceptions of technology. Whilst parents, teachers, and students differed in opinions, there was an overarching consensus that technology, when not harnessed effectively, was more deleterious to academic performance than it was beneficial.

Chapter 9: Discussion

9.1. Introduction

The purpose of this chapter is to interpret the qualitative and quantitative data collected from participants at School A and School B. It aims to identify recurring themes and how they relate to the literature and research questions, including findings that may not have been anticipated. Consequently, it explores limitations from the quasi-experiment design and makes recommendations for possible future directions.

9.2. Quantitative Results

The quantitative analysis presented has examined the results of students' tests for five different videos under three different conditions of ICT use, namely Procedure A (no ICT use), Procedure B (moderated ICT use) and Procedure C (unmoderated ICT use). The procedures used by each class varied for each video and associated test. No significant difference was identified for any of the videos based upon membership in the different procedure groups. This result indicated that students' performance on the tests were not dependent upon which approach was used to make notes of the video or whether the use of ICT was moderated or not.

Another factor that was considered relevant was whether this lack of difference in students' performance on the test based on procedure occurred irrespective of the difficulty associated with the video and test. The box plots in Figure 8-10 show the test results for School A grouped by video.

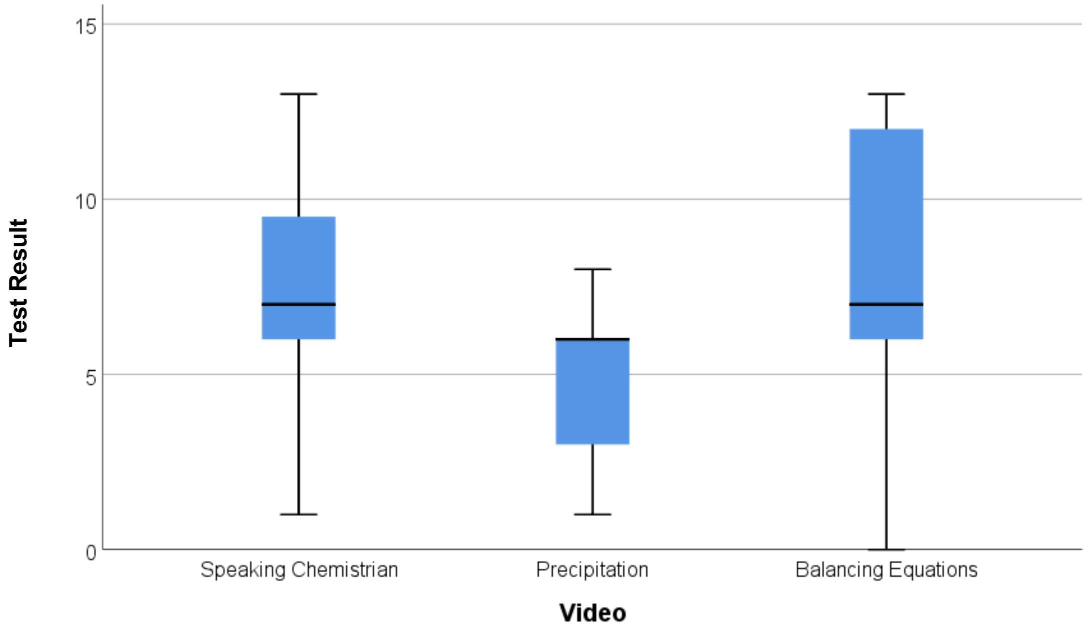

Figure 8. Test results for Procedure A grouped by video

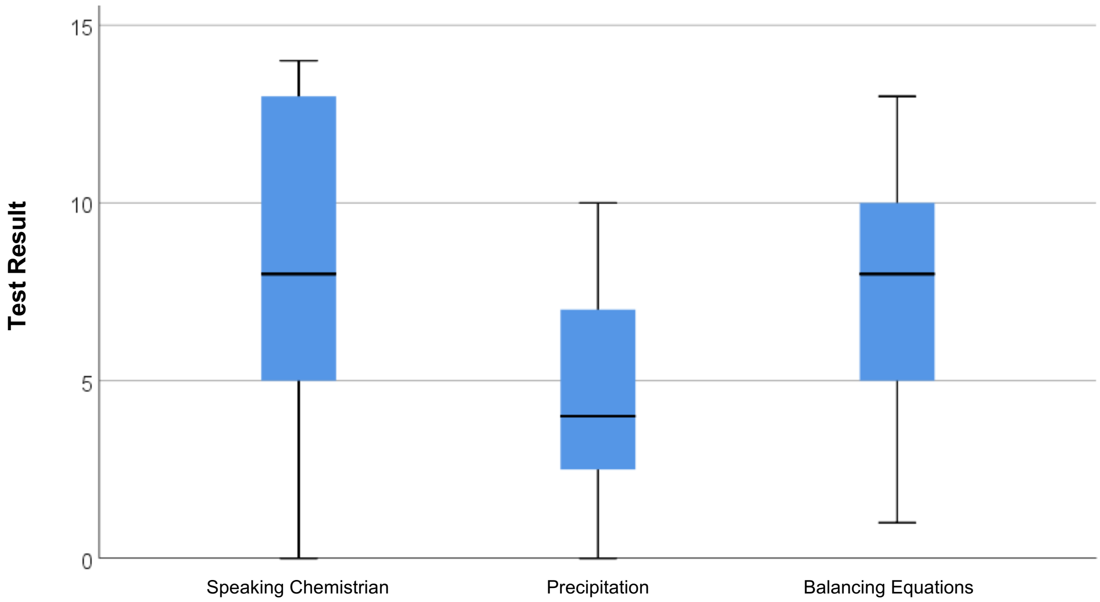

Figure 9. Test results for Procedure B grouped by video

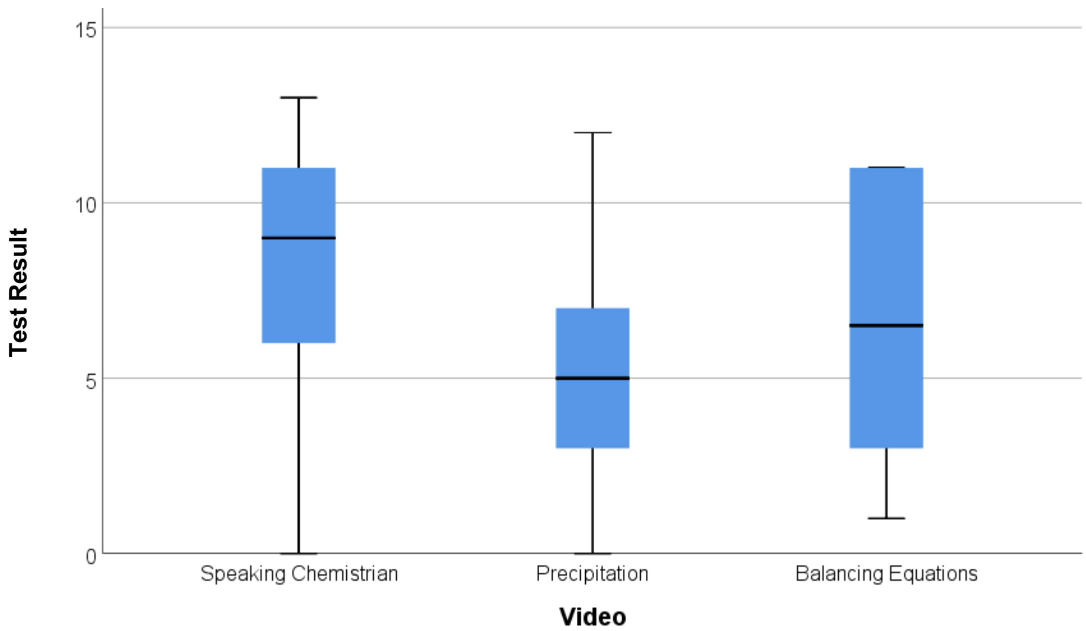

Figure 10. Test results for Procedure C grouped by video

Table 10.

Summary of Kruskal-Wallis H-test for School A grouped by video

Video	Procedure A		Procedure B		Procedure C		*H*	*df*	*p*
	n	*Mean Rank*	*n*	*Mean Rank*	*n*	*Mean Rank*			
Speaking Chemistrian	36	39.86	18	23.67	18	42.61	9.365	2	0.009
Precipitation	20	47.05	20	26.88	41	44.94	9.769	*2*	0.008
Balancing Equations	21	49.50	39	33.31	18	41.25	7.183	*2*	0.028

No statistically significant result was identified, with the mean ranks (Table 10) and box plots indicating that the test results for the Speaking Chemistrian video were significantly lower than the other two videos. Considering that each class was exposed to different procedures at each stage of the intervention, the lack of difference in test performance resulted irrespective of the difficulty of the video test combination.

The purpose of the quasi-experimental design sought to gather data which could be later analysed to identify under which level of ICT access, during the note taking process of a lesson, students would perform best. As discussed, it has been argued that the use of ICTs in the classroom presents a number of cognitive, metacognitive and self-regulatory demands on learners (Kalyuga & Liu, 2015). The ICT used may engage the learner's attention and act as a distraction to what is being learned; however, the quantitative data analysis indicated that, in this quasi-experimental design, this has not been the case. When observing the videos and making notes, the student engaged by watching the video, thinking about the content and made notes of the relevant, important content with both analogue and digital tools. In the case of using their digital device, the pen and paper has been replaced with an ICT resource, namely a laptop or tablet. The quantitative findings suggest that because there is no significant difference in learning between the different quasi-experimental conditions, the multitasking involved and resources required to support the learning process is equivalent. Contrary to the literature which highlights the demands that extraneous load can place on comprehension (Dux et al., 2006; Sweller, 2010), there appears to be no difference in the cognitive challenge involved in the use of pen and paper or digital device. The findings differed from much of the reported literature that contended that technology can have deleterious implications on academic performance (Aagaard, 2015a, 2016a; Karpinski et al., 2013; Lepp et al., 2015). For any assertions to be made about specific platforms, websites, applications or devices being responsible for dividing a student's attention, the condition of distraction would need further clarification.

There was no statistical significance identified at School A to suggest that technology had a possible influence of how it impeded the ability to focus on content delivered in a lesson with the purpose of being able to recall it at a later time. The order effect must be considered, as students' approach to the three tests may have varied over time due to a range of factors such as motivation, fatigue, and rehearsal. However, regardless of the order in which the tests or procedures were administered, student performance on the tests was not statistically different, regardless of which procedure, or intervention, the student completed their test under.

Making a comparison between School A and School B is limited by a range of factors, including the use of different videos and the content of the tests being different. The School B results between the three procedures were not significantly different from each other, and there was no statistically significant interaction between ordering and instruction method, i.e., differences between procedures were not dependent upon ordering. One of the main reasons for this was the absence of data restricted the subsequent analysis to compare only two treatments. To answer this question would require a formal test, or in statistical terms a test of a three-way interaction between gender, order and instruction method. This would seek to ascertain whether the relationship between order and instruction method itself significantly differed between genders, so as to compare numeric values rather than just comparing labels such as significant and non-significant.

As well as the female and male students being based at different schools, with a much higher number of missing values for the female students, the actual tests (e.g., Periodic Table) employed in the procedures were different between male and female students. No statistically significant differences were identified at either School A or School B, indicating that retention of content was not adversely influenced for either the male or female students through the differential use of ICT, irrespective of whether it was moderated or not. However, no conclusions could be made to compare performance based on gender because the schools used different videos and tests. To test whether male and female students were differentially influenced by the different technology usage, further research would be necessary where a cohort containing both male and female students were exposed to the same treatments using common videos and tests.

Future research requires a much larger number of classes, albeit logistically difficult to implement in practice due to the nature of incorporating additional requirements into the school curriculum, with several classes randomly receiving each ordering of procedure. Furthermore, all six possible permutations or orderings of three treatments would be utilised, while ideally there would be a fourth condition. The pen and paper instruction procedure involved the teacher actively monitoring the class, while in the two other procedures students took notes with and without moderation. An extra condition, with pen and paper without teacher monitoring, would allow researchers to ascertain whether the effect of monitoring was stronger for notes on own devices, than for pen and paper recording, should this be of interest.

Further consideration should be afforded to ensure that there is a statistically reliable explanation to verify that the content of each test is of commensurate difficulty. Future research should seek to incorporate data prior to the implementation of the tests to control for such factors the level of academic aptitude of the participant students, as well as seek to ensure the homogeneity with regard to gender, age and numeracy and literacy specific to the subject content being assessed.

9.3. Qualitative Themes

Distraction, self-regulation and the ability to focus were overarching themes from all participants, as identified in the thematic analysis. Teachers, parents, and students all answered a similar set of semi-structured interview questions that sought responses on a variety of themes, from different perspectives. Whilst some responses were specific to the participant group, there were recurring themes throughout the data where all three stakeholder groups held concordant views. Teachers, parents, and students were all cognisant of the practical implications that came with working in the digital space. Issues such as connectivity, data allowances, and access to appropriate software and hardware were all issues raised. The analysis of the tests highlighted a similarity between taking notes with pen and paper, and with moderated technology. Of note was the fact that unmoderated technology did not garner any statistically significant difference to the other procedures. The quantitative data collection was presented with a range of challenges, most significantly acquiring the assent from students at School B to use their data.

Parents, teachers, and students all made reference to there being a need for greater education in how to appropriately use technology for learning. Parents admitted to being confused, and sometimes overwhelmed, with the digital landscape that their children were immersed in. Whilst acknowledging that adolescents would behave, to a certain extent, away from the direct supervision of adults, there was a need for adults to understand what difficulties technology posed to their children. Teachers expressed a need for more time to be dedicated to educating students how to use technology appropriately, yet there was no obvious solution on whose responsibility within the school system this would fall to. The majority of students also felt that they would be well served by greater understanding and awareness on how to manage their technology effectively. All students conceded that they had battled distractions from social media, games and other online content, yet were reliant on being online as part of their daily lives. Therefore, strategies to find the appropriate balance were essential to using a device that serves the dual purpose of learning and recreation. Several students felt like they were, for want of a better term, left to their own devices when it came to managing their digital behaviour. They considered the advice that they received on how to use their devices to be from people who were detached from how adolescents interacted online. There was a desire to hear advice from those who understood the vital role that being connected played for the average young person.

9.4. Classroom Procedure

In this quasi-experimental design, to recap, there were three procedures of note-taking for retention of lesson content, with varying levels of ICT use. Procedure A (no ICT use) involved students viewing the lesson content, delivered by video, and taking notes using the traditional method of paper and pen, whilst the teacher circulated the room to maintain classroom conduct and behaviour. Procedure B (moderated ICT use) allowed students to take notes on their own devices; however, students' use of their ICT was monitored by the circulating teacher. Students were also provided the instruction that their device should strictly be used for note-taking purposes and nothing else. Accountability to this instruction was upheld by the teacher's enforcement and circulation throughout the classroom. Procedure C (unmoderated ICT use) enabled students to use their devices for whatever purpose they deemed appropriate. The teacher provided no other instruction on how to take notes or use their device appropriately and remained static at the front of the classroom. From the position in which the teacher was sat, they were unable to monitor the activity of the students on their devices.

9.5. Technological Distraction and Lesson Retention

The quantitative data collection sought to identify to what extent technological distraction might impede students' ability to comprehend lesson content. As will be discussed, the qualitative interviews revealed a range of issues relating to how distraction creates obstacles to learning. However, the quantitative data identified no significant differences on content retention based on ICT use, which were somewhat contradictory to the anecdotal evidence provided by teachers, parents, and students.

When students were given free rein to engage with their devices in whatever way they deemed appropriate, there was no statistically significant difference between the procedures as a whole. Whilst there may be no statistically significant result to indicate any intrusion may have impeded content retention, no observations or recordings were taken of the specific activities that students partook in when their devices were unmoderated. The overarching theme identified in the qualitative interviews was that students could be hindered by their inability to self-regulate their behaviour and moderate their technology use, yet the quantitative analysis did not support this perspective. When students were given unrestricted access to their devices and their supervising teacher refrained from offering either advice or the enforcement of rules, many students admitted to struggling to attend to the learning task at hand. However, the data indicated that their perception did not always align to overall academic performance. Providing students with open access to technology within the classroom can have detrimental implications for learning (Aagaard, 2015b, 2016b; David et al., 2015; Fauquet–Alekhine, 2015; Taneja et al., 2015), yet its management is what is key to its efficacy. Teachers, parents and students alike all made note of the distraction that technology brought, yet the quasi-experiment suggested that they could still attend to the prescribed learning task if there was a justified rationale and outcome communicated to the students, as was the case with the prescribed tests. This does not suggest that students were impervious to distraction; however, it does go some way to address the ongoing reticence from those who decried the integration of technology as categorically harmful to learning (Fauquet–Alekhine, 2015). If students found themselves disengaged or lacking in motivation to attend to the content presented to them, their devices provided a digital form of escapism. Unlike when a student's opportunity to let their mind stray from the learning objective was limited to their imagination, and perhaps a vision of doodling or daydreaming, the disengaged student now can divert their attention to non-lesson content that requires greater engagement, and subsequently, a further disengagement from what their teacher is trying to achieve.

The allure of social media, games, videos, and the seemingly endless trove of content available to any student with an Internet connection can prove to be a digital distraction too hard to ignore, no matter how much their logical mind may tell them to focus on the lesson they are in (Aagaard, 2015a; Dietz & Henrich, 2014; Goundar, 2014; Taneja et al., 2015). It presents the teacher with a considerable challenge, or battle, as was described by parents and teachers who were interviewed. As many adults conceded, eliminating the distractive magnetism of their own device could be a challenge for even the most self-aware individual. Although adolescents received a significant proportion of derision from media outlets and older generations on how teenagers cannot live without their devices (Blackwell et al., 2016; Patterson, 2016), it is certainly not a modern-day struggle confined to one generation. However, it does highlight how challenging it must be for the developing adolescent if it is a difficult urge to control, even for adults. Adolescents are in a heightened state of neural plasticity compared to adults, with developing brains that are constantly maturing and adapting to their surrounds (Konrad et al., 2013). As such, metacognitive strategies to eliminate distraction and remain focused could be hindered by the fact that their brain, and in particular the prefrontal cortex, is still in the developmental stage (Foroughi et al., 2016).

For the students at School A and School B, their approach to Procedure C, which allowed unmoderated access to technology sought to make it more challenging to remain focused due to there being no imposed process in place to eliminate distractions. Yet, on the whole, students achieved similar results to the tests under Procedure A and B. Students who performed worse may have been disengaged with the lesson content, or simply suffered resumption lag from attending to a brief notification that then took away their ability to process content efficiently and effectively (Monk, Trafton, & Boehm-Davis, 2008). However, the quantitative analysis did not suggest that any disruption to focus was specific to the two procedures that integrated ICTs. Considering the implications of resumption lag and its deleterious effect after just a few minutes of deviating from a primary objective (Borst et al., 2015; Foroughi et al., 2016), it could have substantial implications for a school lesson which can seek to condense a significant amount of information into a confined period of time.

Using the traditional means of pen and paper for note-taking and general schoolwork was endorsed by the majority of interviewed students. The quantitative data supports their belief that they recall information effectively when it is handwritten, yet the results also highlighted that information was just as effectively recalled when their digital devices were used to take notes. Data from School A suggested that there was not a significant difference in results between Procedure A (pen and paper) and Procedure B (moderated technology use). The data indicated that students were equally capable of attending to lesson content and encoding the information for later processing, as was required for the administered test. Procedure C, the condition under which their technology was unmoderated, presented the students with an increased array of options to become distracted by their devices. During this procedure, students were given full autonomy to engage with their technology in whatever way they wished. This meant that students could either use it in a similar way to Procedure B and simply use their device for note-taking, or they could deviate from the task at hand. The absence of a statistically significant result compared to the other procedures makes it difficult to suggest that it was specifically the unmoderated ICTs that impeded their retention of lesson content.

These results indicated that students have developed note-taking skills that are equivalent in both digital and analogue mediums; however, many students noted that they could type significantly faster than they could handwrite. Several students stated that they used their devices for efficient transcription or verbatim note-taking and would then synthesise this information into more digestible content with pen and paper later on. This was an interesting admission, as usual practice might suggest that technology is used at the refinement stage of the schoolwork process, as opposed to retrograding typed notes into handwritten ones. The practice supports the literature which accounts for the method of handwriting content that an individual wishes to effectively memorise (Mogey et al., 2008; Mueller & Oppenheimer, 2014). For some subjects such as science, which was the core focus of the quasi-experimental design, handwriting notes continued to be the preferred method for students who had to transcribe information that was beyond the basic functions of their devices. When it came to mathematical equations or notation, as opposed to just text-based information, teachers and students regarded traditional methods as the most effective practice.

9.5.1. Managing Distraction

The most recurring theme throughout the interviews of all three participant groups was how distraction (or related words such as distracting and distracted) presented a range of challenges. As the title of this research alludes to, understanding how distraction is managed in an age where it infiltrates daily functioning on a multitude of levels is crucial.

Students contended that their biggest concern for technology in the classroom was how distracting it could be. Their self-awareness allowed students to recognise the challenges they faced by having access to their devices whilst at school, yet this introspection did not necessarily translate into higher levels of self-regulation. All students cited issues with distraction from either their laptops, tablets, or smartphones. The technology used by individuals varied and some students had access to multiple devices at any given time.

The access to multiple devices, at first glance, might seem as detrimental to learning; however, several students highlighted how this could be more beneficial. By being able to delineate between, for example, their laptop for schoolwork and their smartphone for social media, they were better equipped to attend to the learning tasks at hand when in school. Most students, regardless of the school policies that were enforced to varying degrees, would still have their smartphone on them at all times. No interviewed student confirmed that they abided by their school's expectations and stored their smartphone away in their locker during period times. Consequently, having a device which was their primary channel of communication with friends and, more broadly, their social media accounts, was a significant distraction when in class. Whilst some students outlined their approaches to stem the flow of distractions from these devices in class, others admitted to it being a constant intrusion on their focus. Although they found it frustrating to receive ongoing notifications, it was a frustration that participants were willing to accept because the alternative of not accessing their smartphone brought them greater anxiety.

Students expressed a fear of missing out, colloquially known as *fomo*, where being removed from their smartphones would lead them to be left out of a social media loop that was in perpetual motion. It was often the case that the greatest activity between friends took place after school hours, where students would continue offline interactions into online conversations and would debrief about the school day, or connect with contacts from other schools and social circles. With an acknowledgement that the majority of their peers were consistently interacting online, the concern with detaching from this connectivity was an overarching apprehension that led students to be tethered to their smartphones, albeit accepting that it was detrimental to their productivity.

Students who identified with a more rigorous academic approach regarded their device as something that needed significant metacognitive strategies to manage effectively. Instead of considering technology simply as a nuisance or impediment to learning, they acknowledged its myriad benefits and how a balance needed to be reached between its advantages and disadvantages. With this came the recurring theme of delineation, where separating technology's academic benefits with its social and recreational benefits was a challenging boundary that was often blurred. A variety of strategies were discussed, from simply turning off notifications to removing access to certain apps or devices entirely. Several students admitted that if they needed a break from their smartphones, the most effective solution was to surrender it to a parent.

Metacognitive strategies and a level of sell-awareness and self-control that attenuated distractions, as cited in the literature, were considered instrumental to effective technology use (Gurbin, 2015; Waters & Schneider, 2010). The rationale behind this was that students were able to acknowledge their lack of self-control and could address this by handing the management of their device over to a responsible other. This approach of self-imposed confiscation was a measure that a range of students implemented, but usually it was confined to times when their workload or study pressures were at their zenith. Examination periods and assessment deadlines were usually precursors to relinquishing their device to a parent; however, the measure was only ever temporary. Several students acknowledged that when they were apart from their smartphone, they were still thinking about it. Some students would designate digital check-in breaks, where they would reward a period of successful focus with some time spent on their device. As the literature suggests, this deviation from cognitively demanding tasks can make it increasingly difficult for individuals to return to their primary objective (Borst et al., 2015; Foroughi et al., 2016).

For those who, for reasons of practicality or predisposition, chose not to remove their device from their physical reach, there were other effective strategies to attenuate the incoming digital intrusions. A range of students accounted for simply turning their smartphone off, whilst others found that silencing their device was effective enough. Smartphone apps also had the capacity to assign specific notifications settings that could address a range of interruptions, including sounds, vibrations, on-screen messages and whether or not a notification is pushed (where the user does not need to actively seek the update) to the smartphone. For students who used apps for both academic and social purposes, restricting notifications could prove to be more challenging. It would be prudent to separate channels of communication in order to streamline the information relevant to learning (Aagaard, 2016b; Mendoza et al., 2018). Although email was still the primary method of communication between teacher and student, it was not a tool that students were reliant upon. Their need for instantaneous, group style communication, required apps that they could intuitively use and were already part of their daily lives. It could be posited for some that the anxiety associated with being offline might be counterintuitive to goals of productivity over an extended period of time (Gazzaley & Rosen, 2016; Rosen, 2010). Therefore, an individual who can acknowledge that their device might be a distraction and consequently remove it from their study space might be more inclined to do so if they can then assign themselves rewards for achieving self-directed goals.

Trust was a recurring theme throughout the responses provided by students. The relational context under which the exchange of ideas and learning occurred was crucial to the learning process (Lee, 2007, 2012), where the way in which teachers and students engaged with each other was crucial to the academic environment. The trust placed in teachers could also influence the intrinsic motivation the student had to learn from their teacher (Davis, 2003). Students referred to their propensity to use their devices for non-learning activities when in class, such as gaming and social media, as the result of being unmotivated and disengaged from the content. This suggested that the relationship between student and teacher is vital to maintaining the motivation required to focus on lesson content. Davis (2003, p. 216) contended that "supportive relationships with teachers continue to predict social and academic outcomes throughout middle school and in the transition to high school". BS1 said that some of her teachers will actively circulate throughout the lesson, which indicated that they do not trust that the students will remain on task of their own accord. She said, however, that "you can kind of tell" which students are off or on task anyway, by simple giveaways such as hand and eye movement across their device. AS6 said that it is a lost battle because it is "pretty easy to hide it" when students are off-task. Where school networks had sought to block certain content from the networks, some students admitted to using their personal devices as a "hot spot" (where cellular data from a smartphone can be accessed via a laptop) to subvert any such restrictions on what they could access.

Several parents lamented that their children spent too much time on their device and they struggled with how to combat the hours of screen time. Often it was unclear whether their child was using their device for schoolwork or not, so confiscation was not always the most effective solution. Nearly all parents mentioned that they expected devices to not be kept in the bedroom overnight. The term screen time is a difficult one to categorise, as it can either be broadly applied to all digital media consumed throughout the day or may be more specific to that of mobile devices. Whilst the consumption of some online content may be entirely passive, or close to habitual (such as scrolling, browsing, watching television, checking unimportant notifications, etc.), other behaviours such as gaming and actively engaging with others on social media have greater intent.

Whereas television once was the singular option for screen time, it is now not uncommon for an individual to be dual or even triple-screening (Dias, 2016). This is where someone may be watching television, whilst simultaneously on their laptop and possibly also on their smartphone or tablet device at the same time. This saturation of screens highlighted the flaws of multitasking, where one's attention could be divided across multiple streams of information concurrently, thus diluting the effective completion of any singular task (Fernandes & Moscovitch, 2000). Whilst this may not have significant ramifications for personal downtime, where someone opts to use multiple devices concurrently, it has the potential to create habits that permeate educational or workplace settings. The use of multiple screens at once could possibly indicate that an individual is in a perpetual state of craving engagement and entertainment to the point where they find it difficult to commit to a single stream of information to satiate their digital appetite (Kim et al., 2018).

9.6. Technology Acceptance and Motivations

Technology acceptance was determined by how motivated individuals were to attend to certain tasks. However, it can be posited that this has always been the case. It can be argued that the significant onus has always been on the teacher to create dynamic lessons that address the needs of all students and the multitude of learning styles present within the one room (Roeser & Peck, 2009). The findings of this research indicated that students considered it challenging to attend to learning tasks when motivation and interest in the lesson waned, irrespective of whether ICT was used or not. Teachers are tasked with communicating a curriculum and specific content that addresses prescribed objectives that cannot necessarily be tailored to the interests of all. It is a fortunate teacher who can make a connection with all the students who sit in front of them; however, the reality is that often the majority of the class have differing interests, motivations and abilities to focus, regardless of the subject.

9.7. Perceived Efficacy of ICT Integration

The teachers who were interviewed expressed a range of views that were both positive and negative, highlighting the complex and multifaceted quandary that technology integration poses to education (Aagaard, 2016a; Bingimlas, 2009; Buabeng–Andoh, 2012; Lisenbee, 2016; Taneja et al., 2015; Tondeur et al., 2010). It was clearly identified that there was not a one-size-fits-all approach to how devices were used, and teachers had to develop teaching methods and the integration of digital resources that both met their needs, but also their students' capabilities. The inclination to integrate technology was dependent on how beneficial the individual teacher perceived it to be. Where a teacher saw it to be an inconvenience, or an imposition on their time to upskill, they were more inclined to either maintain or revert to more traditional teaching methods. This is not to say that reverting to traditional methods of teaching was detrimental to students' learning. As is the reality in the contemporary classroom, the key term in technology integration is *integration*, as opposed to replacement. Students who regarded their teachers as proficient technology integrators considered their key skill to be how to enhance their learning through new and exciting tools, whether this be the gamification of learning, the interactivity offered by online resources, or simply communicating with visuals that go beyond the scope of traditional materials. Students, for the foreseeable future, will continue to be reliant on the relational aspect of learning that is instrumental to student motivation (Hagenauer et al., 2015; Lee, 2007; Modi, 2015). Real time feedback, the ability to have synchronous feedback (both written and verbal), and the dynamics of the classroom environment are all essential elements to learning (Erstad et al., 2015; Frey & Osborne, 2017).

No student expressed a sentiment that their technology had made their teacher redundant in any capacity. As commentary grows regarding how education will eventually evolve into a fully digitised experience (Craft, 2012; Erstad et al., 2015; Halloran & Friday, 2018), it should be noted that the role of the practitioner, or *sage on the stage*, will continue to play a significant role in the learning of young people for some time to come yet.

This abundance of information presented the challenge to many teachers to work out how to manage it all. Both teachers and parents expressed how the wealth of information did not, by osmosis, make anyone more knowledgeable. Therefore, the role of the educator is to take the plentiful information available and, through effective pedagogical practice, help students convert it into knowledge and understanding (Abrami, Venkatesh, & Wozney, 2006; Edwards & Cheok, 2018; Erstad et al., 2015). The delineation here is what qualifies as flexible learning. This is where an individual is able to apply what they have learnt to scenarios and problems they have not yet faced. It requires the individual to attend to critical thinking skills, as opposed to retaining rote facts (Foerde et al., 2006). In the Information Age, this skill will prove to be significant. With facts and figures accessible at the touch of a finger, the ability to simply recall information will no longer be regarded as an essential proficiency to a variety of scenarios. What will be more useful is how this information can be critically interpreted and applied in ways that are not accessible through a mere search function (Fernandes & Moscovitch, 2000). As referred to in the literature, Carr (2011) analogises the information we have access to as the ocean, where, for the most part, we jet ski over the top of it, shallow and at speed. However, to develop a richer understanding of this information, it requires a deep dive to find useful answers. In an era where distinguishing which information is the most reliable can be difficult (Levitin, 2014), the teachers interviewed considered it a significant challenge to help students discern the ‘wheat from the chaff’. It is therefore the challenge not only for the student, but all educational stakeholders, to ensure that the information that is being accessed is the most dependable. Students must learn to be critical in the information they consume and vigilant in their research methods to ensure that the resources they are gathering are the most appropriate. This could involve learning skills to apply more advanced search terms, delve beyond the first page of search engine results, and the verifying of sources to ensure they are reliable.

Some students expressed an interest in receiving more guidance and direction in how to appropriately use their devices. However, the guidance they sought was more to develop metacognitive strategies to address their inability to focus in the face of so many incoming distractions. No students interviewed expressed any resistance to technology or its integration due to being unable to use it properly, as far as functionality or access to ICTs were concerned. The perception of their own digital literacy indicated that they felt equipped to engage with the variety of ICTs at their disposal. However, their teachers provided a different understanding of how these skills applied to schoolwork. It is a fallacy to assume that children have, due to being born in a digital era, inherent skills that make them more proficient with technology (Bennett et al., 2008; Kivunja, 2014). The way that adolescents engage with technology socially and recreationally does not necessarily translate to the skills required for learning and digital literacy relevant to the classroom. It was expressed, with surprise, by one of the interviewed teachers that students could reach senior secondary and still not have basic skills such as uploading attachments to emails. This highlighted how there was still a need to teach technology skills instead of assuming that adolescents arrived to school equipped with such fundamental proficiencies.

The decision-making process about ICTs is often removed from the individual teacher and is usually mandated by tiers of management above the classroom practitioner (Ottestad, 2013). The separation between those who mandated the use of technology and those who were tasked to integrate it on a practical basis was cause for consternation amongst some teachers. This resistance to technology integration occurred when the teacher did not see the tangible academic benefits to their practice. Sometimes this was related to the practical issues related to how software functioned and other times it was more that teachers did not consider the technology to be a superior teaching tool to more traditional approaches.

The tests administered in this research sought to gain an insight into the demands on cognitive load that were posed by multiple streams of concurrent information, where a student may be interacting with a device that is being used for both school tasks and recreational purposes at the same time. For students who were required to address learning objectives, often under the constraints of time, it was important to acknowledge the implications associated with the integration of ICT into lesson plans. Cognitive load theory highlighted how a heavy cognitive load, where students were required to combine a range of mentally challenging tasks concurrently, could present learning challenges as the result of students being required to split their attention across often incongruent information streams (Chandler & Sweller, 1991; Kalyuga & Liu, 2015; Sievertsen, Gino, & Piovesan, 2016). As extraneous information, such as that made available by personal devices, could diminish the effectiveness of a lesson, teachers could seek to monitor what students accessed. It should be noted that this does not suggest that the role of the teacher is to devise lesson plans which only address the most essential parts of the curriculum, without any flexibility to deviate and provide interpretation and expansion. It does, however, suggest that the teacher should be able to exercise their control over the learning environment and remove the distractions that come from interfering sources. On a practical level, this approach is not always as straight forward as it seems. Whilst teachers deliver their lessons and assign the associated tasks, there is an implied level of trust that must be achieved between student and teacher for productivity and motivation to be maintained (Lee, 2007). Whilst an authoritarian teacher, with firm rules and expectations in place, can be confident that they have their classroom under control, the motivation of their students has the potential to be stifled (Roeser & Peck, 2009; Ryan & Deci, 2000). As the literature suggests, when a student felt unmotivated or disengaged in a lesson, their propensity to seek alternative engagement from their devices could be increased (Risko et al., 2013). Conversely, a teacher who was more lenient in their classroom management and afforded students considerable freedom and autonomy may also see the deleterious effects of unmoderated technology (Demirbilek & Talan, 2018; Taneja et al., 2015). With adolescents still developing personal approaches to self-regulate their behaviour and manage the distractive properties of their personal devices, unmoderated technology can be one of the most significant impediments to their focus (Aagaard, 2015b; Crogan & Kinsley, 2012; Risko et al., 2013; Voelke & Roebers, 2016).

Whilst some schools have systems in place to monitor the online activity of their students, this can create a significant commitment of observation that is not always productive or conducive to a positive academic culture (Alim, Cardozo, Gebhart, Gullo, & Kalia, 2017). A recurring theme amongst parents, teachers, and students was an implied level of trust that was required on all parts for technology to be seen as beneficial. Students reported being more engaged in lessons where they were able to interact with their devices, with some expressing the frustration associated when some teachers restricted their online access. For students who expressed that they enjoyed the increased access to technology, some were more motivated by the social aspects that it offered, as opposed to the enhanced learning opportunities enabled by ICTs. For parents at home, this trust-based model was an essential element that many interview participants referred to. Parents needed to make certain concessions that providing their children with technology came with a certain level of relinquished control. For all educational stakeholders then, the value of trust that comes with using technology was a key contributor to its effective integration (Van Maele, Forsyth, & Van Houtte, 2014).

Teachers lamented the fact that their classroom role now involved a considerable amount of patrolling and vigilance to ensure that students remained focused and on task. Whereas the content of what was on a student’s desk was once obvious by nature of the physical materials placed upon it, the supervisory role of the teacher had dramatically shifted to individual screens. The nature of every student having their own screen had physically rearranged the layout of many classrooms, where once the teacher could be confident that they could survey all in their domain while sitting at a desk at the front of the room. As the interviewed students indicated, they were least productive when teachers took this static approach.

A common approach that schools took is to restrict access to a range of websites that were deemed inappropriate. There was the obvious content that was prohibited (pornography, gambling, alcohol, etc.) and then network administrators could block additional content such as social media, video streaming, and gaming websites. Several students noted that they were more productive on their Wi-Fi enabled devices at school, compared to cellular data (which is readily accessed from smartphone devices without Wi-Fi), as accessing the Internet on their school's network would eliminate the distraction associated with a range of sites. However, with the increased access that students had to cellular data, many were now able to subvert the network restrictions due to not being reliant on the school's Wi-Fi. Some students referred to "hot-spotting", where they would use their 4G enabled smartphone to create their own wireless local area network (WLAN). In doing so, they could access content on their laptops irrespective of what network restrictions were assigned by administrators. This practice indicated that the control schools once had over what their students had access to had since been relinquished as part of widely implemented BYOD policies. Therefore, with students having access to all content, whether for academic purposes or not, the role of the teacher in the classroom was key.

Teachers employed a range of strategies to control how devices were used within their classrooms. Ensuring that students had their laptops closed or their tablet screens turned off whenever information was being taught ensured that the cognitive load of the individual was not overwhelmed by what was happening at the front of the classroom and what was happening on their device. Students could be encouraged to type their notes; however, the teacher should put in place firm expectations that stated students should only be using the keyboard if it was for note-taking or other schoolwork oriented tasks. It was important for teachers to accede to this need, as many interviewed students found that typing their notes was far more efficient than handwriting. This does not necessarily suggest that they process the information as effectively; however, it provided the diligent student with the ability to return to their typed notes after a lesson and encode them for flexible learning through handwriting them or expanding upon them further. Teachers should not need to compete for students' attention and restricting smartphone access during class time was essential. School A had clearly defined policies relating to mobile devices being banned in the classroom, whereas School B's guidelines seemed more ambiguous according to the accounts of teachers, parents, and students. It should be noted that since this research was conducted, the Victorian State Government has announced a ban on smartphones in primary and secondary classrooms from the beginning of 2020 (Henriques–Gomes, 2019). Whilst this policy does not apply to Catholic and Independent Sector schools, it could possibly have an impact on how individual institutions seek to align their own expectations with like schools.

9.7.1. Learning Platforms

Teachers and students alike found the online portal, in various configurations at both School A and School B, to be an incredibly useful aspect of ICT. These learning management systems (LMS) allowed teachers to deploy content, communicate in real time with students and provide assessment feedback. Online portals at both schools were not a replacement of teaching or lessons, but rather a repository for resources related to the content taught. This enabled teachers to upload materials that had been discussed in class or supplement their lessons with additional materials to extend their students. At both schools, parents were also able to access these portal pages and gained a digital window into the classroom that had previously not existed. Therefore, interested parents were able to view a range of details about what their child was currently studying.

The LMS enabled parents to be engaged with what was being taught and helped parents follow up on matters such as assessment tasks, due dates and marks published by the teacher. As a recurring theme amongst parents was the challenge faced with discerning whether their child was using their device at home for schoolwork or other purposes, the LMS provided a way to see what school work had actually been assigned. Teachers at School A also found the portal a useful tool to allow students to revisit lesson content. Whether it was for revision or just further clarification, video content created by teachers in their *Teach Me Again* section was a useful way of enhancing teaching with technology. The purpose of the videos meant that students could skip through content that they did not wish to view and slow down or repeat the information they may have missed during the real-time lesson delivery. Such an approach created a significant opportunity for students who may not necessarily grasp all details of a lesson instantly or were simply absent on the day. As was the most recurring theme throughout the interviews, from all three groups, distraction was one of the most significant forces that students were working against. Therefore, enabling students (who may have lost focus) the ability to revisit content post-lesson was a highly valued educational offering. Like all online repositories, the usefulness of the portal was dependent on the administrators of individual pages and it was evident that not all portal pages were created equal. The success of technology integration is ultimately dependent on the motivation of the individual teacher who must incorporate the digital tools at their disposal into their daily teaching practice (Khan, 2003; Rawat, 2015). Teachers were able to create content of their own or share resources from a wide variety of sources. With the Internet came connections that transcended cultural and geographical boundaries and teachers were able to access resources from online communities that were well beyond the physical constraints of their own schools.

Beyond online learning portals, students had developed their own channels and means for sharing materials. Even though the respective LMS at School A and School B were to provide a place for students to access materials and communicate, the students reported turning to social media platforms to discuss academic matters when they were not at school. Students communicated across the networks they felt most comfortable with, which recurringly was Facebook Messenger and Snapchat. Although Instagram presented as another key social media platform for students, it was not cited as having any relevance to schoolwork. The main communication difference between this app and Messenger or Snapchat is that the latter two enabled group chat. Often students would discuss questions, share notes or photograph and disseminate their own work to their peers via group chat, which Instagram did not have as a feature. However, the blurred line between using social media for socialising or schoolwork was a challenging one that presented difficulties for teachers, parents, and students alike.

A student needs to develop metacognitive strategies beyond the rudimentary tasks of how to interact with an operating system, search for information relevant to a learning objective, and produce content in a range of contexts. The ability to control the flow of information and delineate between what is relevant for the objective and what must be eliminated, either because of distraction or irrelevance, is key to digital literacy (Kivunja, 2015).

Students declared that they used social media apps because they felt that it was the most effective and efficient way to reach their peers outside of school hours. The assumption held by most was that their classmates would be online, and therefore could be contacted regarding any queries they might have about homework tasks they may be faced with. Outside of school, students turned to each other more than their teachers. It should be noted that no student suggested that they communicated with their teachers over social media channels. The policy in both School A and School B was that communication within the professional boundaries of the teacher/student relationship should only be conducted via the appropriate channels, and in this instance, with email or through the LMS. Email was the primary method of non-verbal communication between student and teacher, though students suggested that they used email for nothing else. The challenge this presented teachers with was that they could not necessarily rely on students to check their email. Even if their perception of their students was that they were consumed by their devices and were perpetually online, the places they spent their time online were usually far removed from lesson related content.

9.7.2. Tensions Between Stakeholders

Parents, teachers, and students all identified a range of tension points that arose as a result of technology integration. Interestingly, there was not as significant an amount of discord between parent and teacher expectations and how the dynamic of technology disrupted home life and vice versa.

There was an acceptance by all groups that technology was there to stay and consequently needed a range of strategies to be managed effectively. Whereas some in public debate called for extreme measures such as blanket bans of technology or the removal of certain devices, this was not stated as the sentiment from participating teachers, parents or students. The acceptance of ICT in education was universal, yet it did not render it impervious to criticism. Parents were overtly supportive of the initiatives that were introduced to the schools where they had their students enrolled. As the onus, both financially and logistically, was on parents to provide their children with their devices, they had a role to play in how it was effectively managed.

Parents were reliant on their children having a smartphone as it provided them with an essential means of communication. Only one student reported having a smartphone that was not Wi-Fi enabled; however, she noted that this had recently been upgraded and she was all the more pleased with the new technology. In addition to their smartphone, all students who were interviewed had at least one additional device, in either a laptop or a tablet, and had had access to a personal device since at least the commencement of Year 7. As parents supplied their children with a device that they knew could have deleterious ramifications for academic performance, there was a recurring acceptance that they had to introduce household rules to manage the situation. The rules, or expectations, varied significantly from household to household. The majority of parents operated on a basis of trust and open communication, where the key to managing technology successfully at home was maintaining a certain level of flexibility.

Many parents referred to their rules at home being an evolutionary process and one that adapted with the needs of the individual child. They conceded that as their children grew older, exceptions needed to be made for not only the increased academic needs that technology presented, but also the social demands of the maturing adolescent. Issues arose for some parents who had to institute different rules for different members of the family and often this could create tension between siblings who were afforded different privileges. Some parents also declared that the task of managing technology in the home was compounded by expectations of modelled behaviour. For many professional adults, they were as enthralled by their own devices as their children were. Although the way in which they used their own laptops, tablets and smartphones differed significantly from their children, their activity still fell under the umbrella term of screen time. Some parents were high level consumers of technology, whether as a by-product of their profession or simply because of their online recreation and noted that they had to be aware of how their own screen use was perceived by their children. Expectations such as no screens at the dinner table were common amongst many parents and some acknowledged that this was a challenge for themselves, as adults, to adhere to. Therefore, parents could consider being cognisant of modelling behaviour for their children lest they create conflict arising from possible hypocrisy. It should be noted that parents and their children need not abide by all the same rules (just as it would not for other standard household activities such as bed time, consumption of alcohol, and what they can watch on TV, etc.); however, there is merit to setting an example for children to follow.

Just as adolescents interact and develop beyond the watchful gaze of their parents, so too should they be able to use their devices for private communication and social interactions. The tension arose where the parent, who is the provider of the technology, sought to fully control how their child used it. However, there is a risk that this more authoritarian and invasive approach did not engender values based on trust. Parents who sought to control the online behaviour of their children could be well served by adapting their expectations to suit the technology that presents such challenges. This could be done by open communication, establishing an understanding of expectations and helping children to know what is appropriate online behaviour and what is not. For some children it may not necessarily be that their online behaviour is inappropriate, but rather it is the time spent online that creates a point of tension between parent and child.

Whilst some teachers may have minimally integrated ICT into their teaching practice, no teacher reported having absolutely no need for it whatsoever. Not only was it the primary tool for disseminating information to students, but it also acted as the conduit between the classroom and the actively engaged parent. Teachers were aware of the dichotomy posed by asking students to use a device that would inherently be geared towards distracting them. A range of strategies were reported which sought to address classroom behaviour and encourage appropriate use of technology amongst students. Rudimentary techniques such as standing over the shoulder of, or behind, students was an effective way for students to be held to account. As the results of the qualitative data suggest, when the teacher remained static and at the front of the class and without direct view of students' screen activity, it ostensibly offered students the freedom to use their technology for whatever purpose they so wished. For the more motivated student, the watchful eye of the teacher was not the only condition under which he or she would work. However, for the student who felt disengaged, the lack of active supervision by the teacher was considered a green light for them to stray from the assigned schoolwork. Many students discussed ways of presenting an appearance of productivity to their teacher, with the ease of switching between screens being a common tactic for students who noticed their teacher was closing in on them. The challenge that this presented was the resumption lag associated with constant task switching. Using devices that are equipped with apps that are inherently designed to distract and interrupt focus was therefore problematic if these interruptions cannot be either removed or at least reduced. App designers, in the attention economy, are tasked with creating user experiences that not only engage the user's focus, but also leave them desiring more. Functions such as the bottomless feed of Instagram, or the pull-down refresh motion that is designed to replicate a slot machine, are all intentional design features to influence how people interact with their technology and are compelled to return to it, even without explicit reason or purpose (Hsu, 2017).

The satisfaction that comes from the validation offered by social media or the addictive qualities of gaming are contributing factors to how enthralling certain aspects of technology can be, whilst simultaneously detracting from the educational benefits that devices can also offer (Yang & Kim, 2018). For teachers who are tasked with combatting these disruptive apps and vying for their students' attention, it was important for them to be aware that they cannot compete with devices that are not moderated.

A more responsible approach to self-awareness and subsequent self-regulation would be a far more beneficial skill for the students to develop, where the teacher would no longer feel the pressure to constantly hover over students to ensure they are doing the right thing. Beyond alleviating this responsibility from the classroom, such metacognitive strategies would enable the student to approach learning with their devices more responsibly when not under the direct supervision of their observing teacher and to take ownership over their own behaviour. As homework is an inevitable component of the Australian secondary school system, it is important to be able to develop the skills that can be implemented at home where the learning is required to continue. The challenge at home is that there is no longer a supervising teacher whose mere presence can often create the pressure required to remain on task. At home, the student will often undertake their homework with little to no supervision due to the logistical constraints that come with the family environment, where a parent may not have the time nor inclination to linger over their child like a teacher in a classroom would.

The obligation of the teacher is to ensure that any integration of technology is both purposeful and justified. Gamification was a popular theme amongst students and teachers recognised the benefit of engaging their classes with interactive quizzes that provided real time feedback. The rationale behind such educational games is that this heightened level of engagement and motivation had the potential to eliminate the distractive allure of other online activities, as students were inclined to want to be involved with what the whole class was doing (da Rocha Seixas et al., 2016; Wells et al., 2018). If a similar online quiz was implemented, but in a situation where students where only encouraged to complete it, as opposed to compulsorily attend to it, then it is likely that the students with lower self-regulation would deviate from the assigned task. The workload of the teacher could be increased by having to devise strategies and outcomes that attended to the limited attention span of the adolescent; however, they could be buoyed by the fact that the Internet provided them with a repository of shared resources that previously would not have been conceivable.

The use of technology was regarded, unanimously, as being beneficial to education. Students felt more engaged, teachers were empowered by a wealth of digital resources and tools at their disposal, and parents considered digital literacy an important life skill beyond just school-based learning. The degree to how beneficial individual interview participants perceived technology to be varied, often dependent on their own relationship with technology. Students who self-reported greater skills at being able to self-regulate were usually more emphatic about using their devices for academic pursuits, whereas those who felt more at the mercy of distractions and notifications were less enthusiastic about ICT's role in the classroom. Similarly, parents who expressed concern over the distraction that their children's devices caused were more reserved in their support. Teachers had shared frustrations with students who exhibited ongoing behaviour issues relating to distraction in their classrooms and it was acknowledged that it was something that needed ongoing management. As with any disciplinary rules that include broad sanctions imposed on a group of students, it can often address the problematic behaviour in students but also can cause a feeling of injustice in those who have not committed any infractions, yet are still handled in the same way as their less diligent peers. The key for successful management of devices within the classroom is to maintain balance, purpose and flexibility:

Balance: Students should be encouraged to engage with their devices in meaningful ways, where the teacher has directed them to do so. Students who seek to use their devices within the classroom should be made aware of when it is appropriate to do so and equally when the devices should be put away or turned off. Teachers should consider the role that individual devices play in the dynamic of a classroom, where one student's screen has the capability of distracting a nearby neighbours within view.

Purpose: Learning objectives and the ICTs required to complete them should be clearly communicated. Teachers should seek to integrate technology that enhances learning through a range of resources and tools that would otherwise achieve less successful outcomes if non-digital methods were implemented. This means that teachers should not be enticed by the novelty or entertainment factor if it does not, at the forefront of its intention, contribute to the learning needs of the students. If students are not given distinct instruction and rationale for why they are using their device, it provides an opportunity for students to use their device for non-school related activities.

Flexibility: Teachers should use their perception of classroom environments and the atmosphere created by certain activities to inform their teaching strategies. They should encourage the use of personal devices at their discretion and based on their understanding of their students' behavioural tendencies and academic aptitude. Having blanket rules for all classes creates a level of disharmony and dissatisfaction in students, which could prove to be detrimental to successful learning activities. Therefore, if a teacher deems a class to be responsible and engaged enough to use their devices unmoderated, then it should be encouraged. If, however, the inverse is perceived, then teachers should proceed with caution regarding unmoderated technology. Factors such as age, lesson content, aptitude and motivation can all contribute to how inclined a student will be to divide their attention in class.

9.8. Informational Processing Theory and the Classroom

As previously stated, IPT contended that information must be attended to and rehearsed if the brain is to make sense of stimuli and commit it to long-term memory (Lauber, 2014; Slate & Charlesworth, 1989). As committing information to memory is likened to the processing power of a computer, dedicated cognitive resources must be allocated to the process (Dux et al., 2006; Marois & Ivanoff, 2005; Miller, 1956). For students, one of their primary learning objectives was to take the information they had learned during lessons and recall it at a later stage, such as during examinations. The education system relies upon standardised testing and assessment to quantify individual students' performance and compare them with a relative cohort. Whilst this clinical approach to children's learning and development is contentious for some, it is this quantitative data that enables people to best understand student achievement and performance. Interviewed teachers regarded technology as a useful tool in collating and disseminating results to both students and parents, where the analytics made available by the LMS provided overviews of how students were performing. Through the analysis of such data, teachers could develop practices that sought the right balance with ICT integration. As both teachers and students reported, distractions were targeted specifically at disrupting an individual's attention span with information that they find both rewarding and engaging. Wherever possible, distractions could be restricted as much as is practical and feasible within the classroom. Responsibility of this should be shared between teacher and student, with the teacher providing the main guidance. However, students could be encouraged to take ownership over their own learning and also seek strategies to avoid distraction in class. Although this rudimentary advice could just as easily apply to the school environment prior to the introduction of ICTs, the level of distractions have now increased significantly (Demirbilek & Talan, 2018; Tallvid et al., 2015).

9.9. Limitations of the Research

9.9.1. Scale

The small-scale nature of the study limited the generalisability of the findings to a broader student population. Although the results among the three procedures were not statistically different from each other, it appears that there was a statistical interaction between procedure method and the order in which the methods were presented. This last result could also be partly due to possible differences between classes; however, it is not possible to differentiate between ordering and classroom, in that each class only received one ordering of procedure methods.

9.9.2. Generalisability

The purpose of this research was to provide an insight on a relatively small scale into the learning behaviours within the classroom, with an intent to provide a certain degree of generalisability to the broader student population. Conrad and Serlin (2005, p. 362) described generalisability as the 'central bulwark' of educational research, where the discoveries made from a naturalistic quasi-experiment such as this can be applied to broader educational contexts. Whilst the context of this research was limited to specific schools, the design sought to build upon pre-existing literature that had identified the implications of digital distraction within the classroom (Beland & Murphy, 2016; Mendoza et al., 2018).

The purpose of generalising was to be able to make informed predictions about patterns of behaviour exhibited in a certain population. However, one must approach generalising with caution, as what might work for the majority might also neglect to factor in particular minorities within the context of schools. Lincoln and Guba (1985, p. 117) described this "reductionist fallacy" as one where decision making can be simplified and consequently reduce the understanding of more specific details. Circumstances such as individual attitudes, aptitudes, and motivations can all influence an individual's approach to interacting with ICTs in the classroom; however, the findings offer a degree of generalisability. Ritchie et al. (2013) contended that there are three separate, yet linked concepts that underpin research generalisability. Firstly, representational generalisation, where the research findings can be justifiably considered a fair representation of the overarching population from which the sample was taken. Secondly, inferential generalisation, where findings can be inferred to settings or contexts beyond the sampled one. Thirdly, drawing upon theoretical propositions, principles or statements from the research for more general application. However, Lincoln and Guba (1985) suggested that research based on small numbers may require an alternative way of addressing generalisability. Instead of asking how likely the findings are to exist in other instances, the notion of transferability asks to what extent the findings *could* be transferred to other instances.

9.9.3. Quasi-experimental Design

A valid within-subjects design for this study would require the video and test associated with each video to be known to measure the same underlying construct and for the difficulty level of each video/test combination to be consistent. While challenging, this could be achieved through trialling the use of a single participant group of appropriate size and having them complete all video/test combinations, but without changing the procedure. In this way, any variation in test results, which is an indirect measure of their retention of the video content, could be compared using either multiple independent samples *t*-tests or a repeated measures ANOVA. It would be necessary using this approach to identify video/test combinations that demonstrated no significant difference in the overall test result. Additional validation could be achieved by combining all results across the treatments and completing an exploratory factor analysis (EFA) using the raw grading values. If the three video/test combinations were measuring the same underlying construct, a single usable factor should be evident. It should be noted that each item in the tests were marked as either correct or incorrect. EFA uses common variance in item responses and this variance must be adequate to allow a robust factor solution to be identified (Field, 2013). While EFA can be done using items with only two values, such as was used in this study, using multiple choice options for participant responses would provide a more robust analysis to be conducted.

Future designs that seek to replicate this quasi-experiment should seek to control for the different video and test combinations. This would enable researchers to identify more accurately whether the variability within the test results arose from the video, the tests, or the procedure administered. Consideration should also be afforded to the conditions of moderated and unmoderated technology. These generalised terms should be further clarified to ensure that the way in which technology is used, or not used, can be more closely moderated during the context of the lesson. Whilst adding to the complexity of the quasi-experiment, classroom observations might also enhance understanding of how devices were used under the various conditions. Future experiment designs should factor in the measurement of distractions more accurately in order to determine what specific factors consistently intrude on lesson content, such as interruptions from websites, social media and gaming. The current study did not specifically identify what distractions, if any, impeded lesson retention.

9.9.4. Privacy Concerns and Resistance

The *interviewer effect*, where participants respond differently depending on their perceptions of the interviewer, is a consideration worth noting (Denscombe, 2002). The way in which a respondent reacts to the gender, age, and ethnic origins of the interviewer can have a bearing on the outcome of their responses. However, the extent to which this effect occurs relates to the content of the topics being discussed and the relationship between the interviewer and participant.

Denscombe (2002) warned that participants might provide answers that fulfil perceived expectations of their interviewer. Hill (2006, p. 82) cautioned that children could be "highly sensitive to the context in which research takes place". As the researcher was a member of staff at School A, students may have felt compelled to provide answers that would best please a teacher at their school. *Demand characteristics* are where the interviewee is influenced by what they think the situation requires (Gomm, 2008). Therefore, questions relating to their inappropriate use of technology within the classroom may have resulted in more restrained responses than if the interviewer was a wholly unknown and unrelated entity to school life. Conversely, in School B, students may have felt a level of unease or intimidation regarding an unknown entity being placed in their school for this interview process. This scenario may have created a situation where students were more reserved or restrained in their responses to a range of questions.

Students were resistant to the administered tests, regardless of their function being primarily integrated into the science curriculum. The rationale behind the naturalistic quasi-experimental design was to ensure that minimal disruption was caused to students who were participating in the three tests within the classroom environment. However, there was an unexpected reticence from students to provide consent to have their test performance included in the research, even though they had to undertake the tests regardless. A recent survey from the US outlined that there is increasing concern regarding the collection and subsequent use of student data. The report outlined issues such as a lack of transparency, barriers to opting-out of sharing data, and inadequate training relating to ICT privacy for teachers, as some of the overarching concerns relating to technology use in schools (Alim et al., 2017). Closer to home, a survey conducted by the Australian Education Union found 74% of teachers were concerned about private data being collected and used in the absence of conversations relating to privacy, ethics, or the sharing arrangements of school-based data (Lingard, Sellar, Hogan, & Thompson, 2017). Although not all factors were directly relatable to the research undertaken here, the theme of resistance to sharing data (regardless of its assured anonymity) had to be taken into account when statistically analysing data. In particular, School B's, where a considerable amount of students did not consent to their results being used.

This resistance was considerably more evident in School B, where 40 out of 92 students did not provide consent for their data to be used in the research. Possible factors influencing this majority response to deny the sharing of their test results could have been a concern for privacy, the sharing of data, and a lack of understanding of how their data would be used. It is also worth considering the implications of teenage peer pressure and how the mentality of some may have influenced the decisions of others. Measures were undertaken to outline that all data collected would be anonymised, through written communication and as outlined by the participating teachers, yet the predominant difference between School A and School B is that at the girls' school, the lead researcher was an unknown entity. This differed to School A, where the lead researcher was an established member of staff and this name recognition may have created a sense of familiarity or ease that was not established at School B. Although the entirety of communication regarding the process of this research, all ethics forms and subsequent documentation, was from the university, the familiarity or recognition of the teacher's name may have aided in students being more willing to participate. In addition to this, ongoing access to the participating teachers and the open dialogue that existed prior to, during, and post the quasi-experimental design, were beneficial to the data collection process. The researcher's position within the school as both a teacher and active researcher ensured they were available to answer questions and address any concerns relating to all stages of the research. However, determining whether students' familiarity with the researcher or the researcher's mere presence within School A contributed to the greater participation of students is difficult to assess. This accessibility throughout the data collection process should be taken into consideration, and adversely, the absence at School B may potentially have limited the willingness of students to become involved in the research, where no figure was accessible to address any such concerns (albeit having had information sheets with contact details disseminated to all relevant participants).

At School B, the researcher's visits to the school were contained to several scheduled meeting times with school leaders, though interaction with any students only occurred after the tests were administered, and only with nominated interview participants. An initial discussion of the project, a delivery of the materials, and two final visits to conduct qualitative interviews was the total sum of the researcher's presence at the school. In the absence of the researcher, the onus for managing the data collection was solely the responsibility of the head of science and another participant teacher. Their capacity to communicate all key details of the research, its function, purpose, and relevance may have been limited. Consequently, their ability to promote the undertaking to its full extent and endorse its significance may have been restricted by their distance from the overall research goal.

9.9.5. Containment

Conrad and Serlin (2005) noted that effective educational research must be contained, lest it attempt to discover and understand phenomena so broad that it dilutes the initial goal of addressing more specific research questions. They advised that "any study must set limits, that is, restrict the scope of its investigation. And it would be an epic study indeed that gave full treatment to all of the contextual factors of an investigation" (Conrad & Serlin, 2005, p. 479). As the study was conducted on a specific subject area, within a specific year level, the application of the results to a broader context within schools may be somewhat limited. Factors such as age, interest in the subject matter, and even conditions relating to what day of the week and time of day, all have the potential to influence a student's response to formalised testing (Dills & Hernandez–Julian, 2008; Pope, 2016; Sievertsen et al., 2016). For example, Sievertsen et al. (2016, p. 2621) found "for every hour later in the day, test performance decreases by 0.9%" and suggested that the influence of external factors such as these should be controlled for when considering factors that may influence standardised test scores.

The topics introduced to the students through the videos were chosen on the basis that the content would be unfamiliar and new to the students. However, students may have been exposed to similar content or concepts prior to their tests, which may have allowed for a more informed understanding of the test questions relating to the video they had just viewed.

9.9.6. Academic Context

The academic standard of both School A and School B and the overall academic aptitude of the student population needs to be afforded consideration. As students with higher levels of intrinsic motivation may be considered better at regulating their behaviour (Ryan & Deci, 2000), it would be worth researching schools where the population does not share the same traits as these higher performing schools. With regard to performance on the Victorian Certificate of Education (VCE) in 2017, School A was ranked 5th and School B ranked 18th out of 532 schools (Better Education, 2017). Therefore, the influence that technology had on the retention of lesson content needs to be investigated in schools from a broader range of schools, where academic performance is not confined to institutions within the top 1% and 4% of the state respectively.

9.10. Summary

This chapter presented the overarching themes that had been identified from both the quantitative and qualitative data collection. It referred the findings back to the previously established research questions and discussed how the efficacy of technology was perceived by key stakeholders. Incongruity between perception of ICTs and their actual role within the classroom were identified due to no statistically significant result being found throughout the quasi-experimental design. This alluded to the notion that, whilst there may be differing views relating to technology and its role in the educational landscape, it may not necessarily be as detrimental as previously considered.

Chapter 10: Conclusion

10.1. Introduction

The purpose of this chapter is to draw conclusions from the research that has been undertaken. It seeks to highlight the areas of scholarship that have been contributed to and how, in future, the area of technology integration and adolescent learning can be further investigated. It makes final recommendations, based on a combination of evidence and prediction, to ultimately conclude the thesis.

10.2. Significance to Scholarship

This research sought to identify under what levels of technology integration students were able to retain and recall lesson content. The capacity for ICTs to distract students and interrupt focus was a primary interest and the research sought to build upon the literature, much of which highlighted the challenges that education faces in the digital age.

The qualitative interviews aimed to identify how parents, teachers, and students perceived technology for learning and whether perspectives were aligned or incongruous. Responses suggested that distraction was a concern shared by parents, teacher, and students alike. Yet, the quantitative data, interestingly, did not establish any significant difference between the different levels of ICT integration within the classroom. This finding contributes to the often lopsided debate surrounding technology for learning, where its negatives can often be discussed extensively, whilst the positives enabled by effective integration are drowned out. Whilst the concerns raised by interview participants were valid, the research did not posit that the integration of technology as a whole is a detractor or negative from the modern-day educational experience. Contrarily, ICT in all its various forms offers a rich multiplicity of options to the educator. Within the classroom, content can be delivered digitally, traditionally, or in a blended combination of both.

10.3. Recommendations

Schools should look to explicitly teach facets of digital literacy that address metacognitive strategies and the importance of self-regulation. An awareness of resumption lag, the academic implications of divided attention, and the challenges of heavy cognitive load were all important aspects that related to how a student focused at school and beyond. It therefore could not be assumed that adolescents had developed these skills by default of how much time they spent online (Kivunja, 2014; Prensky, 2010). It is the fact they spent so much time online that necessitates a deeper level of education to ensure that it can be time well spent, for a range of purposes. Students should not be taught or made to feel as if the technology they use is illicit or detrimental as its default setting. As is the case with any behaviour that has addictive properties associated with it, the peril is in the absence of moderation, as opposed to its mere existence. Therefore, outright bans, fearmongering, or dissuading students from being online, all run the risk of creating a perception that technology is unhelpful or, in extreme cases, damaging to the individual (Koksal, 2013). Encouraging awareness and understanding of both the positives and the negatives of technology should seek to create a balanced and pragmatic approach to using it at school, at home, and as is the nature of the portable device, everywhere else the individual should choose to take it with them.

Teachers can enhance classroom engagement with learning tools, gamification, collaboration between peers who are both local and distant, offer creative outlets with software and hardware, and better reach an audience who have a predisposition to engage with digital devices in all other facets of their daily life (da Rocha Seixas et al., 2016; Gregory & Lloyd, 2010). Therefore, it would be misguided for teachers and parents to ignore the scope of possibilities available to them in a technologically advanced educational landscape. However, any integration of ICTs should be tempered with thoughtful and considered application of how they could benefit the practice of teaching and learning. Often there can be a rush to integrate new applications, devices, and initiatives that are alluring by default of their newness. Yet, pedagogy does not advance at the same rate as technology, which increases exponentially in power with every year that passes (Holt, 2016).

The ongoing tension between teaching practice and the impetus, if not obligation, to integrate technology has long preceded the Internet age. Cuban (1986, p. 4) described it as the “fickle romance” that teachers have with technology and how it is meant to aid instruction. In his book on classroom technology use throughout the 20th century, much of what is described from several decades ago is still evident in today’s teaching practice. Concerns about the logistics of use, technical imperfections, and an incompatibility with teaching programs have all been factors contributing to the resistance to technology integration, ever since equipment more advanced than the pencil and paper has been introduced into classrooms (Cuban, 1986).

The present model of school-based learning has been replicated the world over for centuries, with many elements of the post-industrial classroom being evident in that of the 21st century one. The main difference in contemporary society is that today's students are immersed in a technologically rich and online environment (Anderson & Rainie, 2012; Courage et al., 2015). Traditional education, which is based around teacher-centered instruction, remains fundamentally unchanged in its core goals. Its purpose is the transmission of facts, knowledge and ideas from one generation to another in an attempt to develop understanding and an ability to apply this knowledge flexibly in circumstances beyond the student's own education (Larsen, 2012). The process of didactic instruction, quantitative assessment of a student's ability to retrieve said instruction, and a repeat of this process in incremental stages of difficulty annually throughout the stages of a student's life, remains relatively unchanged (Lang, 2016).

What has changed significantly is the audience who now consumes the content delivered by the teacher (Erstad et al., 2015; Kivunja, 2014). Due to the ubiquity of technology and their propensity to be consistently engaged by their devices outside of the classroom, adolescents are predisposed to seek immediate gratification and have a limited capacity to afford towards instances that do not capture their interest or attention (Blackwell et al., 2016; Cranor et al., 2014). The immediacy of their communication with family, friends, and peers; their habitual inclination to check their devices regularly; and their dependence on the multitude of social and psychological imperatives of a life lived online, all contribute to the ongoing commitment to technology that is demanded by the digital age (Deloitte, 2017; Posso, 2016).

For an adolescent to be removed or separated from this level of connectivity, it can have implications that may seem both foreign and unfounded to a generation of outsiders who have not developed the same level of engagement, if not dependency, on technology (Wolfe, 2017). Therefore, teachers and parents must acknowledge that the way today's school children learn and interact is dramatically different from their own lived experience. Expecting social mores and learning environments to have remained the same, whilst everything else around them has progressed, would be attaching one's predilection for nostalgia over progressing with the status quo.

As discussed, technology's primary hindrance to learning is its propensity to distract from the prescribed objectives of the lesson, activity or instruction (Aagaard, 2016b; Beland & Murphy, 2016; Mendoza et al., 2018). An individual's capacity to recall and retrieve complex information is impeded by divided attention, where one's cognitive capacity is limited to only processing a limited amount of information at any one time (Craik et al., 1996; Fernandes & Moscovitch, 2000). A student who is digitally literate or born after a certain arbitrary date does not by default have an increased capacity to attend to multiple cognitively taxing tasks concurrently. Hill (2006) contended that assuming young people are predisposed to being more proficient with technology is an oversimplification. Therefore, a student must be conscious of their proclivity to multitask, which requires a certain level of self-regulation and awareness to address (Eisenberg et al., 2014).

10.4. Research Questions

Research questions 1 and 2 sought to investigate how varying levels of technology integration affected lesson content retention. From unmoderated ICTs through to traditional pen and paper, students were tested to see how different levels of access to technology enhanced or impeded their ability to respond to test questions. The value and perceptions of ICT integration can often be incongruous with its actual use. With no statistically significant differences identified from the experiment design, the results suggested that devices in the classroom are not as detrimental as stakeholders perceived them to be.

The quantitative data collected from the two schools does not necessarily align with the varying perspectives that came from male and female interview participants. Whilst many students who were interviewed made note of the negative implications that ICTs had on their learning, the quantitative data suggests that they were able to attenuate the distractions when assigned a specific learning task. Although male students expressed greater concerns with the distractive qualities of their devices, it is interesting to note that their performance on the tests were not significantly affected by the varying levels of ICTs. For the female students, their academic performance with traditional pen and paper methods was not notably higher than in the procedures where they were interacting with ICTs, both moderated and unmoderated.

Whilst a recurring theme abounds with regard to the distractive allure of technology, this research highlighted how perception and academic outcomes are not necessarily always aligned. Parents, teachers, and students associated the use of digital devices as problematic, yet widely essential, which is the crux of the dichotomous debate surrounding technology's place in contemporary education. Seeking to address the issues that technology, and in particular personal devices, present by its complete removal would be misguided. Purporting the value of ICT and understanding its role within schools is key to informing best practice and appropriate use. A more optimistic and progressive approach towards technology, for educational use and beyond, would benefit all partners in the learning process.

Research questions 2 to 5 sought to investigate the perceived efficacy of technology for learning, as viewed by the key educational stakeholders in parents, teachers, and students. Eliminating distractions became increasingly difficult when the student found themselves subjected to lesson content that neither interested nor motivated them. The implications of this are significant, as it highlighted the increasing pressure on the teacher to create and deliver content to an increasingly fickle, yet demanding, audience who may deviate from the teacher's instruction if they deem it dull or tedious (Roeser & Peck, 2009; Ryan & Deci, 2000). As a result of this, teachers should ensure that devices are moderated effectively and that their use is task oriented and outcome based. Students conceded that their ability to attend to lesson content became diminished when their motivation was low. Students who once may have let their mind wander out the window or indulged in day-dreaming within the classroom are now subjected to a very different approach to mind-wandering and distraction (Risko et al., 2013). As opposed to the mind being able to subconsciously travel to other places, the constant stream of information that now comes from an individual's device eradicates any room for such wandering. Students considered the incessant stream of incoming data on their device as a hindrance to their capacity to attend to the learning goals which could be the most prescient task on their laptop or smartphone.

Teachers, parents, and students alike felt there was a greater need to learn how to attenuate distraction and improve the ability to focus. Metacognitive strategies and an awareness of self-regulation were skills that many felt should be actively taught at school to remedy the distractive qualities of the technology that schools were mandated to integrate into the curriculum. Gurbin (2015, p. 1579) highlighted the importance of this, stating "attention to effective metacognitive processes will help students to incorporate and fine-tune valuable skills while eliminating regulating efforts that are ineffective". Teachers lauded the many positives that came from integrating technology into their practice, and students suggested that their devices helped them learn in new and exciting ways that increased engagement. Therefore, the removal or banning of ICTs is not a logical solution and any educational administrators or authorities that consider this to be the viable option have not yet devised strategies to harness the potential academic benefits of technology for learning (Colker, 2017; Lang, 2016). Conversely, it could be misguided for educators to determine that the easiest way to manage technology is to assume that digital natives will inherently develop an ability to manage and purposively use their technology by osmosis, intuition, or merely by the fact that they are so engaged by their devices. Using technology for learning is a skill that is not developed solely by how an individual may use the same device for socialising, recreation, and entertainment (Eshet–Alkalai, 2004).

The key word, if such a contention was to be synthesised into a single word, would be *balance.* Without this balance, the debate around technology and adolescents would continue to be lopsided. The challenge, as was admitted by many students, was how to stem the flow of distraction and its enticements, when it was the very content that may be the escape to remedy the disengagement they felt from the class they were sitting in. The challenge for those who are charged with supporting adolescents in the digital age, namely parents and teachers, is to establish an understanding that technology, when used appropriately, can enrich and enhance life and learning in ways that previously were not possible.

10.5. Future Directions

The purpose of this research has been to further the understanding of how the ever-present role of technology within the classroom has considerable implications for the way in which teaching and learning is conducted. Future research could expand on this model of research through using a more extensive sample of students. Students in various key learning stages, in a variety of subjects, would enable a broader understanding of how adolescents engage with technology throughout their school careers. The sample population for future research should extend to schools that are more inclusive, address a broader socio-economic demographic and are located beyond metropolitan

Melbourne. A larger sample with a similar quasi-experimental design would enable a broader understanding of how students, in a variety of contexts beyond those explored at School A and B, retain lesson content in the face of varying levels of technology integration. Additionally, qualitative interviews would provide added depth to how a broader population perceives and accepts technology for learning. Future quasi-experimental designs should seek to remedy the flaws within this study design which did not adequately determine the commensurate difficulty of the assigned comprehension tests.

10.5.1. Scope and Scale

Although logistically difficult to implement in practice, future research would require a much larger number of classes, with several classes randomly receiving each ordering of procedure method. The scale of further quasi-experiments and the ability to implement tests across a broader range of classes would be dependent on a range of factors, such as school size and availability of participant classes. School A had a student population of 2,056, equating to around 250 pupils per senior school year level. Therefore, a school of this size would be an appropriate focus for further investigation. Furthermore, all six possible permutations or orderings of three procedures would be utilised, while ideally there would be a fourth procedure. The pen and paper instruction method involved the teacher actively monitoring the class, while in the two other procedures students took notes with and without moderation. An extra condition, with pen and paper without monitoring, would allow researchers to ascertain whether the effect of monitoring was stronger for notes on students' own devices, than for pen and paper recording, should this be of interest.

Future research could look to widen the scope and variation of schools invited to participate. This could include schools from government, independent, and Catholic sectors. Additionally, schools beyond metropolitan Melbourne could be included. The quasi-experimental design could be replicable beyond an Australian context as its overall structure is not confined to constructs such as location, culture, or language. Coeducational schools could also provide insight into the learning dynamic that occurs within a mixed sex school and whether this plays a role in the outcome. Further research could seek to identify whether the gender enrolment (all boys, all girls, or mixed) of the school has any relation to overall performance pertaining to this quasi-experimental design.

The context of the data collection was within the Year 10 science curriculum; however, the nature of the design would enable it to be adapted to a broader educational context. Conrad and Serlin (2005) suggested that a level of disenchantment can exist with educational research, where research conducted through universities can offer little tangible benefit to policymakers and those responsible for the reality of classroom teaching. Therefore, it is incumbent upon the researcher to provide both feasible and logical recommendations that can be derived from the research they have undertaken.

10.5.2. Age Considerations

Further research could seek to determine differences between age groups and how the ability to self-regulate and develop metacognitive strategies varies amongst different age cohorts within the school framework. As the ubiquitous role of technology becomes increasingly embedded in the classroom, to the point where its absence is more noticeable than its presence, longitudinal data collection could investigate whether the ability to attend to learning tasks in the face of digital intrusions and distractions becomes more manageable overtime. Such research could attend to the popular conception that digitally native students have an innate capacity to multitask across a range of media channels and devices, whilst also addressing the learning objectives at hand. However, cognitive load theory would suggest that no arbitrary period in which the child was born will by default engender them with superior abilities to divide their attention successfully.

10.5.3. Gender

Whilst this research qualitatively assessed the integration of technology and its implications for learning for both females and males, it did not necessarily seek to identify trends or comparisons between genders. In an extensive literature review of the gender differences in technology usage, Goswami and Dutta (2015, p. 51) determined that “gender has been attributed as a significant variable in explaining the technology acceptance behaviour of humans”. To attend to the disparity between genders, Orji (2010) suggested that further investigation is required to understand why (in some societies) there is a gender imbalance when it comes to technology proficiency and how this can be best attenuated. The acceptance of technologies, as per the TAM, could be used to identify differing motivations between gender (Scherer et al., 2019). Further research could seek to modify the quasi-experimental design to ensure that all variables were consistent for all participants. Subsequent data could then be used to better inform any comparisons that could be made between demographics such as gender.

10.5.4. Subject Areas

Further research would not necessarily need to be confined to the science curriculum. The rationale behind this original quasi-experimental design was to nominate content that could be objectively and easily assessed in tests with simplified correct or incorrect responses pertaining to the video content presented. If students were required to provide answers that were open to subjective interpretation, such as personal critique or analysis, then the variable of their test assessor would need to be factored into the results. However, exploring other subjects and course content would be a way to address the interest and motivation of the student and whether this has an overarching impact on how they attempt to focus on lesson content (Roeser & Peck, 2009).

With regard to the qualitative research, future interviews could be conducted by researchers who were independent and unknown to the participant, as was the case with School B in this research. This relationship between the interviewer and the parent, teacher, or student, may garner results of a more honest nature if the person they are revealing particular thoughts to was not connected to their school environment or community in any way.

For a similar quasi-experimental design to be implemented throughout a range of subject areas, consideration would need to be given to the content of the tests and the necessity for answers to be objectively marked. Should answers be required that are open to subjective interpretation, then the confounding variable may be too strong to properly quantify test results across a large cohort. In an effort to address more authentic and equitable assessment, Wiggins (2011, p. 89) stated that "reliability is only a problem when judges operate in private and without shared criteria. In fact, multiple judges, when properly trained to assess actual student performance using agreed-upon criteria, display a high degree of interrater reliability". Additional consideration should be given to the way in which students might engage with video content as the primary source of lesson delivery, as opposed to teacher delivered content. The rationale behind video delivery was to remove any variables such as the quality of the teaching, the consistency of content addressed, and the relational aspects that could influence how a student responds to their teacher's individual expectations (Klem & Connell, 2004; Lee, 2012).

10.6. Summary

Technology continues to advance at a rate which provides people with greater processing power, for significantly more accessible costs (Holt, 2016). Global connectivity means that the devices that permeate society are increasingly online and the opportunities that this presents are both exciting, multifaceted, and unpredictable. With the ever-increasing saturation of technology into daily life, the ramifications for education will continue to be significant. As technology becomes embedded into the way that individuals communicate, create and operate, its role will become one that is as standard within learning spaces as functioning plumbing and reliable electricity, if this is not already the case. With this era of technology, the phase of novelty that once drove its integration will pass and educators will utilise it for a range of functions that enhance learning, both actively (interactive teaching tools, gamification, self-paced instruction, etc.) and passively (sharing information, data and analytics). Augmented and virtual reality, game-based learning, advancements in 3D printing, cloud computing, increasingly affordable software and hardware, and cheaper devices will all contribute to the rich suite of resources that educators will have access to in a range of settings. With the passing of time will also come the changing in generations of teachers, with millennials infiltrating the profession and hopefully bringing with them an understanding and appreciation of the digitally native lifestyle. Students will enter the classroom with a high-level of familiarity with a range of devices and will expect that the technology they access outside of school will be available to them in school. Whilst technology will become increasingly embedded in social dynamics, it will not necessarily enhance the individual's cognitive capacity or mental processing power. Information that needs to be processed for later recall will still require full attention and traditional methods of teaching and learning will be one way to facilitate this. Technology will enhance the information that is available to teachers and students alike, yet its successful conversion from information to knowledge will be dependent on the individual's motivation to learn it.

At the centre of education are students, who should be encouraged to develop an understanding of how to maximise the potential of technology. In a life where the boundaries between online and offline activity become increasingly blurred, this affirmative approach should instil parents, teachers, and students with confidence in technology and its rightful place in the learning landscape.

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Appendices

Appendix A: Information Sheet

LEARNIN[redacted]ION

Research Project Information Sheet

Sacré Cœur

X March, 2017

Dear parents and students,

Both children and adults alike are faced with a constant barrage of technological interruption as the result of our hyperconected lives. In an age where distraction is one of the greatest barriers to productivity, it will be key for individuals to develop meta-cognitive strategies to find the balance between embracing technology and permitting it to hinder daily life.

Karl Sebire, in partnership with his supervisors, Associate Professor Sue Gregory and Dr Michelle Bannister-Tyrell at the University of New England, and Sacré Cœur, are undertaking a leading research initiative that will investigate the impact of technological distraction on learning. This emerging field is instrumental for students, parents and teachers to better understand the way that ICTs impact learning. The ubiquitous nature of technology means our devices are integral to educational, recreational and social contexts. Therefore, developing an understanding of how to achieve balance in the digital world is key to using technology effectively. Whilst 21st century education strives to embrace the Information Age, it is critical that strong pedagogical rationale and a balanced approach guides all learning goals.

STUDY DESIGN [redacted]

Participants: Year 10 Science Students, selected teachers and parents.

Lesson Facilitators: Sacré Cœur Science Faculty

Quantitative Study: Students will participate in a series of comprehension tests throughout the Year 10 Science course, whilst being exposed to varying levels of technology within the classroom. The purpose of this study will be to determine under which conditions students comprehend lesson content most effectively.

Qualitative Study: Students, teachers and parents that are connected to this study can volunteer to participate in an anonimised interview. The purpose of this interview will be to determine the perceived efficacy of technology use within an educational context.

The research will be lead by Mr Karl Sebire, in partnership with the School of Education, University of New England. Further details are tabled overleaf.

Regards, [redacted]

School of Education
University of New England
Armidale, NSW 2351
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Mr Karl Sebire
MEd, MDes, BComm, GradDipEd, MACE

Researcher

Appendix B: Assent Form School A

[redacted]

ASSENT FORM FOR CHILDREN

Research Project Learning in the Age of Distraction: Assessing the efficacy of technology integration on adolescent learning.

une
University of New England

Please write your name after 'I,', and tick the yes/no answer you want.	Yes	No
I, ……………………………………………………………………………., have read the Information Sheet for Students and any questions I asked have been answered and I understand them.		
I agree to take part in this work		
I know that I can change my mind at any time.		
I agree that any work taken and anything we talk about will be written about using an invented name.		
I agree to having my interview audio recorded and transcribed.		

Consent	Name	Signature	Date
Student			
Researcher	Mr Karl Sebire		

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Mr Karl Sebire
MEd, MDes, BComm, GradDipEd, MACE

Researcher

Appendix C: Assent Form School B

[redacted]

PARENTAL CONSENT FORM FOR CHILD PARTICIPANTS
Research Project Learning in the Age of Distraction: Assessing the efficacy of technology integration on adolescent learning.

Quantitative Study	Yes	No
I, ……………………………………………………………………………, have read the information contained in the Information Sheet for Participants and any questions I have asked have been answered to my satisfaction.		
I agree for my child, ___________________ to participate in this activity, realising that they may withdraw at any time.		
I agree that research data gathered for the study may be quoted and published using a pseudonym.		
Qualitative Study (Do not tick if N/A)		
I agree to my child being contacted to participate in a subsequent interview		
I agree to having my interview audio recorded and transcribed.		
I am older than 18 years of age.		

Consent	Name	Signature	Date
Parent/Guardian			
Student Researcher	Mr Karl Sebire		

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Mr Karl Sebire
MEd, MDes, BComm, GradDipEd, MACE

Researcher

Appendix D: HREC Approval

Ethics Office
Research Development & Integrity
Research Division
Armidale NSW 2351
Australia
Phone 02 6773 3449
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jo-ann.sozou@une.edu.au
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HUMAN RESEARCH ETHICS COMMITTEE

MEMORANDUM TO: A/Prof Sue Gregory, Dr Michelle Bannister-Tyrrell & Mr Karl Sebire

School of Education

This is to advise you that the Human Research Ethics Committee has approved the following:

PROJECT TITLE:	Learning in the Age of Distraction: Assessing the efficacy of technology integration on adolescent learning
APPROVAL No.:	HE17-150
COMMENCEMENT DATE:	26 July, 2017
APPROVAL VALID TO:	26 July, 2018
COMMENTS:	Nil. Conditions met in full

The Human Research Ethics Committee may grant approval for up to a maximum of three years. For approval periods greater than 12 months, researchers are required to submit an application for renewal at each twelve-month period. All researchers are required to submit a Final Report at the completion of their project. The Progress/Final Report Form is available at the following web address: http://www.une.edu.au/research/research-services/rdi/ethics/hre/hrec-forms

The NHMRC National Statement on Ethical Conduct in Research Involving Humans requires that researchers must report immediately to the Human Research Ethics Committee anything that might affect ethical acceptance of the protocol. This includes adverse reactions of participants, proposed changes in the protocol, and any other unforeseen events that might affect the continued ethical acceptability of the project.

In issuing this approval number, it is required that all data and consent forms are stored in a secure location for a minimum period of five years. These documents may be required for compliance audit processes during that time. If the location at which data and documentation are retained is changed within that five year period, the Research Ethics Officer should be advised of the new location.

[redacted]

Jo-Ann Sozou
Secretary/Research Ethics Officer

26/07/2017 A17/76

Appendix E: School A Approval

[redacted]

From the Headmaster

Thursday 18 May 2017

To whom it may concern

I write with regard to the following research project, which is being undertaken by Mr Karl Sebire [redacted]

> Learning in the Age of Distraction: Assessing the efficacy of technology integration on adolescent learning.

As Headmaster, I am most cognizant of the significance of this area of study given the impact on our young people. I am in support of Mr Karl Sebire working with students and staff from [redacted] in order to gather data and to investigate the impact of technological distraction on learning.

Yours sincerely

[redacted]

[redacted]

[redacted]

Appendix F: School B Approval

[redacted]

25 May 2017

To whom it may concern,

I write with regard to the following research project, which is being undertaken by Mr Karl Sebire [redacted]

Learning in the Age of Distraction: Assessing the efficacy of technology integration on adolescent learning.

As a School Principal, I am most cognizant of the significance of this area of study given the impact on our young people. I am in support of Mr Karl Sebire working with students and staff from [redacted] in order to gather data and to investigate the impact of technological distraction on learning.

With kind regards,

[redacted]

Principal

[redacted]

Appendix G: How to Speak Chemistrian Comprehension Test

HOW TO SPEAK CHEMISTRIAN	
1	**The chemical symbols we use in equations are called:**
/1	
2	**Atoms become ions by gaining or losing what?**
/1	
3	**Atoms that become an ion with a positive charge are called:**
/1	
4	**Atoms that have become an ion with a negative charge are called:**
/1	
5	**The most basic ions are formed from single atoms and are called:**
/1	
6	**How is the sodium ion written?**
/1	
7	**How is the chloride ion written?**
/1	
8	**What would you call the cation of potassium?**
/1	
9	**What would you call the anion of oxygen?**
/1	
10	**What comes first in the name of an ionic compound, the cation or anion?**
/1	

Year 10 Science: Comprehension Test
Condition: OA OB OC

Appendix H: Precipitation Comprehension Test

PRECIPITATION	
1	A precipitation reaction is best described as:
/1	
2	Precipitation reactions are important for industry mainly because:
/1	
3	What name is given to the ionic substance produced when metal ions combine with non-metal ions?
/1	
4	What type of substances can form precipitates?
/1	
5	Besides sodium, what other metal contributes to significant amounts of the dissolved salts in the oceans?
/1	
6	Sodium is a metal and therefore when dissolved in solution as a salt will form:
/1	
7	What happens when sodium chloride is added to silver nitrate in a beaker?
/1	
8	The advantage of just writing the net ionic equation when dealing with precipitate reactions is that:
/1	
9	What is the name given to the ion NO_3^- ?
/1	
10	Is NO_3^- normally soluble or insoluble?
/1	

Year 10 Science: Comprehension Test
Condition: OA OB OC

PRECIPITATION (Continued)			
11	**Explain why silver makes insoluble compounds with bromine and iodine as well as chlorine**		
/1			
12	**Why is silver represented as Ag? What does it stand for?**		
/1			
13	**Complete the following table:**		
/1	***Type of Ion***	***Charge on Ions***	***Element Type***
			Metal
Total	**Video**	**Student Name**	
/13	*www.youtube.com/watch?v=lIu16dy3ThI&t=43s* *(Video Length: 11:20)*		

Appendix I: Balancing Equations Comprehension Test

BALANCING EQUATIONS	
1	**What does a balanced equation do?**
/1	
2	**What does diatomic mean?**
/1	
3	**How do you overcome having fractions of atoms?**
/1	
4	**What must always be the same in a formula?**
/1	
5	**How do you know when an equation is balanced?**
/1	
6	**How can you make things easier if there are polyatomic ions (i.e. sulfate)?**
/1	
7	**What word can be used for the → in an equation?**
/1	
8	**Balance the following:** $Al + O_2 \rightarrow Al_2O_3$
/1	$Al + O_2 \rightarrow Al_2O_3$
9	**Balance the following:** $C_2H_4 + O_2 \rightarrow CO_2 + H_2O$
/1	$C_2H_4 + O_2 \rightarrow CO_2 + H_2O$

Year 10 Science: Comprehension Test
Condition: OA OB OC

BALANCING EQUATIONS (Continued)	
10	**Balance the following:** $C_2H_6 + O_2 \rightarrow CO_2 + H_2O$
	$C_2H_6 + O_2 \rightarrow CO_2 + H_2O$
11	**Balance the following:** $Fe_2O_3 + H_2SO_4 \rightarrow Fe_2(SO_4)_3 + 3H_2O$
/1	$Fe_2O_3 + H_2SO_4 \rightarrow Fe_2(SO_4)_3 + 3H_2O$
12	**Balance the following:** $CO_2 + H_2 \rightarrow CH_4 + H_2O$
/1	$CO_2 + H_2 \rightarrow CH_4 + H_2O$
13	**Balance the following:** $CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 + NaCl$
/1	$CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 + NaCl$

Total	Video	Student Name
/13	www.youtube.com/watch?v=RnGu3xO2h74 *(Video Length: 14:27)*	

Appendix J: Periodic Table Comprehension Test

PERIODIC TABLE		
1	State the periodic law	
/1		
2	How are the elements in the periodic table arranged?	
/1		
3	What particle can be used to predict the properties of elements?	
/1		
4	How many groups and periods are there in the modern periodic table?	
/1		
5	What groups can the element hydrogen be located in?	
/1		
6	What type of compounds does hydrogen form with metals and non-metals?	
/1		
7	When moving from left to right on the periodic table what properties increase?	
/1		
8	What are the letter names of the first 4 shells in atoms?	
/1		
9	How many electrons would it take to fill the third shell?	
/1		
10	The number of bonds an atom forms can be predicted by knowing what property of atoms?	
/1		
Total	**Video**	**Student Name**
/10	www.youtube.com/watch?v=ywvzPxBCarM *(Video Length: 11:22)*	

Year 10 Science: Comprehension Test
Condition: ○A ○B ○C

Appendix K: Hydrocarbon Comprehension Test

HYDROCARBON		
1	**What are hydrocarbons?**	
/1		
2	**What process separates the hydrocarbons found in crude oil?**	
/1		
3	**Why are alkanes saturated?**	
/1		
4	**What is the general formula of alkanes?**	
/1		
5	**What is the formula for pentane?**	
/1		
6	**Why are alkenes unsaturated?**	
/1		
7	**What is the general formula of alkenes?**	
/1		
8	**What is the name of C_4H_8?**	
/1		
9	**What type of bond is found in alkynes?**	
/1		
10	**What is the formula of ethyne?**	
/1		
Total	**Video**	**Student Name**
/10	www.youtube.com/watch?v=b2jPBviM7jI *(Video Length: 11:57)*	

Year 10 Science: Comprehension Test
Condition: ○A ○B ○C

	HOW TO SPEAK CHEMISTRIAN (Continued)
11	**Are anions predominantly on the left or right hand side of the periodic table?**
/1	
12	**What can you deduce about the copper ions in copper (II) sulfate?**
/1	
13	**What is the name of $HClO_3$?**
/1	
14	**What is the name of $HClO_2$?**
/1	

Total	**Video**	**Student Name**
/14	www.youtube.com/watch?v=mlRhLicNo8Q *(Video Length: 10:42)*	

Year 10 Science: Comprehension Test
Condition: OA OB OC

Appendix L: Quasi-experiment Design Information Sheet 1

Why should [redacted] care about this research?

The ubiquitous nature of technology means our devices are integral to educational, recreational and social contexts. Therefore, developing an understanding of how to achieve balance in the digital world is key to using technology effectively. Whilst 21st century education strives to embrace the Information Age, it is critical that strong pedagogical rationale and a balanced approach guides all learning goals.

Both children and adults alike are faced with a constant barrage of technological interruption as the result of our hyperconected lives. In an age where distraction is one of the greatest barriers to productivity, it will be key for individuals to develop meta-cognitive strategies to find the balance between embracing technology and permitting it to hinder daily life.

Karl Sebire, in partnership with his supervisors, Associate Professor Sue Gregory and Dr Michelle Bannister-Tyrell at the University of New England, and Sacré Cœur, are undertaking a leading research initiative that will investigate the impact of technological distraction on learning. This emerging field is instrumental for students, parents and teachers to better understand the way that ICTs impact learning.

Context
The ubiquity of technology demands that educators are constantly at the forefront of effective ICT integration and pedagogical practices to cater to the world of the digital native.

Significance
There is a need to investigate how adolescent students' learning is impacted by digital distractions in order to develop strategies to address this shift in attention and learning.

Intent
The proposed experimental design aims to determine how varying levels of ICT implementation impact Australian middle school students' processing of lesson content through the delivery of controlled content and subsequent multiple choice comprehension tests.

Current Literature
Students are now equipped with an abundance of ICT resources (Brand & Todhunter, 2015), with 99% of 15-17 year olds using the internet (Australian Bureau of Statistics [ABS], 2016). It is imperative to equip them with necessary skills to manage the distractions that come with such connectivity. Bennett, Maton, and Kervin (2008, p. 781) observed that "education has a vitally important role in fostering information literacies that will support learning."

Teachers are mandated to integrate technology in to their curriculum (Australian Institute for Teaching and School Leadership [AITSL], 2015) in order to address the needs of a generation of millennials that are considered by Howe and Strauss (2007) to be optimistic, team-orientated achievers who are talented with technology.

Although laptops can increase rates of in-class participation and student motivation (Fitch, 2004; Gulek & Demirtas, 2005; Stephens, 2005), Fried's (2008) study revealed that laptop use negatively related to several measures of student learning.

Some proponents of raising awareness to the detriments of technology suggest that this "rewiring" of the brain can have deleterious effects (Greenfield, 2015), where the need to constantly be engaged is impacting the ability to focus.

The NSW Department of Education and Training (2010, p. 7) contends that there is a need for more research to understand the "technological world of students."

Kivunja (2015, p. 167) affirms that educators, from preparatory through to tertiary, must "preserve the essentials" of 20th century education whilst acknowledging that 21st century tools must be embraced for this new learning paradigm.

This call for further research is echoed by a multitude of researchers who have studied a range of implications of technology on learning in recent years (Ackerman & Goldsmith, 2011; Duncan et al., 2012; Mangen et al., 2013; Mueller & Oppenheimer, 2014; Sana et al., 2013).

www.karlsebire.com

Appendix M: Quasi-experiment Design Information Sheet 2

EXPERIMENT DESIGN

Learning in the Age of Distraction: Assessing the efficacy of technology integration on adolescent learning.

H_0 Digital devices do not impact comprehension of lesson content.
H_1 Digital devices negatively impact comprehension of lesson content

Population: Secondary School students
Sample: Middle-senior school students from two Melbourne secondary schools. (n 120)

Over a semester of coursework, students are delivered 3 lessons and are tested at the completion of the lesson to determine their level of comprehension (dependent variable) of the lesson just delivered.

Over the 3 lessons, each student will be exposed to three different learning conditions (independent variables):
⦸No ICT use,⊖Moderated ICT use,○Un-moderated ICT use

If 3 classes (avg. 20 students each) from 2 schools are tested 3 times, there would be 360 test results to compare across all three conditions (⦸x120, ⊖x120,○x120,) to determine whether there is a significant difference in overall test results between conditions.

SCHOOL	**SKC**			**SC**		
CLASS	A1	A2	A3	B1	B2	B3
LESSON 1	⦸	⊖	○	⦸	⊖	○
LESSON 2	○	⦸	⊖	○	⦸	⊖
LESSON 3	⊖	○	⦸	⊖	○	⦸

EXPERIMENT DESIGN

Lesson Time	**Task**	**Lesson 1** ⦸	**Lesson 2** ⊖	**Lesson 3** ○
5	Class administration and explanation	Teacher introduces unit. Outlines instructions/ conditions for the lesson. Commences video.	Teacher introduces unit. Outlines instructions/ conditions for the lesson. Commences video.	Teacher introduces unit. Outlines instructions/ conditions for the lesson. Commences video.
20	Video	Students take notes *on pen and paper.* Teacher circulates around classroom and monitors student activity	Students take notes on *their devices.* Teacher circulates around classroom and monitors student activity	Students take notes on *their devices.* Teacher remains at front of class and *does not* monitor student activity
15	Comprehension Test	Students may refer to notes on paper. Teacher actively circulates.	Students may refer to notes on device. Teacher actively circulates.	Students may refer to notes on device. Teacher actively circulates.
5	Class Conclusion	Teacher collects comprehension test for marking.	Teacher collects comprehension test for marking.	Teacher collects comprehension test for marking.

Appendix N: Semi-Structured Interview Questions

Qualitative Measure: Participant Interviews

The purpose of these qualitative interviews is to gather multiple perspectives on technology and its role in and outside of the classroom for learning.

Questions for Students

1. How useful do you believe technology is to learning in the classroom?
2. What do you see as the main benefits of using technology for learning?
3. What do you see as the main detractors of using technology for learning?
4. How do you manage the distraction that comes from your technology in the classroom?
5. How do you manage the distraction that comes from other's technology in the classroom?
6. How do you feel when you are separated or prohibited from using your devices?
7. How do you manage the distraction that comes from technology when working at home?

Questions for Teachers

1. How useful do you believe technology is to learning in the classroom?
2. What do you see as the main benefits of using technology for learning?
3. What do you see as the main detractors of using technology for learning?
4. How do you manage the distraction that comes from students' technology in the classroom?
5. How do you monitor/restrict/control how students are using their technology within the classroom?
6. How do students react when separated or prohibited from using their devices?
7. How do you advise students manage the distraction that comes from technology when working at home?

Questions for Parents

1. How useful do you believe technology is to learning in the classroom?
2. What do you see as the main benefits of using technology for learning?
3. What do you see as the main detractors of using technology for learning?
4. How do you manage the distraction that comes from your child's technology at home?
5. How do you think your own technology use influences your child?
6. How does your child respond when their use of technology is restricted?
7. How do you determine when your child is using technology for learning or recreation?

Appendix O: Information Sheet to Parents

LEARNING IN THE AGE OF DISTRACTION: ASSESSING THE EFFICACY OF TECHNOLOGY INTEGRATION ON ADOLESCENT LEARNING

Research Project Parent Information Sheet

[redacted]

14 August, 2017

Dear Parents,

You are invited to participate in a study conducted by myself, Karl Sebire, supervised by Associate Professor Sue Gregory and co-supervised by Dr Michelle Bannister-Tyrell at the School of Education, University of New England. As part of my PhD, this leading research initiative will investigate the impact of technological distraction on learning. The purpose of this research is to gain a better insight into the way in which students learn in the digital age. Both children and adults alike are faced with a constant barrage of technological interruption as the result of our hyperconected lives. In an age where distraction is one of the greatest barriers to productivity, it will be key for individuals to develop strategies to find the balance between embracing technology and permitting it to hinder daily life.

This emerging field is instrumental for students, parents and teachers to better understand the way that ICTs impact learning. The ubiquitous nature of technology means our devices are integral to educational, recreational and social contexts. Therefore, developing an understanding of how to achieve balance in the digital world is key to using technology effectively. Whilst 21st century education strives to embrace the Information Age, it is critical that strong pedagogical rationale and a balanced approach guides all learning goals.

STUDY DESIGN

Participants: Year 10 Science Students, selected teachers and parents.

Lesson Facilitators: [redacted] Science Faculty

Quantitative Study: Students will participate in a series of comprehension tests throughout the Year 10 Science course, whilst being exposed to varying levels of technology within the classroom. The purpose of this study will be to determine under which conditions students comprehend lesson content most effectively.

Qualitative Study: Students, teachers and parents that are connected to this study can volunteer to participate in an anonimised interview. The purpose of this interview will be to determine the perceived efficacy of technology use within an educational context.

Further details are tabled overleaf.

[redacted]

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Mr Karl Sebire
MEd, MDes, BComm, GradDipEd, MACE

Researcher

LEARNING IN THE AGE OF DISTRACTION: ASSESSING THE EFFICACY OF TECHNOLOGY INTEGRATION ON ADOLESCENT LEARNING

Research Project Parent Participant Information Sheet

[redacted]

14 August, 2017

Dear Parents,

Both children and adults alike are faced with a constant barrage of technological interruption as the result of our hyperconected lives. In an age where distraction is one of the greatest barriers to productivity, it will be key for individuals to develop strategies to find the balance between embracing technology and permitting it to hinder daily life.

I, Karl Sebire, Associate Professor Sue Gregory and Dr Michelle Bannister-Tyrell at the School of Education, University of New England are undertaking a leading research initiative as part of my PhD that will investigate the impact of technological distraction on learning. This emerging field is instrumental for students, parents and teachers to better understand the way that ICTs impact learning. The ubiquitous nature of technology means our devices are integral to educational, recreational and social contexts. Therefore, developing an understanding of how to achieve balance in the digital world is key to using technology effectively. Whilst 21st century education strives to embrace the Information Age, it is critical that strong pedagogical rationale and a balanced approach guides all learning goals.

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Mr Karl Sebire
MEd, MDes, BComm, GradDipEd, MACE

Researcher

Research Project	Learning in the Age of Distraction: Assessing the efficacy of technology integration on adolescent learning.
Aim of the research	This study aims to observe how adolescents approach learning tasks and how the efficacy of their outcomes are influenced by the digital distractions they are subjected to. Comprehension tests will be supported by semi-structured interviews to provide an insight into the perceived efficacy of technology integration.
Interview	Individuals will be invited to participate in interviews. The interview will take approximately 20 minutes. With your permission, I will make an audio recording of the interview to ensure that I accurately recall the information your child provides. Following the interview, a transcript will be provided to you if you wish to see one.
Confidentiality	Any personal details gathered in the course of the study will remain confidential. No individual will be identified by name in any publication of the results. All names will be replaced by pseudonyms; this will ensure that your child is not identifiable. If you agree I would like to quote some of your child's responses. This will also be done in a way to ensure that your child is not identifiable.
Participation is Voluntary	Please understand that your child's involvement in this study is voluntary and I respect your child's right to withdraw from the study at any time. Your child may discontinue the interview at any time without consequence and they do not need to provide any explanation if they decide not to participate or withdraw.
Questions	The interview questions will not be of a sensitive nature: rather they are general, aiming to enable you to enhance my knowledge of the role that technology plays in teaching and learning.
Use of information	I will use information from the interview as part of my doctoral thesis, which I expect to complete in 2018. Information from the interview may also be used in journal articles and conference presentations before and after this date. At all times, I will safeguard your identity by presenting the information in a way that will not allow you to be identified.
Upsetting issues	It is unlikely that this research will raise any personal or upsetting issues but if it does you may wish to contact your local Community Health Centre or Lifeline on 13 11 14.
Storage of information	Any electronic data will be kept on a password protected server at the University of New England within the secure cloud. Only the research team will have access to the data.
Disposal of information	All the data collected in this research will be kept for a minimum of five years after successful submission of my thesis, after which it will be disposed of by deleting relevant computer files, and destroying or shredding hardcopy materials.

Further Questions

Principal Researcher	Associate Professor Sue Gregory	sue.gregory@une.edu.au	+61 2 6773 5054
Co-Supervisor	Dr Michelle Banister-Tyrrell	mbannist@une.edu.au	+61 2 6773 3840
Student Researcher	Mr Karl Sebire	ksebire@myune.edu.au	+61 3 9822 4965

If you have any complaints about the way this research is conducted, please contact the Research Ethics Officer at the following address

Mrs Jo-Ann Sozou	University of New England	ethics@une.edu.au	+61 2 6773 3449
Research Services	Armidale, NSW 2351		+61 2 6773 3543 (Fax)

This project has been approved by the Ethics Committee at the University of New England (Approval No. HE17-150, valid to 26/07/18)